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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

The present document provides a summary of each and every 3GPP Release 18 Feature, and more generally of all Work Items for which a summary has been agreed to be provided. By default, the following items are not summurised here: studies, testing items, spectrum-related items, protocol enhancements.

These summaries are based on the inputs issued by the Work Item Rapporteurs, sometimes modified by the Work Plan manager to ensure overall consistency of this document. The original inputs can be retrieved as temporary document (tdoc). The original tdoc number is provided just below the table of each clause.

The present document presents the "initial state" of the Features introduced in Release 18, i.e. as they are by the time of publication of this document. Each Feature is subject to be later modified or enhanced, over several years, by the means of Change Requests (CRs). To further outline a feature at a given time, it is recommended to retrieve all the CRs which relate to the given Feature, as explained in its Reference section.

1 Scope

The present document provides a summary of each Release 18 Feature or, whenever needed, of each significant Work Item.

The information provided in the present document is limited to an overview of each Feature, explaining briefly its purpose and the main lines of the system's behaviour to execute the Feature.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] TR 21.905: "Vocabulary for 3GPP Specifications".

NOTE: Due to the specificity of the present document, consisting in a collection of independent summaries, the references are given at the end of each clause rather than in this clause.

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply.
An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1]. Abbreviations specific to a given clause are provided in the clause they appear.

KPI Key Performance Indicator
Rel 3GPP Release

4 Rel-18 Executive Summary

920042	**Technical Enhancements and Improvements for Rel-18**	**TEI18**		-	**Alain Sultan, ETSI MCC**

Release 18 specifies further improvements of the 5G-Avanced system.

These improvements consist both in enhancements of concepts/Features introduced in the previous Releases and in the introduction of new topics.

Some of the key improvements are:

- a further integration of the Satellite (NTN) access (introduced in Rel-17) in the 5G System (5GS),
-a more efficient support of Internet of Things (IoT), Machine-Type Communication (MTC), including by satellite coverage
-and also several aspects of proximity communication and location (Sidelink, Proximity, Location and Positioning, better support of the industrial needs (Verticals, Industries, Factories, Northbound API), Multicast and Broadcast Services (MBS), Network Slicing or Uncrewed Aerial Vehicles (UAV).

As for the new topics, some of the key aspects are:

- Energy Efficiency (EE)
- Artificial Intelligence (AI)/Machine Learning (ML)
- eXtended, Augmented and Virtual Reality (XR, AR, VR), immersive communications

5 Satellite / Non-Terrestrial Network (NTN)

5.1 5G system with satellite backhaul

970056	**5G system with satellite backhaul**	**5GSATB**		SP-230111	**Xu Hui, CATT**
920035	**Stage 1 of 5GSATB**	5GSATB	S1	SP-210528	**Xu Hui, CATT**
940060	*Study on Support of Satellite Backhauling in 5GS*	FS_5GSATB	S2	SP-211639	**Hucheng Wang, CATT**
970018	**Stage 2 of 5GSATB**	5GSATB	S2	SP-230111	**Hucheng Wang, CATT**
980053	CT3 aspects of 5GSATB	5GSATB	C3	CP-232131	**Hou, Yunjing, CATT**
980054	CT4 aspects of 5GSATB	5GSATB	C4	CP-232131	**Hou, Yunjing, CATT**
1020024	Charging Aspects of Satellite Backhaul in 5GS	5GSATB_CH	S5	SP-231707	**Yingying, Liu, CATT**
1020029	Management aspects of 5G system supporting satellite backhaul	5GSATB_OAM	S5	SP-231708	**Wen Qi, China Telecom**

Summary based on the input provided by CATT in SP-231613.

The work item "5G system with satellite backhaul" (5GSATB) specifies two different aspects: the 5G system enhancements needed to support dynamic satellite backhaul; and the User Plane Function (UPF) onboard GEO satellite.

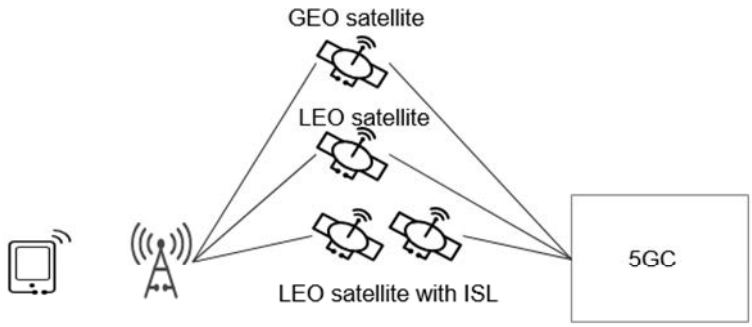

Figure 1: satellite backhaul (satellite link used between 5GC and 5GRAN)

The requirements, specified by SA1 in TS 22.261, provide the capabilities (latency and/or bandwidth) of the satellite backhaul change over time, due to e.g. use of varying inter-satellite links as part of backhaul.

From a Stage 2 perspective, a study (FS_5GSATB) was conduced in TR 23.700-27[4], and identified three Key Issues: “PCC/QoS control enhancement considering dynamic satellite backhaul”; “Support of Satellite Edge Computing via UPF on board”; and “Support of Local Data Switching via UPF on-board”.

It concluded that Stage 2 normative work was needed to standardize some identified solutions, by updating specifications TS 23.501 [1], TS 23.502 [2], TS 23.503 [3].

As for Stage 3, CT3 and CT4 also updated specifications TS 29.512[5], TS 29.514[6], TS 29.518[7], TS 29.525[8], TS 29.508[9], TS 29.523[10], TS 29.502[11] and TS 29.571[12] to implement the solution identified by SA2.

These solutions are:

Policy and Charging Control (PCC) and Quality of Service (QoS) control considering dynamic satellite backhaul

While using satellites as the backhaul, a gNB may be subject to variable backhaul delay or bandwidth if the backhaul connection involves varying inter-satellite links or if it has different types of satellite backhaul. The change of satellite backhaul delay has impact to PCC/QoS control, hence following enhancements are introduced:

- New dynamic satellite backhaul categories, i.e. DYNAMIC_GEO, DYNAMIC_MEO, DYNAMIC_LEO and DYNAMIC_OTHERSAT, are defined. If AMF is aware that satellite backhaul category changes (e.g. at handover), the AMF reports the current satellite backhaul category and indicates the satellite backhaul category change to SMF.

- Based on the dynamic satellite backhaul category indication, the SMF or PCF can determine to enforce QoS monitoring to measure the packet delay between UE and PSA UPF.

UPF onboard GEO satellite to enable edge computing and local switch

As dynamic satellite backhaul may introduce long packet delivery latency and limited bandwidth, for a communication, the shorter satellite backhaul connection is involved, the better experience the user can get. Edge computing and local switch via UPF onboard satellite is a way to avoid/reduce using satellite backhaul. However, deploying UPF on NGSO satellite would lead to UPF mobility, which may bring too much impact to current 5G network architecture. Therefore, Rel-18 only considers the scenario where UPF is onboard GEO satellite, and focuses on system enhancements on support edge computing via UPF deployed on GEO satellite and local switch for UE-to-UE communications via UPF deployed on GEO satellite.

Enhancements for satellite edge computing:

A UE can establish a PDU session with PSA UPF onboard GEO satellite, or a PDU session with an UL CL/BP and local PSA UPF onboard GEO satellite, to access satellite edge computing service. The SMF selects UPF on board GEO satellite as the PSA UPF or UL CL/BP and local PSA based on the DNAI corresponding to the GEO Satellite ID reported by the AMF and other factors. The AMF determines the GEO satellite ID based on network configuration if it detects that the satellite backhaul category is GEO or DYNAMIC_GEO.

To assist a UE establishing a PDU session with PSA UPF onboard GEO satellite to access satellite edge computing services, the PCF may take GEO satellite backhaul category reported into account to generate or update the URSP rule to include an appropriate Route Selection Descriptor for services deployed on GEO satellite, where the AMF is enhanced to send the satellite backhaul category to the PCF. The UE determines appropriate S-NSSAI and/or DNN based on the received URSP rule, and includes them in the PDU session establishment request. The SMF then determines DNAI to select the PSA UPF onboard GEO satellite based on local configuration, the received S-NSSAI and/or DNN, and GEO Satellite ID.

In order to insert an UL CL/BP and local PSA UPF onboard GEO satellite into a PDU session to let the UE access satellite edge computing services, the SMF needs also to determine DNAI based on local configuration, S-NSSAI and/or DNN, and GEO Satellite ID, then select UPF on board GEO satellite as the UL CL/BP and local PSA based on the DNAI.

Enhancements for local switch for UE-to-UE communication:

The UE to UE traffic may be locally routed by UPF(s) deployed on GEO satellite (i.e. through local switch) to the target UE without traversing back to the satellite gateway on the ground. In Rel-18, only the communication between UEs within same 5G VN group is supported.

For local switching with PSA UPF deployed on satellite, the UPF local switching, N6-based forwarding and N19-based forwarding methods defined for 5G VN group communication can be re-used.

For local switching with UL CL/BP and local PSA UPF deployed on satellite, the SMF determines to activate local switching and N19 forwarding for the UEs using the GEO satellite backhaul, based on AF request including UE identifiers of communication parties, and/or destination IP address(es) reported by PSA UPF on the ground. If local switch for UE-to UE communication can be activated, e.g., the UEs are served by same GEO satellite, the SMF may select and insert the UPF deployed on GEO satellite according to the DNAI as UL CL/BP and L-PSA, and configures UL CL/BP with rules to route the data traffic received from the UE and destined to IP address(es) of the target UE(s) to

the L-PSA. The SMF configures the Local PSA with local forwarding rules to forward the data traffic to the target UEs directly. If the selected L-PSAs are different for the UEs in the communication group, N19 tunnel is established between the L-PSAs.

Management aspects

The corresponding management capabilities, covered by updates to specifications TS 28.541 [13] and TS 28.552 [14], support the following aspects:

Satellite backhaul category indication: introduce new attributes to AMFFunction to specify the satellite backhaul category associated with the Global RAN Node ID.

QoS control considering dynamic satellite backhaul. It **a**dds satellite backhaul information to the QFQoSMonitoringControl IOC to make QoS monitoring more specific for dynamic satellite backhaul features and enhance its overall generality. It also clarifies the performance measurement for UPF to measure the packet delay between UE and PSA UPF can be applied to the satellite backhaul scenario.

UPF onboard GEO satellite to enable edge computing and local switch. It **i**ntroduces new attribute to AMFFunction to specify the GEO satellite ID associated with the deployment of UPF, as well as to the SMFFunction to specify the association of DNAI and GEO satellite ID.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970056,920035,940060,970018,980053,980054

[1] TS 23.501: "System Architecture for 5G System; Stage 2".
[2] TS 23.502: "Procedures for 5G System; Stage 2".
[3] TS 23.503: "Policy and Charging Control Framework for the 5G System; Stage 2".
[4] TR 23.700-27: "Study on 5G System with Satellite Backhaul".
[5] TS 29.512: "Session Management Policy Control Service; Stage 3".
[6] TS 29.514: "Policy Authorization Service; Stage 3".
[7] TS 29.518: "Access and Mobility Management Services; Stage 3".
[8] TS 29.525: "UE Policy Control Service; Stage 3".
[9] TS 29.508: "Session Management Event Exposure Service; Stage 3".
[10] TS 29.523: "Policy Control Event Exposure Service; Stage 3".
[11] TS 29.502: "Session Management Services; Stage 3".
[12] TS 29.571: "Common Data Types for Service Based Interfaces; Stage 3".
[13] TS 28.541: " Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".
[14] TS 28.552: " Management and orchestration; 5G performance measurements".

5.2 Discontinuous coverage: “Satellite access Phase 2”

989998	**Satellite access Phase 2**	**5GSAT_Ph2**		SP-230109	**Jean-Yves Fine, Thales**
980014	**(Stage 2 of 5GSAT_Ph2) 5GC/EPC enhancement for satellite access Phase 2**	5GSAT_Ph2	S2	SP-230109	**Jean-Yves Fine, Thales**
990024	CT1 aspects of 5GSAT_Ph2	5GSAT_Ph2	C1	CP-232167	**Amer Catovic, Qualcomm**
990056	CT6 aspects of 5GSAT_Ph2	5GSAT_Ph2	C6	CP-232167	**Amer Catovic, Qualcomm**
1010018	Charging aspects of 5GSAT	5GSAT_Ph2_CH	S5	SP-231152	**Yingying, Liu, CATT**

Summary based on the input provided by Thales in SP-240402 for the General aspects abd by CATT in SP-240401 for the charging aspects.

General aspects

Rel-18’s 5GSAT_Ph2 complements Rel-17’s introduction of a satellite access to the 5G System (“5GSAT”). More specifically, it specifies the system enhancements required to support **satellite discontinuous coverage**.

Dynamic support of discontinuous coverage is required for initial NGSO constellation deployment but as well to support evolution of the constellations such as loss of satellites, different releases supported in a given constellation. UE may have access to satellite service coverage only at specific time and places due to sparse constellation. UE location may not be timely aware of by the network to enable efficient paging, due to which mobility management mechanism needs to be enhanced. Moreover, UE may not always have to stay awake for the sake of power efficiency, especially for

MIoT UE. Hence, the prediction, mechanisms on awareness and notification of UE wake-up time and data storage and forwarding for UEs temporarily out of coverage may be needed.

At 5G Core Network (5GC) architecture level, a dedicated study on architecture aspects for using satellite access in 5G (FS_5GSAT_Ph2) was conducted in SA2 to select the solutions able to cope with discontinuous coverage key issues. The TR23.700-28[2], outcome of the study, identifies solutions to cope with discontinuous coverage, given following key issues:

- **Mobility Management enhancement with discontinuous satellite coverage**: identify and solve the gaps in Rel-17 solution designed in EPS (e.g. concerning minimizing a period of no coverage and/or minimizing power consumption), considering at least to study how to reduce the impact to target RAT or system due to large number of UEs triggering signalling load on the target RAT or system to receive normal service.

- **Power saving enhancement for UE in discontinuous coverage**: based on the coverage information of the UE, whether and how to enhance the power saving mechanisms, e.g. PSM, MICO mode and eDRX in CM-IDLE state, in order to make sure that the UE does not attempt PLMN access when there is no network coverage; and, when there is network coverage the UE attempts PLMN access as needed e.g. to transfer signalling, transfer data or receive paging, etc.

The 5GSAT_Ph2 work item, following the study, updated architecture specifications (TS23.501[3]/ TS23.502[4] /TS23.503[5]) to implement identified solutions.

The "5GC/EPC enhancement for satellite access Phase 2" work item specifies the architectural enhancements of 5G System (5GS) and Evolved Packet System (EPS) to support satellite discontinuous coverage as per conclusions reached within TR 23.700-28[2] (clause 8), in order to provide solutions on identified key issues in (clause 5), on the follow aspects:

- General mobility management and/or power saving with discontinuous coverage: Principles of system behaviour; the information AMF/MME has and how AMF/MME receives it; the role of AMF/MME; the information UE has and how UE retrieves it; the role of the UE

- Signalling overload control when recovering coverage.

RAN aspects

See next section, on "NR NTN enhancements".

Charging aspects

In SA5, TR 28.844 [10] studied the charging business scenarios, charging requirements and charging solutions, 5GSAT_ Ph2_CH led to update TS 32.255 [6], TS 32.256 [7], TS 32.291 [8] and TS 32.298 [9].

It resulted in specifying: the converged charging business scenarios, charging principle, charging requirements and charging information for 5G Satellite Access charging, including SMF based solution for charging of data connectivity via satellite access has specified in 32.255 [6] and AMF based solution for charging of connection and mobility via satellite access has specified in 32.256 [7].

The corresponding Open API and ASN.1 for 5G Satellite Access charging are specified in TS 32.291 [8] and TS 32.298 [9].

See also section "5.3 Charging and Management aspects of Satelite"

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=989998,980014,990024,990056,1010018

[1] TS 22.261, "Service Requirements for the 5G System".
[2] TR 23.700-28: "Study on Integration of satellite components in the 5G architecture; Phase 2";
[3] TS 23.501: "System architecture for the 5G System (5GS), Stage 2";
[4] TS 23.502: "Procedures for the 5G System (5GS), Stage 2";
[5] TS 23.503: "Policy and charging control for the 5G System (5GS), Stage 2";
[6] TS 32.255: "Telecommunication management; Charging management; 5G Data connectivity domain charging; stage 2"
[7] TS 32.256: "5G connection and mobility domain charging".

[8] TS 32.291:" Telecommunication management; Charging management; 5G system; Charging service, stage 3".
[9] TS 32.298:"Telecommunication management; Charging management; Charging Data Record (CDR) parameter description".
[10] TR 28.844: “Study on charging aspects of satellite in the 5G System (5GS)”

5.3 Radio-only satellite/NTN aspects

5.3.1 NR NTN enhancements

941006	**NR NTN (Non-Terrestrial Networks) enhancements**	NR_NTN_enh		RP-232669	**Nicolas Chuberre, Thales**
941106	**Core part: NR NTN (Non-Terrestrial Networks) enhancements**	NR_NTN_enh-Core	R2	RP-232669	**Nicolas Chuberre, Thales**
941206	**Perf. part: NR NTN (Non-Terrestrial Networks) enhancements**	NR_NTN_enh-Perf	R2	RP-232669	**Nicolas Chuberre, Thales**
960091	**Study on requirements and use cases for network verified UE location for Non-Terrestrial-Networks (NTN) in NR**	FS_NR_NTN_netw_verif_UE_loc	RP	RP-221820	**Thales**
1000060	**30 MHz Channel Bandwidth for NR NTN (non-terrestrial networks) in FR1 (frequency range 1)**	NR_NTN_CBW_30MHz	R4	RP-232647	**Dorin Panaitopol, THALES**

Summary based on the input provided by Thales in RP-240922.

"NR NTN enhancements" (NR_NTN_enh) introduces enhancements for the support of non-terrestrial networks into the NR and NG-RAN architecture, as defined in Rel-17’s “NR_NTN”. These enhancements include:

- Offer increased uplink coverage performance especially when addressing commercial smartphones with -5.5 dBi antenna gain and 3 dB polarisation loss (per antenna port)
- Support of Geostationary Orbit (GSO) as well as non-Geostationary Orbit (NGSO) deployment scenarios in the [DownLink: 17.7 -20.2 GHz; UpLink: 27.5 – 30.0 GHz] frequency bands
- Support the verification by the network of the location (i.e. GNSS coordinates) reported by the UE assuming a single satellite in view in order to fulfil the regulatory requirements (e.g., Lawful intercept, emergency call, Public Warning System, …)
- Provide NTN-TN and NTN-NTN measurement, mobility and service continuity enhancements considering the NTN characteristics such as large propagation delay and satellite movement
- Define 30 MHz channel bandwidth for n256 and n255 for 5G NR-NTN and introduce the corresponding SAN and UE RF core requirements, limited to clause 5 (Operating Bands and Channel Arrangement) requirements for these specifications

Compared to the solutions enabling NR/NG-RAN to support NTN, Release 18 has defined a set of enhancements which are described here after.

System aspects and core networks aspects are covered in Rel-18 SA WI ”5GSAT_Ph2”.

Uplink coverage enhancements

To improve NR uplink coverage in NTN, the following enhancements are introduced in Rel-18 :

- PUCCH repetition for Msg4 HARQ-ACK:
  - Supported number of transmissions are 1, 2, 4, 8.
    - If a single value from {2, 4, 8} is configured via SIB, the configured repetition factor is applied.
    - If multiple values from {1, 2, 4, 8} are configured via SIB, one of the multiple values is indicated in DAI field of DCI format 1_0 with CRC scrambled by TC-RNTI.
  - The existing mechanism on repetition slot counting (as in section 9.2.6 of TS 38.213) is applied.
  - Frequency hopping mechanism in R15/16/17 defined for PUCCH transmission for Msg4 HARQ-ACK, in every slot is applied.
  - A RSRP threshold can be configured via SIB when the number of repetitions is configured by SIB. If the RSRP threshold is configured, UE capable of PUCCH repetition for Msg4 HARQ-ACK reports the capability of PUCCH repetition for Msg4 HARQ-ACK via Msg3 PUSCH only if measured RSRP is lower than the configured RSRP threshold. If the RSRP threshold is not configured, UE capable of

PUCCH repetition for Msg4 HARQ-ACK reports the capability of PUCCH repetition for Msg4 HARQ-ACK via Msg3 PUSCH.
    - The repetition factor applied to Msg4 HARQ-ACK is used also for any PUCCH transmission before dedicated PUCCH resource is provided.
- NTN-specific PUSCH DMRS bundling enhancement that enables DMRS bundling in presence of timing drift, whereby UE maintains phase continuity considering effects of transmission delay variation between UE and uplink time synchronization reference point to enable improved channel estimation.

NR-NTN deployment in above 10 GHz bands a.k.a FR2-NTN frequency range (17300 MHz – 30000 MHz)

To support NR NTN deployment in FR2-NTN using FDD duplexing mode, the following aspects were considered in Release-18:

- For operation in FR2-NTN, the value range in ms for K_offset and K-MAC shall be the same as for Rel-17 NR over NTN.
- For operation in FR2-NTN, use a reference SCS of 15 kHz for the indication of K_offset and K_MAC.
- For operation in FR2-NTN and for Rel-18, no additional MAC CE TCI application delay is introduced to facilitate mechanical beam steering with VSAT.
- For operation in FR2-NTN, for cell search procedure, Case D and Case E in TS 38.213 are used to allow FDD operation in bands defined by FR2-NTN without any update to SSB pattern.
- From RAN1 perspective, for operation in FR2-NTN, the granularity used for TA reporting is the same as corresponding to the reference subcarrier spacing applied for K_offset.
- For PRACH configuration for operation in FR2-NTN, Table 6.3.3.2-4 of TS 38.211 is used as baseline.

In Release-18, the following NTN operating bands in above 10 GHz for satellite networks (FR2-NTN) have been introduced:

n512[1]	27.5 - 30.0 GHz	17.3 - 20.2 GHz	FDD
n511[2]	28.35 - 30.0 GHz	17.3 - 20.2 GHz	FDD
n510[3]	27.5 - 28.35 GHz	17.3 - 20.2 GHz	FDD
NOTE 1: This band is applicable in the countries subject to CEPT ECC Decision(05)01 and ECC Decision (13)01. NOTE 2: This band is applicable in the USA subject to FCC 47 CFR part 25. NOTE 3: This band is applicable for Earth Station operations in the USA subject to FCC 47 CFR part 25. FCC rules currently do not include ESIM operations in this band (47 CFR 25.202).			

Moreover, the following VSAT classes and types have been introduced:

UE class	**UE type**	**Type description**
Fixed VSAT	1	Fixed VSAT supporting **GSO and LEO** with mechanical steering antenna.
	2	Fixed VSAT supporting **GSO and LEO** with electronical steering antenna.
	3	Fixed VSAT supporting **LEO only** with electronical steering antenna.
Mobile VSAT	4	Mobile VSAT supporting **GSO** with mechanical steering antenna.
	5	Mobile VSAT supporting **GSO** with electronical steering antenna.
Note: Assuming that UE has single beam towards one single satellite at a given time.		

Network verified UE location

Release-18 introduced necessary enhancements to multi-RTT to support the network verified UE location in NTN assuming a single satellite in view.

The target accuracy for position verification purposes is as documented in clause « recommendations » of the TR 38.882 (i.e. 10 km granularity).

For UE location verification based on multi-RTT with single satellite in NTN, at least the following UE and gNB measurements specified in [1-4] are reported: gNB receive-transmit time difference at the uplink time synchronization reference point, UE receive-transmit time difference, UE receive-transmit time difference subframe offset and DL timing drift.

The assistance information reported to the CN may include ephemeris information including accurate satellite position and velocity at the time of multi-RTT measurement, and common TA parameters (ta-Common, ta-CommonDrift, ta-CommonDriftVariant, Epoch time).

Note that network verified UE location is an optional UE feature. The verification is triggered by the CN and is up to the CN to decide when to trigger the procedure.

Mobility Management enhancements

Mobility management enhancements to ensure service continuity covers inter-satellite, inter-gNB, inter-RAT.

For the NTN to TN mobility, the Non-Terrestrial network may broadcast NR and EUTRA TN cell coverage areas and cell information in the new SIB25. The coverage information consists in a list of geographical TN areas, with associated frequency information. UE can reduce its power consumption by skipping TN measurement based on the TN coverage information.

For the TN to NTN mobility, the TN cell can broadcast NTN neighbour satellites ephemeris via SIB 19. The UE can use ephemeris to connect to the NTN.

RACH-less handover is supported in NR NTN [2-6], [2-7]. It is a L3 mobility procedure that avoids a RACH procedure during the handover (between gNBs or during feeder/satellite switch), reducing random access congestion in the target cell.

Conditional handover associated to a time-based or a location-based trigger condition already introduced for quasi-Earth fixed cells is also supported for Earth-moving cells. For the location condition, the candidate cell's reference location re-use the cell reselection procedure as the cell moves. CondEventD2 event is introduced that includes a reference location and distance threshold for source and target cell. Moreover, for the time-based, the CHO procedure can be combined with the RACH-less HO procedure.

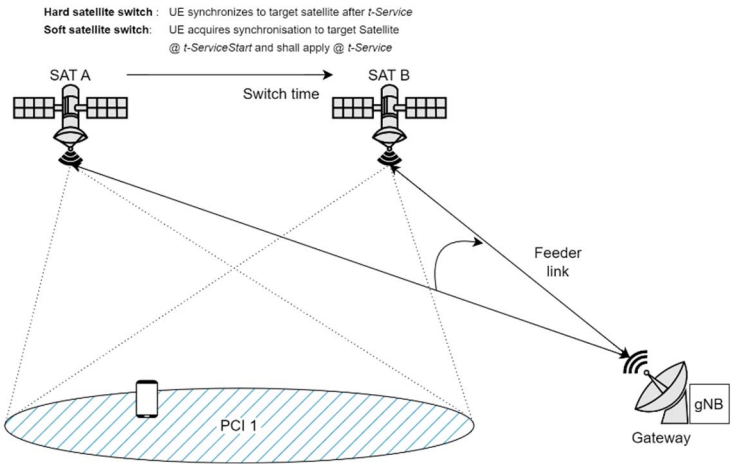

Figure 1 Satellite switch with re-sync

Satellite switch with-resync allows the UE to synchronize with the target satellite without handover, i.e. no L3 mobility, no PCI change, upon both hard and soft satellite switch over in the quasi-Earth fixed scenario with the same SSB frequency and the same gNB. CHO can be configured simultaneously. In the soft switch case, the capable UE can start synchronizing with the target satellite before the source satellite ends to serve the cell without required to be connected to both satellites, as long as the SSBs from the source satellite and target satellite are not overlapped in time.

Channel bandwidth up to 30 MHz in FR1

In the previous the channel bandwidth was limited to 20 MHz in FR1 bands. With this release, channel bandwidth can be set up to 30 MHz for n256 and n255 frequency bands. The corresponding SAN and UE RF core requirements have been introduced however, limited to clause 5 (Operating Bands and Channel Arrangement) requirements. To support this channel bandwidth additional RF and RRM requirements need to be defined in a REL-independent way starting with REL-17.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941006,941106,941206,960091,1000060

RAN1
[1-1] TS 38.212 NR; Multiplexing and channel coding
[1-2] TS 38.213 NR; Physical layer procedures for control
[1-3] TS 38.214 NR; Physical layer procedures for data
[1-4] TS 38.215 NR; Physical layer measurements
RAN2
[2-1] TS 37.355 LTE positioning protocol (LPP)
[2-2] TS 38.300 NR; NR and NG-RAN Overall description; Stage-2
[2-3] TS 38.304 NR; User Equipment (UE) procedures in idle mode and in RRC Inactive state
[2-4] TS 38.305 NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN
[2-5] TS 38.306 NR; User Equipment (UE) radio access capabilities
[2-6] TS 38.321 NR; Medium Access Control (MAC) protocol specification
[2-7] TS 38.331 NR; Radio Resource Control (RRC); Protocol specification
RAN3
[3-1] TS 38.413 NG-RAN; NG Application Protocol (NGAP)
[3-2] TS 38.423 NG-RAN; NG-RAN; Xn Application Protocol (XnAP)
[3-3] TS 38.455 NG-RAN; NR Positioning Protocol A (NRPPa)
RAN4
[4-1] TS 38.101-5 NR; User Equipment (UE) radio transmission and reception, part 5: Satellite Access Radio Frequency (RF) and performance requirements
[4-2] TS 38.133 NR; Requirements for support of radio resource management
[4-3] TS 38.108 NR; Satellite Access Node radio transmission and reception
[4-4] TS 38.101-5 NR; User Equipment (UE) radio transmission and reception, part 5: Satellite Access Radio Frequency (RF) and performance requirements
[4-5] TR 38.863 NR; Solutions for NR to support non-terrestrial networks (NTN)

See also:

1000060	**30 MHz Channel Bandwidth for NR NTN (non-terrestrial networks) in FR1 (frequency range 1)**	**NR_NTN_CBW_30MHz**	**R4**	RP-232647	**Dorin Panaitopol, THALES**
1001060	Core part: 30 MHz Channel Bandwidth for NR NTN (non-terrestrial networks) in FR1 (frequency range 1)	NR_NTN_CBW_30MHz-Core	R4	RP-232647	**Dorin Panaitopol, THALES**

5.3.2 Introduction of the satellite L-/S-band for NR

981043	**Introduction of the satellite L-/S-band for NR**	**NR_NTN_LSband**		RP-230706	**Alexander Sayenko, Apple**
981143	Core part: Introduction of the satellite L-/S-band for NR	NR_NTN_LSband-Core	R4	RP-231179	**Alexander Sayenko, Apple**
981243	Perf. part: Introduction of the satellite L-/S-band for NR	NR_NTN_LSband-Perf	R4	RP-231179	**Alexander Sayenko, Apple**
970028	*Study on Security Aspects of Satellite Access*	FS_5GSAT_Sec	S3	SP-220875	**Wei Lu, Xiaomi**
960026	*Study on Management Aspects of IoT NTN Enhancements*	FS_IoT_NTN	S5	SP-220490	**Sun Mingrui, China Unicom**
960091	*Study on requirements and use cases for network verified UE location for Non-Terrestrial-Networks (NTN) in NR*	FS_NR_NTN_netw_verif_UE_loc	RP	RP-221820	**Thales**
980028	*Study on charging aspects of Satellite in 5GS*	FS_5GSAT_CH	S5	SP-221162	**Yingying, Liu, CATT**

Summary based on the input provided by Apple in RP-233308.

NR_NTN_LSband introduces the support of the satellite L-/S-band (UL 1610-1626.5MHz and DL 2483.5-2500MHz) as band n254. The main technical aspects of this band are captured in the corresponding TR 38.741 "Non-Terrestrial Networks (NTN) L-/S-band for NR" [1].

The main differences of this band comparing to the common NTN RF requirements are as follows:

- System parameters, such as frequency range, available channel bandwidth, Rx-Tx separation distance, and asymmetric channel bandwidths.
- Tx requirements covering emission requirements, new A-MPR values (depending on the channel bandwidth, its location, and the number of allocated RBs) and UE co-existence requirements.
- Rx requirements covering the REFSENS values, in-band and out-of-band blocking requirements.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=981043,981143,981243

[1] TR 38.741: "Non-Terrestrial Networks (NTN) L-/S-band for NR"

5.4 Guidelines for Extra-territorial 5G Systems

860010	**Guidelines for Extra-territorial 5G Systems**	FS_5GET	S1	SP-191042	**Cyril MICHEL,Thales**

Summary based on the input provided by Thales in RP-233321.

The WI "Guidelines for Extra-territorial 5G Systems" has produced a technical report referenced TR 22.926 which addresses:

- Use cases and associated conditions generating extraterritoriality of public 5G systems (e.g. HAPS and satellite access covering multiple countries or international waters, aeronautical networks),
- 3GPP features (e.g. emergency calls, PWS, LI, charging) and technical aspects (e.g. MCC/MNC, location of UE/NW) for which extraterritoriality is relevant, and types of regulations that may be applicable.
- Guidelines on the fulfilment of relevant regulatory requirements (e.g. routing to a core network in a specific country, use of MCC).

This report provides general guidance regarding considerations of regulations and their application in 3GPP specifications, as related to extra-terrestrial communication. These considerations apply in particular to PLMN access that can be offered through radio access technologies whose coverage could extend well beyond the political borders of countries. This is the case for instance with satellite access, and this could also be the case with High Altitude Platforms. Another example of extraterritorial access is where a PLMN ID is used for a local network on e.g. a ship or plane travelling in/over international waters.

For services provided over international waters, for aeronautical communications, or terrestrial mobile networks, the fundamental question is which requirements apply? It is expected that UEs and networks will apply the regulations applicable to the sovereign territory in which the UE is positioned, even in cases where the sovereign territory is determined by a vessel carrying the UE. This has implications on the design and operation of the corresponding 5G system. The following 3GPP Services/features can be affected by extraterritoriality:

- Public Warning System
- Charging and Billing
- Emergency calls
- Lawful Intercept
- Data Retention Policy in cross-border scenarios and international regions
- Network access

Extraterritoriality is considered as either:

- the location of the UE and its access to the 5G network; The regulatory implication will differ depending on whether the UE is in border regions, in Vessels, in Exclusion Areas, in Extraterritorial Areas or migrating between Areas

- the location of the 5G network for the services to be delivered, as per the two use cases: “Network selection with extra territoriality” or “Network access and Exclusion Areas”

To support regulated services and features, 3GPP networks have the capability to locate each UE in a reliable manner and determine the policy that applies to their operation depending on their location and/or context.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=860010

[1] TR 38.861: "Study on high power UE (power class 2) for one NR FDD band"

5.5 5G system with satellite access to Support Control and/or Video Surveillance

920034	**5G system with satellite access to Support Control and/or Video Surveillance**	SCVS	S1	SP-210527	**Dong Chen, Xiaomi**

Summary based on the input provided by Xiaomi in SP-240869.

This feature updates KPI table to 5G system with satellite access in TS 22.261 [1] clause 7.4.2, specifying requirements for 5G system with satellite access to support equipment control and/or video surveillance.

To support video surveillance and control of video surveillance for 5G system with satellite access, performance requirements for 5G system with satellite access are added for the scenario.

References

Related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920034

[1] TS 22.261: " Service requirements for the 5G system; Stage 1".

5.6 Management aspects of Satelite

990033	**Management Aspects of NTN**	OAM_NTN	S5	SP-230183	**Sun Mingrui, China Unicom**

Summary based on the input provided by China Unicom in SP-240285.

This work item mainly specifies the requirements and solutions enabling Management Aspects of IoT and NR to support non-terrestrial networks (NTN) based on RAN and SA2 aspects. It includes reference management architectures and scenarios for integrated satellite components, use cases and solutions related to the general management of satellite RAN with transparent satellite components, use cases and solutions related to the monitoring of satellite RAN components, and use cases and solutions for supporting mobility management enhancement.

For 3GPP Management System, for scenarios where BS cannot be deployed or inconvenient to maintain, such as maritime transportation, energy collection, agriculture, and environmental protection, network introduces satellites to support cellular terrestrial network. This requires 3GPP management system should be able to support non-terrestrial network information to be provided NG-RAN/E-UTRAN and 5GC/EPC to support UE which uses NR/NB-IoT/eMTC RAT type access to the non-terrestrial network. In addition, the 3GPP management system is required to make corresponding enhancements to provide support of discontinuous satellite network coverage.

Management support for NTN overall architecture

In order to provide management support for NTN, the 3GPP management system need to support the capabilities to enable the integration of satellite in 5G/4G network. The reference architecture depicted in figure 1 considers the case of a 3GPP RAN integrating a satellite NR-RAT and satellite NBIoT/e-MTC RAT, possibly together with a Terrestrial RAT.

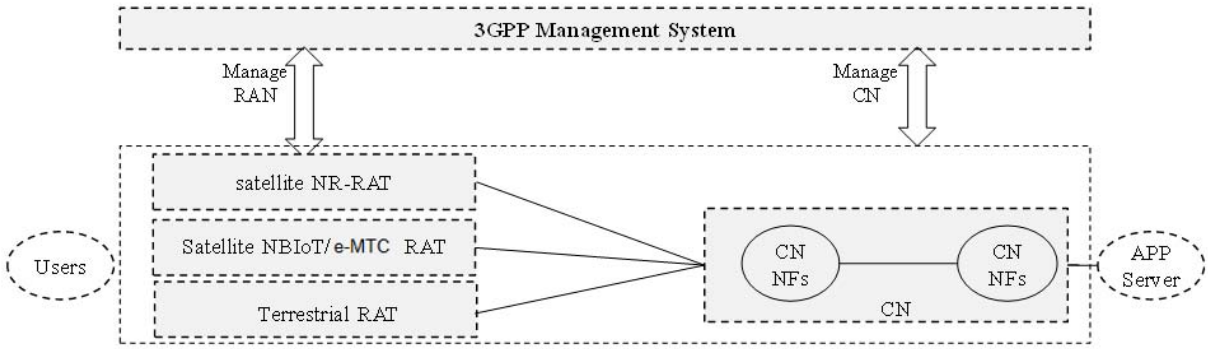

Figure 1: Reference architecture for the management aspects of NTN

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990033

[1] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3"
[2] TS 28.552: "Management and orchestration; 5G performance measurements"
[3] TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)"
[4] TS 28.530: "Management and orchestration; Concepts, use cases and requirements)"
[5] TS 28.657: "Telecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Requirements"
[6] TS 28.658: "Telecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"
[7] TS 28.659: "elecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions"

5.7 IoT (Internet of Things) NTN enhancements

941004	**IoT (Internet of Things) NTN (non-terrestrial network) enhancements**	**IoT_NTN_enh**		RP-223519	**Abhishek Roy, MediaTek**
940104	Core part: IoT (Internet of Things) NTN (non-terrestrial network) enhancements	IoT_NTN_enh-Core	R2	RP-231407	**Abhishek Roy, MediaTek**
950284	Perf. Part: IoT (Internet of Things) NTN (non-terrestrial network) enhancements	IoT_NTN_enh-Perf	R4	RP-231407	**Abhishek Roy, MediaTek**

Summary based on the input provided by MediaTek in RP-233261.

Rel-17's work item "IoT_NTN" first introduced NTN for connecting the NB-IoT and eMTC devices. However, there were bottlenecks identified in performance, mobility, and coverage discontinuity aspects.

Rel-18's "IoT_NTN_enh" further enhances the IoT_NTN, with functionalities in three major areas: (1) Performance (HARQ and GNSS enhancements), (2) Measurement & mobility enhancements in idle as well as connected mode, and (3) Enhancements in discontinuous coverage. It also complements the work done by SA2 study on 5GC enhancements for satellite access Phase 2.

The following functionality is introduced to improve performance:

- **HARQ feedback Enabling/Disabling:** HARQ feedback of downlink packets can be enabled or disabled per HARQ process by dedicated RRC signalling and/or DCI based indication to mitigate the impact of HARQ stalling in NB-IoT/eMTC NTN. Disabling HARQ feedback allows scheduling a HARQ process with a downlink packet before one HARQ RTT has elapsed since last scheduled, which allows lower layer latency and higher data rates per UE. Disabling HARQ feedback can be configured even for NB-IoT with single HARQ process. For HARQ process with DL HARQ feedback disabled, the UE will not start the corresponding DL HARQ RTT timer. The (re)starting of downlink drx-

inactivity timers are adjusted depending on configuration of HARQ enabling/disabling status, single or multiple TB scheduling and HARQ Ack bundling.

In the uplink two HARQ modes: HARQ mode A and HARQ mode B are introduced and configured per HARQ process basis. UL HARQ mode configuration is based on RRC signalling. For HARQ process in HARQ mode B, UE will not start the corresponding UL HARQ RTT timer. For NB-IoT NTN with single HARQ process in HARQ mode B, the UE will start/restart drx-inactivity timer in the subframe containing the last repetition of the corresponding PUSCH transmission. HARQ mode B is not applicable for UL transmission using PUR. For eMTC new LCP restrictions are introduced corresponding to HARQ enabling/disabling. UE (re)starts drx-InactivityTimer accordingly based on the configured UL HARQ mode.

• **Improved GNSS operations:** During long connection times and for reducing GNSS measurements impact on UE power consumption, a UE supporting improved GNSS operations can be triggered to perform or configured to autonomously perform its GNSS acquisition If ul-TransmissionExtensionEnabled is configured, a time duration starts at the end of GNSS validity duration and a UE can perform autonomously GNSS acquisition using an autonomous gap starting at the end of the time duration, or the UE can be triggered to perform GNSS acquisition before the end of the time duration. This allows a UE in RRC_CONNECTED to apply UE pre-compensation of satellite delay and Doppler to maintain UL synchronization for UL transmission in an NTN cell. While network can trigger connected UE to perform GNSS measurement using DL MAC CE, UE autonomous GNSS-triggering measurement will be configured by RRC dedicated signalling. If there is neither network trigger nor network configuration of UE autonomously GNSS measurement, UE moves to RRC_IDLE after GNSS becomes invalid. UE will report the GNSS validity duration by using a UL MAC CE and assumes the GNSS location is valid upon successful GNSS measurement. Network enables this reporting of GNSS position fix duration, in SIB2 and in dedicated signalling (for handover).

• Moreover, for measurement and mobility enhancements:

- New time-based and location-based triggers are introduced. UE can start intra/inter frequency measurement in connected mode before the specific time. A serving cell reference location and a distance threshold / radius for UE is introduced to detect when to trigger connected mode measurements. A new SIB is introduced for the network to broadcast the neighbor cell/satellite information. Satellite ids are introduced for serving and neighbor satellites. Location-based measurement initiation can also be optionally used in idle mode for cell re-selection purposes.

- For CHO in eMTC NTN, time and location-based trigger conditions may be configured independently (i.e., without a jointly configured measurement condition.

• In addition, in case of discontinuous coverage,

- An enhancement to RRC Release is introduced. UE may directly go to RRC_IDLE after RLF is triggered if there is not enough time for the UE to finish the procedure of RRC re-establishment due to the discontinuous coverage.

- Based on the conclusion of SA2 study, a new cause value "Release due to discontinuous coverage" is introduced for the S1AP UE Context Release Request procedure. There is no need to enhance the existing S1AP procedure to support the tracking area reported by RAN before AN release. In this release, the paging enhancement for power saving and mobility management enhancement for discontinuous coverage are not pursued. In addition, IoT NTN has also aligned with the progress of NR NTN on the mobility issues, such as the introduction of time-based CHO over X2. While the progress of NW verified UE location in NR NTN is not considered in IoT NTN, since this topic is out of scope on IoT NTN.

• Finally, for UE's RRM core requirements the following are identified: for NB-IoT and eMTC UEs in IDLE mode, cell re-selection requirements for location-based measurement triggering are specified; for NB-IoT and eMTC UEs in CONNECTED mode, RAN4 specified the requirements for neighbour cell measurements and the corresponding measurement triggering before RLF; for NB-IoT and eMTC UEs in CONNECTED mode, RAN4 specified the RRM requirements considering the GNSS reacquisition; for eMTC UEs in CONNECTED mode, RAN4 specified the Conditional Handover requirements for location-based and time-based events.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941004,940104,950284

See also:

991041	**Introduction of the Extended L-band (UL 1668-1675MHz, DL 1518-1525MHz) for IoT NTN**	**IoT_NTN_extLband**	**R4**	RP-232686	**Inmarsat**

991141	Core part: Introduction of the Extended L-band (UL 1668-1675MHz, DL 1518-1525MHz) for IoT NTN	IoT_NTN_extLband-Core	R4	RP-232686	**Luca Lodigiani, Inmarsat**
991241	Perf. part: Introduction of the Extended L-band (UL 1668-1675MHz, DL 1518-1525MHz) for IoT NTN	IoT_NTN_extLband-Perf	R4	RP-232686	**Luca Lodigiani, Inmarsat**
991043	**Introduction of FDD LTE band (L+S band) for IoT NTN operation**	**IoT_NTN_FDD_LS_band**	**R4**	RP-230792	**Aijun CAO, MediaTek**
991143	Core part: Introduction of FDD LTE band (L+S band) for IoT NTN operation	IoT_NTN_FDD_LS_band-Core	R4	RP-231479	**Aijun CAO, MediaTek**
991243	Perf. part: Introduction of FDD LTE band (L+S band) for IoT NTN operation	IoT_NTN_FDD_LS_band-Perf	R4	RP-231479	**Aijun CAO, MediaTek**
950074	**NB-IoT/eMTC Core and Perf requirements for NTN**	**LTE_NBIOT_eMTC_NTN_req**		RP-223437	**Tim Frost, MediaTek**
950174	Core part: NB-IoT (Narrowband IoT)/eMTC (enhanced Machine Type Communication) core & performance requirements for Non-Terrestrial Networks (NTN)	LTE_NBIoT_eMTC_NTN_req-Core	R4	RP-221556	**Tim Frost, MediaTek**
950274	Perf. part: NB-IoT (Narrowband IoT)/eMTC (enhanced Machine Type Communication) core & performance requirements for Non-Terrestrial Networks (NTN)	LTE_NBIoT_eMTC_NTN_req-Perf	R4	RP-223437	**Hsuanli Lin, MediaTek**
981034	UE Conformance - NB-IoT (Narrowband IoT)/eMTC (enhanced Machine Type Communication) core & performance requirements for Non-Terrestrial Networks (NTN)	LTE_NBIOT_eMTC_NTN_req-UEConTest	R5	RP-223064	**Dan SONG, Danbo Fu (MediaTek), CMCC, MediaTek**

6 Internet of Things (IoT), Machine-Type Communication (MTC)

6.1 Personal IoT and Residential networks

930029	**Personal IoT and Residential networks**	**PIRates**		SP-211505	**Xiaowan Ke, vivo**
880041	*Study on Personal IoT Networks*	FS_PIN	S1	SP-200592	**Adrian Buckley, vivo**
880040	*Study on Enhancements for Residential 5G*	FS_Resident	S1	SP-200576	**Toon Norp, KPN**
930022	**Stage 1 of PIRates**	PIRates	S1	SP-211505	**Xiaowan Ke, vivo**
940065	*Study on Personal IoT Networks*	FS_PIN	S2	SP-230089	**Zhenhua Xie, vivo**
980011	**(Stage 2 of) Personal IoT Networks**	PIN	S2	SP-221343	**Zhenhua Xie, vivo**
990018	CT1 aspects of PIN	PIN	C1	CP-230197	**Hui Wang, vivo**
990058	CT3 aspects of PIN	PIN	C3	CP-230197	**Hui Wang, vivo**
990059	CT4 aspects of PIN	PIN	C4	CP-230197	**Hui Wang, vivo**

Summary based on the input provided by vivo in SP-231586.

The "Personal IoT Networks" work item specifies enhanced feature for providing local connectivity between PIN elements (PINE) i.e., UEs and/or non-3GPP devices. A Personal IoT Network (PIN) has at least one PIN element with Gateway Capability (PEGC) and at least one PIN Element with Management Capability (PEMC), both are UEs. A PIN is managed by PEMC, which may be assisted by an AF for PIN if deployed. PIN elements communicate using PIN direct communication without traversing 5G network, as well as PIN indirect communication and the PIN-DN communication with traversing 5G network. For the PIN indirect communication and PIN-DN communication, the data traffic and management traffic pass via a UE acting as PEGC.

Overall architecture and general aspects

As illustrated in Figure 1, a PIN in 5GC consists of one or more devices providing gateway/routing functionality known as the PEGC, and one or more devices providing PIN management functionality known as the PEMC to manage the PIN and device(s) called the PINE. A PINE can be a non-3GPP device. A PIN is managed at the PIN application layer.

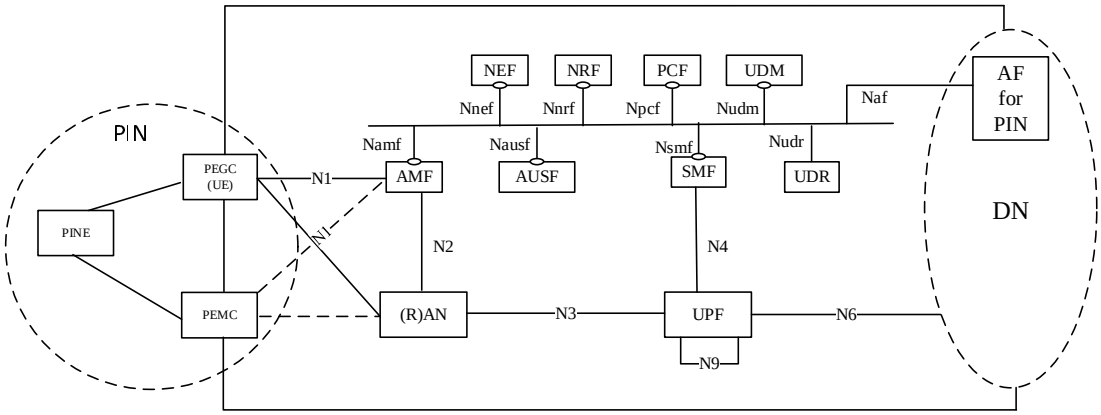

Figure 1: PIN reference architecture

The PIN may also have a PIN Application Server that includes an AF functionality. With PIN-DN communication, the PEMC and PEGC communicate with the PIN Application Server at the application layer over the user plane. The PEGC and PEMC can communicate with each other via PIN direct communication using 3GPP access (e.g., PC5) or non-3GPP access (e.g., WiFi, BT) or via PIN indirect communication using a PDU Session in the 5GS.

UE policy delivery for PIN

The 5GC is enhanced to support the delivery of URSP rules that include only a PIN ID as Traffic Descriptor to UE acting as PEGC, which may be based on the information provided by an AF for PIN.

A unique PIN ID in a PLMN is designated to a PIN, e.g., by PIN application layer. In 5GS the PIN ID is only used in the traffic descriptor of URSP rules, for routing traffic of specific PIN towards a dedicated (DNN, S-NSSAI) combination.

Session management and traffic routing for PIN

The PEGC is a UE with subscription data related to PIN within the 5GS (i.e., (DNN, S-NSSAI) combination(s) for PIN) and shall register to 5GS as UE in order to support PIN indirect communication and PIN-DN communication via dedicated PDU session. The UE acting as PEMC does not have subscription data related to PIN within the 5GS and behaves as normal UE if it is registered in 5GS.

During PDU session establishment and PDU session modification, if the SMF provides the PEGC with QoS flow descriptions, the SMF may additionally signal Non-3GPP QoS Assistance Information (N3QAI) for each QoS flow to the PEGC based on the (DNN, S-NSSAI) combination of the PDU Session for enabling the PEGC to perform QoS differentiation for the PINEs in the non-3GPP network behind the PEGC. Multiple QoS flows can share same N3QAI.

For PIN indirect communication and PIN-DN communication via PEGC and 5G network, non-3GPP delay is the delay between the PEGC and the PINE. 5GC may need to be aware of the non-3GPP delay and compensate for this delay in 5GS. If the PEGC supports requesting of the non-3GPP delay budget for a specific traffic flow, the PEGC may use the UE requested PDU Session Modification procedure to request a non-3GPP delay budget for a set of packet filters. Based on the (DNN, S-NSSAI) combination of the PDU Session, the SMF adjusts the dynamic CN PDB for the related GBR QoS flow by the non-3GPP delay (i.e., the network determined original PDB value is unchanged, but it needs to cover non-3GPP delay, besides the AN PDB and CN PDB) according to operator policy and implementation, and signals the updated dynamic CN PDB to NG-RAN.

An AF may provide QoS parameters for PIN traffic to 5GC.

If a PIN has multiple PEGCs as illustrated in Figure 2, 5G VN group communication mechanisms can be used for PIN indirect communication (i.e., communication between PIN Elements belonging to the same PIN but served by different PEGCs).

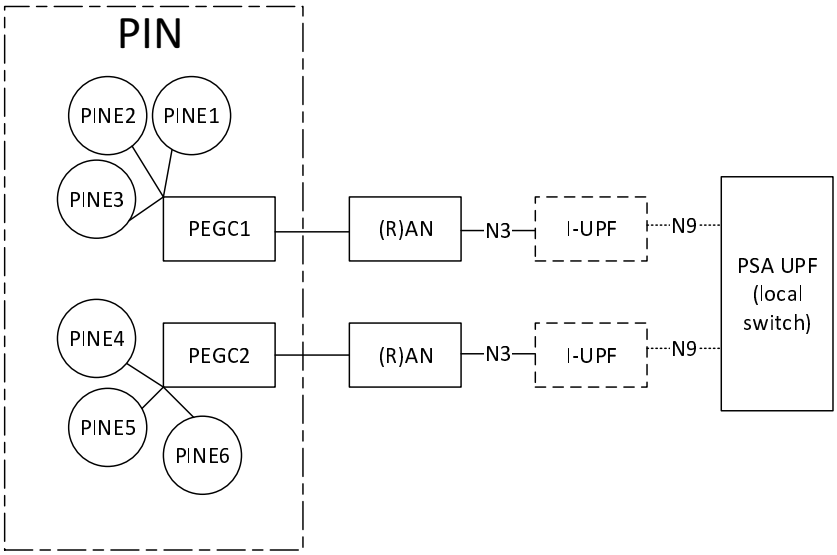

Figure 2: Local-switch based user plane architecture for PIN

NOTE: Figure 2 does not show traffic from a PEMC.

In this case a dedicated SMF set is used for managing the PIN related PDU Sessions from all the PEGCs of that PIN. The user plane handling for 5G LAN-type services is applicable with the difference that N19-based traffic forwarding is not used for PIN indirect communication.

The PEMCs can also be grouped together with the PEGCs using the 5G VN group management functionality for enabling the PEMCs to communicate with PEGCs via UPF local switch in order to manage the PIN.

Attention (AT) commands for N3QAI and non-3GPP delay budget

To support the usage of N3QAI and non-3GPP delay budget end-to-end, the AT commands for N3QAI and non-3GPP delay budget are added to exchange the parameters between Mobile Termination (MT) and Terminal Equipment (TE).

The PEGC may receive N3QAI from the network during PDU session establishment or PDU session modification procedure. An AT command for N3QAI enables the MT to inform the N3QAI to the TE.

To ensure the non-3GPP delay budget is transmitted from the UE to the network, an AT command for non-3GPP delay budget enables the MT to retrieve the non-3GPP delay budget from the TE.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930029,930022,980011,990018,990058,990059

[1] TS 22.261: “Service Requirements for the 5G System”
[2] TS 23.501: “System architecture for the 5G System (5GS), Stage 2”
[3] TS 23.502: “Procedures for the 5G System (5GS), Stage 2”
[4] TS 23.503: “Policy and charging control for the 5G System (5GS), Stage 2”
[5] TS 24.501: “Non-Access-Stratum (NAS) protocols for the 5G System (5GS), Stage3”
[6] TS 29.007: “AT command set for User Equipment, Stage3”

6.2 Enhanced support of Reduced Capability (RedCap) NR devices

970080	**Enhanced support of reduced capability NR devices**	**NR_redcap_enh**		RP-233637	**Johan BERGMAN, Ericsson**
970180	Core part: Enhanced support of reduced capability NR devices	NR_redcap_enh-Core	R1	RP-233637	**Johan BERGMAN, Ericsson**
970280	Perf. part: Enhanced support of reduced capability NR devices	NR_redcap_enh-Perf	R1	RP-233637	**Johan BERGMAN, Ericsson**

940086	*Study on further NR RedCap (reduced capability) UE complexity reduction*	FS_NR_redcap_enh	R1	RP-221161	**Johan BERGMAN, Ericsson**
940056	*Study on RedCap Phase 2*	FS_REDCAP_Ph2	S2	SP-220074	**Qian, Chen, Ericsson**

Summary based on the input provided by Ericsson in RP-233638.

NR_redcap_enh introduces enhancements of Rel-17 RedCap functionality [3] by introducing features for further UE complexity reduction (through UE peak data rate reduction and UE baseband bandwidth reduction) and further UE power saving (through enhanced eDRX in RRC Inactive state) to expand the market for RedCap use cases with low-tier eRedCap devices similar to LTE UE category 1/1bis, between existing 3GPP LPWA (NB-IoT/LTE-MTC) devices and Rel-17 RedCap devices.

The following key functionalities are introduced as part of this work item, and the related RAN CR packs can be found in references [7] – [12].

Further UE complexity reduction (through UE peak data rate reduction and UE baseband bandwidth reduction)

The Rel-17 RedCap work item [3] introduced a reduced capability (RedCap) UE type which implements one or more UE complexity reduction techniques (reduced maximum UE Rx/Tx bandwidth, reduced number of UE Rx antennas, etc.) to enable NR to efficiently serve midrange IoT use cases (wearables, industrial wireless sensors, video surveillance, etc.).

Rel-18 introduces an eRedCap UE type allowing for further complexity reduction using the following techniques [1]:

- UE peak data rate reduction in FR1
- UE baseband bandwidth reduction in FR1

The work item [1] was preceded by a study item documented in [4], where the UE peak data rate reduction is referred to as Option PR1, and the UE baseband bandwidth reduction is referred to as Options BW3/PR3 for PUSCH/PDSCH.

The UE peak data rate reduction restricts the peak rate in DL and UL to 10 Mbps. For every eRedCap UE, the peak rate target is 10 Mbps in UL and DL regardless of what other features the UE may support.

- The UE peak data rate reduction is supported with or without UE baseband bandwidth reduction. The initial access procedure for UE peak data rate reduction without UE baseband bandwidth reduction is the same as for UE peak data rate reduction with UE baseband bandwidth reduction.

The UE baseband bandwidth reduction restricts the maximum number of PRBs for PDSCH/PUSCH that the UE needs to process per slot. This maximum number of PRBs corresponds to about 5 MHz, or more precisely 25 PRBs for 15 kHz SCS and 12 PRBs for 30 kHz SCS (referred to as '25/12 PRBs' below).

- The restriction on the number of PRBs only affects PDSCH/PUSCH, no other signals/channels.
- For PUSCH, up to 25/12 PRBs can be allocated contiguously within a BWP of up to 20 MHz.
- For unicast PDSCH, up to 25/12 PRBs can be allocated contiguously or distributed within a BWP of up to 20 MHz.
- For broadcast (SIB/paging/Msg2) PDSCH, the number of allocated PRBs is not restricted, i.e., any number of PRBs can be allocated within 20 MHz, but it is assumed that the UE is allowed to serialize its processing of these PRBs if they exceed 25/12 PRBs, so that the UE baseband parts process no more than 25/12 PRBs per slot, meaning that it may take more than one slot for the UE to demodulate and decode the whole PDSCH. For SIB and paging, this is not expected to be a problem. However, to give the UE enough time to process Msg2 PDSCH, it was agreed to specify a relaxed Msg2-Msg3 timeline, which is described below.

- There are some relaxations of the requirements on simultaneous reception of two PDSCHs.

As mentioned above, if a gNB wants to schedule a Msg2 PDSCH with more than 25/12 PRBs, then an eRedCap UE may need a relaxed Msg2-Msg3 timeline. This means that the minimum time between Msg2 and Msg3 is increased by 1 slot. A similar relaxation applies in case of 2-step RACH. The relaxed Msg2-Msg3 timeline was motivated by the UE baseband bandwidth reduction, but it has been agreed that it applies to all eRedCap UEs regardless of whether they support UE baseband bandwidth reduction or not.

Similar early indications have been specified for eRedCap UEs as for Rel-17 RedCap UEs (in the Uu and F1 interfaces). This means that an eRedCap UE always indicates in Msg3 PUSCH (or MsgA PUSCH in case of 2-step RACH) using special LCID that it is an eRedCap UE, and that it also indicates this in Msg1 PRACH if gNB has configured eRedCap-specific PRACH resources.

Similar access barring bits have been specified for eRedCap UEs as for Rel-17 RedCap UEs (in the Uu, Xn, and F1 interfaces). This means that gNB can indicate separately for 1-Rx eRedCap UEs and 2-Rx eRedCap UEs whether they are allowed to access the cell or not.

Further UE power saving (through enhanced eDRX in RRC Inactive state)

The Rel-17 RedCap work item [3] introduced extended DRX cycles for RRC Idle state (up to 10485.76 seconds, i.e., ~3 hours) and RRC Inactive state (up to 10.24 seconds) as an optional feature for both RedCap and non-RedCap UEs. For use cases with relatively relaxed requirements on downlink reachability/latency, the network may configure an extended DRX cycle, which may reduce the UE power consumption substantially during periods with large enough packet inter-arrival time.

Rel-18 takes a step further by introducing support for enhanced eDRX cycle length in RRC Inactive state beyond 10.24 seconds, up to the same eDRX cycle length as for RRC Idle state (up to 10485.76 seconds, i.e., ~3 hours), making the RRC Inactive state more power-efficient. The RAN/SA work items [1, 5] were started after a study [6] had assessed that this would be feasible.

For eDRX cycles longer than 10.24 seconds, new procedures between RAN and CN have been defined to enable/disable buffering of data and signalling in the CN, based on the RAN configured eDRX cycle and paging time window (PTW). A new RAN paging request is defined from CN to RAN to page the UE in RRC Inactive state based on the long eDRX cycle information. Regarding PTW, different PTW lengths can be configured for RRC Idle state and RRC Inactive state, respectively (in the range 1.28 to 40.96 seconds). The configured eDRX cycle length for RRC Inactive state is upper bounded by the configured eDRX cycle length for RRC Idle state.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970080,970180,970280

[1] RP-233637, “Revised WID on Enhanced support of reduced capability NR devices”
[2] RP-233636, “Status report for Enhanced support of reduced capability NR devices”
[3] RP-221163, “Summary of WI on support of reduced capability (RedCap) NR devices”
[4] TR 38.865 V18.0.0, “Study on further NR RedCap UE complexity reduction”
[5] SP-220803, “New WID: 5GS support of NR RedCap UE with long eDRX for RRC_INACTIVE State”
[6] TR 23.700-68 V18.1.0, “Study on support of reduced capability NR devices; Phase 2”
[7] RP-232478, “Introduction of Rel-18 - Enhanced support of reduced capability NR devices”, RAN1
[8] RP-233717, “Corrections to Rel-18 - Enhanced support of reduced capability NR devices”, RAN1
[9] RP-233899, “Enhanced support of reduced capability NR devices”, RAN2
[10] RP-233815, “Introduction of NR Redcap Enhancement for NGAP”, RAN3
[11] RP-233816, “Introduction on NR Redcap Enhancement”, RAN3
[12] RP-233361, “RAN4 CRs to Open REL-18 NR or NR+LTE WIs related to RAN1”, RAN4

6.3 NR RedCap UE with long eDRX for RRC_INACTIVE State

980113	**NR RedCap UE with long eDRX for RRC_INACTIVE State**	**NR_REDCAP_Ph2**		SP-220803	**Qian, Chen, Ericsson**
970013	**(Stage 2 of) NR RedCap UE with long eDRX for RRC_INACTIVE State**	**NR_REDCAP_Ph2**	**S2**	SP-230171	**Qian, Chen, Ericsson**
980068	CT4 aspects of NR_REDCAP_Ph2	NR_REDCAP_Ph2	C4	CP-223021	**Frank Yong Yang, Ericsson**
980069	CT1 aspects of NR_REDCAP_Ph2	NR_REDCAP_Ph2	C1	CP-223021	**Frank Yong Yang, Ericsson**

Summary based on the input provided by Ericsson in SP-240289.

The Rel-17 work item enhanced the support of NR RedCap UE in 5GS, including the power saving mechanism (MICO, eDRX) support for NR RedCap UE. However, the eDRX for RRC_INACTIVE state is only limited to 10.24s.

This Rel-18 work item enables the usage of eDRX for NR RedCap UE in RRC_INACTIVE state beyond 10.24s, i.e., the same eDRX value range is applicable to both UE in CM-IDLE mode and UE in RRC_INACTIVE state.

It also supports MT-SDT handling for UE in RRC_INACTIVE state as alignment with Rel-18 RAN work NR_redcap_enh.

The support for the request of CN based MT data and signalling handling includes a procedure that can be used by NG-RAN to request the CN based MT data and signalling handling for UE in RRC_INACTIVE state; and the NG-RAN provides necessary information for CN to calculate the UE reachability.

The support for CN triggered Connection Resume handling includes a CN triggered connection resume procedure for UE in RRC_INACTIVE state; and the AMF calculates the UE reachability based on information provided by NG-RAN.

The support for indication from NG-RAN to CN for MT data and signalling delivery includes a procedure for indication when UE resumes in the same NG-RAN as the one when UE enters RRC_INACTIVE state; a procedure for the indication when UE resumes in a new NG-RAN which is different from the one when UE enters RRC_INACTIVE state; and CN triggers the MT data and signalling delivery based on the indication.

The support for MT-SDT for UE in RRC_INACTIVE state includes UPF/SMF reports DL data size per QoS flow to AMF when UPF triggers downlink data notification for UE in RRC_INACATIVE state with CN MT data handling activated; and the AMF provides the DL data size per QoS flow to NG-RAN when UE is considered reachable by AMF.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980113,940056,970013,980068,980069,970080

[1] TS 23.501: "System Architecture for the 5G System; Stage 2".
[2] TS 23.502: "Procedures for the 5G System; Stage 2".
[3] TS 29.502: "5G System; Session Management Services; Stage 3".
[4] TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".
[5] TS 29.244: "Interface between the Control Plane and the User Plane nodes".
[6] TS 29.571: "5G System; Common Data Types for Service Based Interfaces; Stage 3".
[7] TS 29.272: "Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol".
[8] TS 24.008: "Mobile Radio Interface Layer 3 specification; Core Network Protocols; Stage 3".
[9] TS 38.413: "NG-RAN; NG Application Protocol (NGAP)".

6.4 Application layer support for Personal IoT Network

990106	**Application layer support for Personal IoT Network**	**PINAPP**		SP-221236	**Huazhang Lv, vivo,**
940021	*Study on Application layer support for Personal IoT Networks*	FS_PINAPP	S6	SP-220095	**Huazhang Lv, vivo**
980052	**Stage 2 of PINAPP**	PINAPP	S6	SP-221236	**Huazhang Lv, vivo,**
990017	CT1 aspects of PINAPP	PINAPP	C1	CP-230332	**Yizhong ZHANG, vivo**
990061	CT3 aspects of PINAPP	PINAPP	C3	CP-230332	**Yizhong ZHANG, vivo**

Summary based on the input provided by vivo in SP-231590.

Personal IoT Networks (PIN) is based on the greatly increasing number of consumers IoT devices. Users create Personal IoT Networks out of all these Personal IoT devices mainly in their homes or around their body wearables. This technical specification provides application enabler layer architecture and related procedures for enabling PIN applications over 3GPP networks.

Overall architecture and general aspects

The PIN elements contains PIN client and/or application clients. The PIN Element with gateway capability (PEGC) performs the role of an entity supporting gateway capability for PIN. The PIN Element with management capability (PEMC) performs the role of an entity supporting management capability for PIN. A PIN includes at least one PEGC and at least one PEMC. The roles of PEGC and PEMC act as UEs in 5GS.

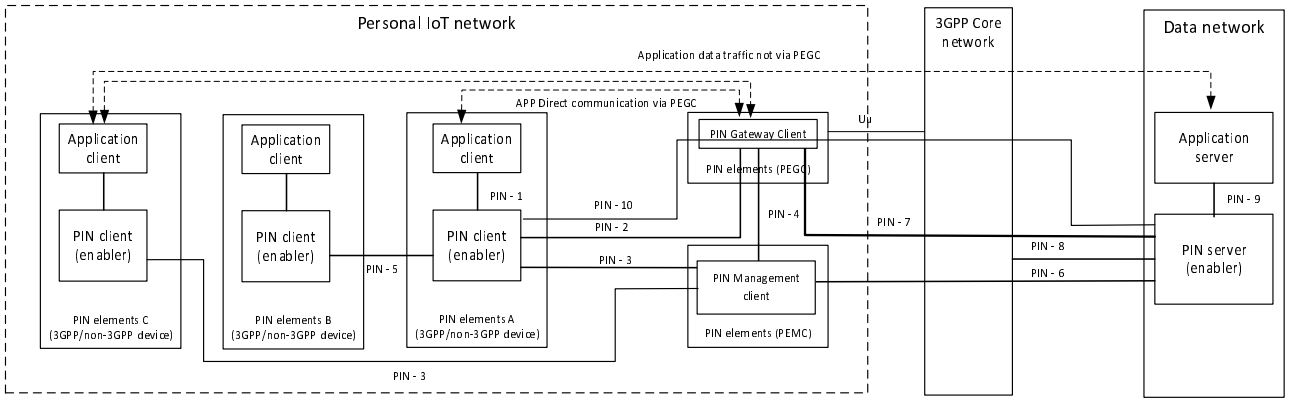

Figure 1: PINAPP reference architecture

The PIN enabler architecture consists of PIN client deployed in PIN element and PIN server deployed in Data network. The following interaction are supported in the PIN enabler architecture:

- The PIN client interacts with Application Client on the PINE over PIN-1 to provide and consume services in the PIN.
- The PIN server interacts with Application Server(s) over PIN-9. These interactions are supported using the CAPIF architecture as specified in TS 23.222 [7].
- The PIN server interacts with 3GPP networks over PIN-8 to consume 3GPP network services.
- The PIN management client(s) interact with PIN server over PIN-6 for services related to management of PIN.
- The PIN client(s) interact with PIN server over PIN-10. These interactions traverse via the PEGC.
- The PIN gateway client(s) interact with PIN server over PIN-7.
- PIN client(s) interact with PIN gateway client over PIN-2.
- PIN management client interacts with PIN gateway client(s) over PIN-4.
- PIN management client interacts with PIN client(s) over PIN-3.
- A PIN client interacts with other PIN client(s) over PIN-5.

PIN Management

The PINAPP architecture shall provide mechanisms to PIN management, for example, to create PIN for UE or PIN elements, to delete PIN either triggered by PINEs or by PIN server, to support PIN modification procedure, for example, PEMC/PEGC relocation and etc.

After the UE or PINE acquires the role of PEMC and receives the address of PIN server, the UE or PINE can trigger a creation of PIN towards PIN server.

Below are the possible scenarios when the PEMC request for the creation of PIN:

- No PIN elements or PEGC have established connection with PEMC;
- One or more PIN elements including PEGCs, PEMCs have established connection with PEMC via non-3GPP access. In this case the PEMC can trigger creation of PIN with these PIN elements in group.

After the creation of PIN is accepted by network, the PIN server responds to PEMC containing the details of the PIN including the PIN ID, the PEGC information, access control information configured in PEGC etc.

At the network side, a PIN server should be deployed. The PIN server is responsible for the authorization of the Creation request of PIN, and arranges the PEGC information about access control to PIN.

The PIN which is in use can be deleted based on the decision by PEMC or PIN server as described below:

- Decided by PEMC. The PEMC of a PIN decides to delete the PIN and sends request to PIN server. The PIN server accepts the request and deletes the PIN.
- Decided by PIN server. If the PIN is configured to exist for a particular duration and if it continues to exist post the duration the PIN server can decide to delete the PIN and release the resources associated with the PIN.

Once the PIN is deleted, the PIN elements in PIN shall not be able to utilize the services by the PIN or 5GS anymore and cannot access the application server. The network resources allocated for this PIN will be released.

Since the configuration related to the duration of the PIN is available with PEMC and when the duration of the PIN expires, the PEMC can directly delete the PIN locally and without having to be authorized by the PIN server. After the PIN is deleted by PEMC, the PEMC can update the status of PIN to the PIN server.

PINAPP enable 5GS communication

For a certain PINE, it has the subscription whether the PINE has the permission to use 5GS to communicate.

The PIN client within a PIN can communicate with other devices, services and applications within the same PIN. Furthermore, PIN client can connect the 5G Network via a PEGC. Also, as a feature, some of the PIN client in PIN has the permissions that they can communicate with other UE or application outside of PIN with the help of 5GC.

- There are two methods to enable the PIN with 5GS communication:
- Establish QoS for PINE with AF support.
- PEGC triggers PDU session establishment/modification for PINE.

For the AF related procedure, the AF trigger the QoS create/modification procedure with parameters of Packet filters, DN specific ID, to request the 5GS to arrange resource for PIN.

For PEGC related procedure, the PIN element sends PIN Communication Request to the PEMC. The PEMC sends Create/Update/Remove Communication Request (PIN ID, Packet filters, requested QoS) to the PEGC. The PEGC configures the local rule accordingly, or according to the Packet filters, the PEGC may initiate PDU Session Modification with the Packet filters and requested QoS towards 5G system in order to make 5GC configure the N4 rules for UPF(s).

Service Switch

PIN service switch procedures enable a PIN Element participating in a PIN to transfer application session(s) to a different PIN Element participating in the same PIN. For example, a first PIN Element (e.g. a UE) can transfer a video streaming session to a second PIN Element (e.g. a television). PIN service switch can be triggered by a PIN Element when needed, for example when the first PIN Element joins a PIN and determines that an application flow can be switched to a second PIN Element present in that PIN.

Two scenarios are specified for PIN service switch:

- PIN service switch with PIN server support.
- PIN service switch without PIN Server support (e.g. using only internal PIN communication).

Application server discovery and registration in PIN

The PEMC and PIN Server have capabilities for maintaining information related to application servers that may be available to the PINE(s) within a PIN. Application server information may be pre-provisioned in the PIN Server or the PEMC; the application server may also register with the PEMC or the PIN Server if it has such capability.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990106,940021,980052,990017,990061

[1] TS 22.261: “Service Requirements for the 5G System”.
[2] TS 23.501: “System architecture for the 5G System (5GS), Stage 2”;
[3] TS 23.502: “Procedures for the 5G System (5GS), Stage 2”;
[4] TS 23.542: “Application layer support for Personal IoT Network; Stage 2”
[5] TS 24.583: “Application layer support for Personal IoT Network (PINAPP); Stage 3”
[6] TS 29.583: “Application layer support for Personal IoT Network (PINAPP); Personal IoT Network (PIN) server services; Stage 3”
[7] TS 23.222: “Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs; Stage 2”

6.5 5G Timing Resiliency System

6.5.1 General aspects and RAN aspects

910039	**5G Timing Resiliency System**	**5TRS**		SP-210211	**Betsy Covell, Nokia**
880037	*Study on 5TRS*	FS_5TRS	S1	SP-200573	**Betsy Covell, Nokia**

940055	*Study on 5G Timing Resiliency and TSC&URLLC enhancements*	FS_5TRS_URLLC	S2	SP-211634	**Devaki Chandramouli**
910033	**Stage 1 for 5TRS**	5TRS	S1	SP-210211	**Betsy Covell, Nokia**
970024	**Stage 2 of Timing Resiliency and URLLC enhancements**	TRS_URLLC	S2	SP-230107	**Devaki Chandramouli**
980102	CT1 aspects of TRS_URLLC	TRS_URLLC	C1	CP-231360	**Apostolos Papageorgiou (Nokia)**
980103	CT3 aspects of TRS_URLLC	TRS_URLLC	C3	CP-231360	**Apostolos Papageorgiou (Nokia)**
980104	CT4 aspects of TRS_URLLC	TRS_URLLC	C4	CP-231360	**Apostolos Papageorgiou (Nokia)**
950028	*Study on Management Aspects of URLLC*	FS_URLLC_Mgt	S5	SP-230772	**Wang,Zhaoning,China Unicom**
940088	*Study on enhancement for resiliency of gNB-CU (Central Unit)-CP (Control Plane)*	FS_gNB_CU_CP_resiliency	R3	RP-222249	**Masato Taniguchi, NTT DOCOMO, INC.**
991036	**NR Timing Resiliency and URLLC enhancements**	**TRS_URLLC-NR**	**R3**	RP-232863	**Sean Kelley, Nokia**
991136	Core part: NR Timing Resiliency and URLLC enhancements	TRS_URLLC-NR-Core	R3	RP-232863	**Sean Kelley, Nokia**

General aspects

5GS network timing synchronization status and reporting

Timing resiliency provides the ability for 5G timing service to be used in critical infrastructure with the intention to be used as a land-based backup for GNSS (or even as alternative to GNSS), 5G itself has to be less dependent on GNSS. 3GPP specified support for 5G-A timing resiliency as an evolution of the timing synchronization service. Timing resiliency leverages the monitoring of the time synchronization status of the network elements involved in the time distribution chain (e.g., the serving NG-RAN node or the UPF/NW-TT). Based on that monitoring, the NG-RAN or UPF/NW-TT can detect timing synchronization degradation, failure, or improvement, and report the status to the subscribed consumers of the status information.

If a timing status change is detected, the RAN node notifies UE(s) subscribed to the service regarding timing synchronization status. The reporting to the UE can either indicate acceptable or not based on acceptance criteria or provide detailed clock quality information. In addition, TSCTSF may receive timing synchronization status from RAN and/or UPF. If the TSCTSF determines there is a status change for a time synchronization service provided to UEs for which an AF originally requested the service, the TSCTSF may inform the AF about the timing synchronization status for those UEs.

Interworking with TSN network deployed in the transport network

This feature enables the 3GPP system to interwork with Time Sensitive Networking (TSN) network deployed in the transport network (TN) to ensure that the TN adheres to the QoS requirements of the QoS flows supported within the 3GPP system. This interworking is applicable when the TN deploys fully centralized configuration model as defined in IEEE Std 802.1Q-2022 and deploys a TN CNC.

Adapting downstream and upstream scheduling based on RAN feedback for low latency communication

This feature enables the application to adapt both downstream and upstream traffic scheduling based on RAN feedback for ultra-low latency communication. The Application Function (AF) may provide its burst timing adaptation capabilities to the gNB via the 5GC. The gNB derives feedback based on e.g. the radio configuration and radio protocol signalling, and provides burst arrival time (BAT) and periodicity feedback to the AF via the 5GC. RAN feedback can be provided proactively (e.g., before the application starts sending data bursts) or reactively (e.g., based on observed BAT of the received data bursts).

RAN-specific aspects

Summary based on the input provided by Nokia, Nokia Shanghai Bell in RP-122865.

The RAN-specific aspects to support the Rel-18 enhancements for timing resiliency and ultra-low latency in tight coordination with the transport network and application, are built on top of Rel-17's WID NR_IIOT_URLLC_enh-Core. Rel-18 covers three main aspects : 5GS network timing synchronization status and reporting:, Interworking with TSN network deployed in the transport network and Adapting downstream and upstream scheduling based on RAN feedback for low latency communication. This was

5GS network timing synchronization status and reporting

Time synchronization service can be offered by the 5GS based on 5G Access Stratum TIme (ASTI) distribution. The network timing synchronization status of a gNB may change, resulting in timing synchronization degradation or improvement which is detected locally by the gNB. The gNB's network timing synchronization information includes a list of one or more of the following attributes depending on gNB implementation: synchronization state, traceability to UTC, traceability to GNSS, clock frequency stability, clock accuracy, and parent time source. Within the gNB, the gNB-DU monitors the timing synchronization information and reports it to the gNB-CU. When there is a timing synchronization status update available at the gNB-CU, it may be reported to:

- Time Sensitive Communication and Time Synchronization Function (TSCTSF) using control plane signalling at node level via the AMF. The AMF controls the gNB node level reporting using NGAP messages.

- UE consuming time synchronization service according to parameters stored in the UE context. The UE receives clock quality information via dedicated RRC signalling in the form of either a UE-specific indication whether the clock quality is acceptable/not acceptable, or the node level timing synchronization attributes. The gNB indicates to UEs that the clock quality has changed via SIB9, which triggers UE in RRC_INACTIVE or RRC_IDLE state to reconnect in order to receive the clock quality information.

Interworking with TSN network deployed in the transport network

This feature enables the 3GPP system to interwork with Time Sensitive Networking (TSN) network deployed in the transport network (TN) to ensure that the TN adheres to the QoS requirements of the QoS flows supported within the 3GPP system. This interworking is applicable when the TN deploys fully centralized configuration model as defined in IEEE Std 802.1Q-2022 and deploys a TN CNC. It is assumed that the NG-RAN, 5GC, and transport network are time synchronized with each other using the 5GS internal system clock. The NG-RAN/UPF may include AN-TL/CN-TL function to support enhanced End Station functionality as defined in IEEE 802.1 TSN standards. The CUC is collocated with the SMF and interacts with TN CNC. The SMF/CUC communicates with AN-TL/CN-TL via TL-Containers that convey the configuration data sets over the N2/N11 and N4 interfaces. When the AN-TL/CN-TL function is not supported, the SMF/CUC can communicate with the NG-RAN/UPF for assignment of distinct N3 tunnel end point addresses per QoS flow.

Adapting downstream and upstream scheduling based on RAN feedback for low latency communication

This feature enables the application to adapt both downstream and upstream traffic scheduling based on RAN feedback for ultra-low latency communication. The Application Function (AF) may provide its burst timing adaptation capabilities to the gNB via the 5GC. The gNB derives feedback based on e.g. the radio configuration and radio protocol signalling, and provides burst arrival time (BAT) and periodicity feedback to the AF via the 5GC. RAN feedback can be provided proactively (e.g., before the application starts sending data bursts) or reactively (e.g., based on observed BAT of the received data bursts).

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910039,880037,940055,910033,970024,980102,980103,980104,950028,940088,991036,991136

General aspects:
[g1] TS 22.104: "Service requirements for cyber-physical control applications in vertical domains"
[g2] TS 22.261: "Service requirements for the 5G system"
[g3] TS 23.501: "System architecture for the 5G System (5GS)"
Radio aspects:
[1] RP-232864, Status report for WI: Core part: NR Timing Resiliency and URLLC enhancements, Nokia

6.5.2 Charging Aspects of Time-Sensitive Networking (TSN)

970032	*Study on Time Sensitive Networking (TSN) Charging*	FS_TSNCH	S5	SP-220979	**CHEN SHAN, Huawei**
1010014	**Charging Aspects of TSN**	TSN_CH	S5	SP-231151	**Deng, Yimeng, Huawei**

Summary based on the input provided by Huawei in SP-240075.

The work item specifies the charging aspects of time sensitive networking, including specifying the new charging trigger functions, i.e. TSCTSF and TSN AF, and specifying the charging architectures, principles and information.

A new specification TS 32.282 [1] specifies the converged charging for the time sensitive networking domain, covering the following charging scenarios:

- the TSN 5GS bridge configuration and management charging.
- the enabler of time sensitive communication (TSC) and time synchronization (TS) charging.
- the time sensitive communication (TSC) traffic charging.

The TSN AF (CTF) collects and reports the charging information to support the converged charging for 5GS bridge configuration and management, based on PEC, IEC and ECUR scenarios. The reference point between TSN AF and CHF is N104.

The TSCTSF (CTF) collects and reports the charging information to support the converged charging for the enabler of TSC and TS, based on PEC, IEC and ECUR scenarios. The reference point between TSCTSF and CHF is N105.

The converged charging for exposure of TSC and TS may be supported by the service exposure charging by NEF (CTF), as specified in TS 32.254 [2].

The converged charging for TSC traffic may be supported by the interaction between SMF, C-CHF and B-CHF, as specified in TS 32.255 [3]. The SMF (CTF) may collect and report TSN related charging information.

References

[1] TS 32.282: "Telecommunication management; Charging management; Time-Sensitive Networking (TSN) charging".
[2] TS 32.254: "Telecommunication management; Charging management; Exposure function Northbound Application Program Interfaces (APIs) charging".
[3] TS 32.255: "Telecommunication management; Charging management; 5G Data connectivity domain charging; stage 2".

6.6 Mobile Terminated-Small Data Transmission (MT-SDT) for NR

941000	**Mobile Terminated-Small Data Transmission (MT-SDT) for NR**	**NR_MT_SDT**		RP-222993	**Eswar Vutukuri, ZTE Corporation**
941100	Core part: Mobile Terminated-Small Data Transmission (MT-SDT) for NR	NR_MT_SDT-Core	R2	RP-222993	**Eswar Vutukuri, ZTE Corporation**

Summary based on the input provided by Nokia, Nokia Shanghai Bell in RP-122865.

In Rel-17, the work item for small data enhancements (NR_SmallData_INACTIVE) enabled transmission of small signalling and/or data packets whilst the UE remains in RRC_INACTIVE state. These Rel-17 enhancements supported only the Mobile Originated Small Data Transmissions (MO-SDT).

In Rel-18 MT-SDT specifies the Mobile Terminated Small Data Transmissions. For DL, MT-SDT (i.e. DL-triggered small data) allows similar benefits as MO-SDT i.e. 1) reducing signalling overhead and UE power consumption by avoiding unnecessary transitions to RRC_CONNECTED and reducing latency by allowing fast transmission of (small and infrequent) packets, e.g. for positioning.

For a UE in RRC_INACTIVE state, MT-SDT is initiated by the network with an indication to the UE in the paging message when DL data awaits transmission for radio bearers configured for SDT; based on the indication, the UE initiates the MT-SDT only if the DL RSRP is above a configured threshold. When MT-SDT is initiated by the UE, a resume cause indicating MT-SDT is included in the RRCResumeRequest/RRCResumeRequest1 message. It is possible for the network to enable MO-SDT or MT-SDT or both MO-SDT and MT-SDT in a cell. MT-SDT procedure can be initiated with either a transmission over RACH or over Type 1 Configured Grant (CG) resources (configured via dedicated signalling in RRCRelease).

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941000,941100

[1] RP-232864, Status report for WI: Core part: NR Timing Resiliency and URLLC enhancements, Nokia

6.7 New Rel-18 NR FDD bands for RedCap

991039	**Adding new NR FDD bands for RedCap (Reduced Capability) in Rel-18**	**NR_FDD_bands_R18_redca**	**R4**	RP-230743	**Chunhui Zhang, Ericsson**
991139	Core part: Adding new NR FDD bands for RedCap (Reduced Capability) in Rel-18	NR_FDD_bands_R18_redcap-Core	R4	RP-231049	**Chunhui Zhang, Ericsson**

Summary based on the input provided by Ericsson in RP-233798.

This work item introduces additional FDD band to support RedCap feature as release independent feature starting from Rel-17.

Band n105 is added as release independent FDD band for RedCap in Rel-18.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990106,940021,980052,990017,990061

[1] TS 38.101-1, “NR User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone”
[2] 38.307, NR; Requirements on User Equipments (UEs) supporting a release-independent frequency band
[3] R4-2321923, “CR for adding RedCap UE for release independent feature”
[4] R4-2313470, “CR adding REFSENS for HD-FDD RedCap UE for band n105”

6.8 Signal level Enhanced Network Selection

920033	**Signal level Enhanced Network Selection**	**SENSE**	**S1**	SP-210525	**Bischinger, Kurt; Deutsche Telekom**
970059	CT1 aspects of SENSE	SENSE	C1	CP-222237	**Reinhard Lauster, Deutsche Telekom**
970060	CT6 aspects of SENSE	SENSE	C6	CP-222237	**Reinhard Lauster, Deutsche Telekom**
1010052	UE Conformance - Signal level Enhanced Network Selection	SENSE-UEContest	R5	RP-232362	**Huawei**

Summary based on the input provided by Deutsche Telekom in SP-240392.

The feature Signal level Enhanced Network SElection (SENSE) [1] was introduced to solve problems with unattended stationary deployed devices which sometimes select networks during the automatic network selection process which are not suitable for a stable and reliable data transmission. As a result, manual on site intervention is often needed.

It allows an operator to set a specific signal strength threshold per access technology on a USIM. The UE gives higher priority to networks if the received signal quality of the candidate PLMN/access technology combination is equal to or higher than the Operator controlled signal threshold per access technology.

The support of the feature is mandatory for UEs supporting any, or a combination, of NB-IoT, GERAN EC-GSM-IoT and Category M1 or M2 of E-UTRA.

The home operator can configure certain UEs to take the signal level into account during the initial steps of network selection after switch on or recovery from loss of coverage and during all steps of the periodic re-selection, by introducing an Operator controlled signal threshold per access technology on the USIM that can be updated using the Steering Of Roaming (SOR) mechanism.

The automatic network selection procedures are enhanced in that way that in case the Operator controlled signal threshold per access technology is set

- in a first iteration the UE additionally applies the Operator controlled signal threshold as an additional criterion in each step of the selection process;
- if registration cannot be achieved during the first iteration a second iteration of the process is performed as today, i.e. without applying the Operator controlled signal threshold.

Stage 1, requirements for the enhancement of network selection, is defined in [1], stage 2 in [2].

In Stage 3 the following changes were introduced:

- Update of timer handling for unavailability period activation due to the newly introduced timer TSENSE [3],
- Enhancement of NAS management object to be able to configure whether SENSE is used or not [4],
- Update of SOR to support update of the SENSE related USIM file EFOCST [5],
- Introduction of a new AT command to retrieve parameters for SENSE [6],
- Enhancement of USIM EFs and addition of EFOCST to store SENSE parameters [7].

Conformance test cases are specified in [8].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920033,970059,970060,1010052

[1] TS 22.011: “Service accessibility”
[2] TS 23.122: “Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode”
[3] TS 24.301: “Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3”
[4] TS 24.368: “Non-Access Stratum (NAS) configuration Management Object (MO)”
[5] TS 24.501: “Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3”
[6] TS 29.007: “AT command set for User Equipment (UE)”
[7] TS 31.102: “Characteristics of the Universal Subscriber Identity Module (USIM) application”
[8] TS 36.523-1: “Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Packet Core (EPC); User Equipment (UE) conformance specification; Part 1: Protocol conformance specification”

6.9 IoT NTN enhancements

Covered in 5, under “satellite” aspects.

7 Energy Efficiency (EE)

7.1 Enhancements of EE for 5G Phase 2

940037	**Enhancements of EE for 5G Phase 2**	EE5GPLUS_Ph2	S5	SP-211441	**Cornily Jean-Michel, Orange**

Summary based on the input provided by vivo in SP-231590.

This work item was the continuation of the Rel-17 Energy Efficiency work items. It focused on three main topics:

- measurement and collection of energy consumption of network functions / elements,
- definition of energy efficiency KPIs,
- energy saving use cases, requirements and solutions.

It used input from the Rel-18 Study on new aspects of EE for 5G networks Phase 2 (FS_EE5G_Ph2).

- With regard to the measurement of the energy consumption of Virtualized Network Functions, (VNF), this work item defined new Energy Consumption KPIs for virtual compute resources, based on their virtual disk usage and their I/O traffic, both provided by NFV MANO.

- With regard to Energy Efficiency, roles involved to build EE KPIs in different organizational scenarios have been described, in particular in case of non-virtualized RAN and in case of virtualized 5G Core network on telco cloud. Several corrections and enhancements were made to already existing EE KPI definitions, e.g. to the eMBB network slice EE KPI and to the latency-based URLLC network slice EE KPI.

- With regard to Energy Saving, an energy saving compensation procedure was added and a solution for UPF energy saving was added as well in TS 28.310.

- Energy Efficiency related terms including energy consumption, energy efficiency have been defined in TS 28.310.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940037

[1] TS 28.310: “Management and orchestration; Energy efficiency of 5G”
[2] TS 28.554: “Management and orchestration; 5G end to end Key Performance Indicators (KPI)”

7.2 Network energy savings for NR

981037	**Network energy savings for NR**	**Netw_Energy_NR**		RP-223540	**Yi Wang, Huawei**
981137	Core part: Network energy savings for NR	Netw_Energy_NR-Core	R1	RP-230566	**Yi Wang, Huawei**
981237	Perf. part: Network energy savings for NR	Netw_Energy_NR-Perf	R4	RP-230566	**Yi Wang, Huawei**

Summary based on the input provided by Huawei in RP-233657.

Network energy savings is key to 5G/NR success to reduce environmental impact (greenhouse gas emissions), and for operational cost savings. An initial study was conducted in RAN WGs where various techniques from time, frequency, spatial and power domain were investigated based on a network energy consumption model for base station, with the outcome captured in [1]. Following that, the Rel-18 work item introduced the following new features:

- CSI enhancements for adaptations in spatial and power domains
- Cell DTX/DRX mechanism in time domain
- SSB-less SCell operation for inter-band CA
- Mechanism to prevent legacy UEs camping and enhancements on CHO procedure
- Inter-node beam activation and enhancements on paging

CSI enhancements for adaptations in spatial and power domains

In order to perform dynamic adaptation in spatial and/or power domain for energy saving at gNB, precise CSI are critical. A new CSI reporting framework is introduced, which enables the UE to report N>=1 CSI sub-report(s) in one reporting instance. This is achieved by network configuring L>=N sub-configurations in a CSI report setting, and each sub-configuration contains parameters for either spatial domain (SD) adaptation or power domain (PD) adaptation. SD adaptation can be further characterized into Type 1 SD adaptation and Type 2 SD adaptation, where Type 1 SD can reduce the number of antenna ports based on a common CSI-RS resource and Type 2 SD can reduce the number of antenna elements associated to the antenna ports without reducing the number of the latter. Joint operation of SD and PD adaptation is also supported. A UE can then derive the CSIs according to the sub-configurations in CSI report setting and map them into respective CSI sub-report in a same CSI report. Periodic, semi-persistent or aperiodic CSI reporting are supported. The occupied CPU concerns the CSI-RS resources per each sub-configuration that is to be used for deriving a CSI. The counting for active CSI-RS resource and CSI-RS ports concerns the CSI-RS resources and CSI-RS ports per each referred sub-configuration and CSI-RS resource type.

Cell DTX/DRX mechanism in time domain, for UEs in RRC_CONNECTED mode

To facilitate reducing gNB transmission/reception activity time, functionality for aid of gNB Discontinuous Transmission (DTX) and Discontinuous Reception (DRX), i.e. cell DTX and cell DRX operation is introduced. A UE can be configured with a periodic cell DTX/DRX pattern (i.e. active and non-active periods of the gNB). The cell DTX and cell DRX pattern can be configured and activated separately or together, with a maximum of two cell DTX/DRX patterns per MAC entity for different serving cells. The feature was designed with a focus on the case where cell DTX in RRC can only be configured when UE C-DRX is configured. During non-active periods of cell DTX/DRX, certain channels/signals are not received/transmitted on the corresponding cell by the UE. Cell DTX/DRX can be activated/deactivated by RRC signalling or L1 group common signalling of DCI format 2_9. DCI format 2_9 can also be used for dynamic enabling/disabling NES-specific CHO execution condition. This feature is only applicable to UEs in RRC_CONNECTED state and does not impact Random Access procedure, SSB transmission, paging, and system information broadcasting.

SSB-less SCell operation for inter-band CA for FR1 and co-located cells for frequency domain

To further save network energy consumption by reducing the SSB from SCell (SSB-less), SSB-less operation is extended from intra-band contiguous FR1 co-located scenario (supported in Rel-15) to inter-band FR1 co-located scenario. The SSB-less SCell can be activated relying on a reference inter-band cell. The inter-band SSB-less SCell activation requirements are defined based on periodic TRS/Aperiodic TRS on the SSB-less SCell, when the corresponding conditions are fulfilled, which include the receive timing difference/EPRE difference/QCL relation between the SSB-less cell and the reference cell.

Mechanism to prevent legacy UEs camping on cells adopting the Rel-18 NES techniques

UEs incapable of cell DTX/DRX operation may attempt to access a cell configuring cell DTX/DRX. A new barring bit, optionally present in SIB1, was introduced to allow only UEs capable of cell DTX/DRX to access a cell that has enabled this technique. If this bit is not present, the legacy barring mechanisms are used.

Enhancements on CHO procedure for NES cell(s)

To handover a UE to other cells as fast as possible if the source cell enters NES mode, NES-specific CHO event(s) can be configured to the UE, and the event is only considered fulfilled if the UE is notified via DCI that the NES-specific CHO execution condition is enabled and entry condition(s) is met.

Inter-node beam activation and enhancements on paging

For inter-node beam activation, a NG-RAN node owning a coverage cell can request neighbouring NG-RAN node(s) owning a capacity booster cell to switch on some SSB beams within the cell. The receiving NG-RAN node should act accordingly, and respond with the activated SSB beams. A network energy saving cause is defined to indicate that the SSB beams are deactivated for energy saving. Optional assistance information of allowed cell list is defined for CU/DU split case. A NG-RAN node can page certain UEs (e.g., stationary UEs) in RRC_INACTIVE state on a limited set of beams. Recommended SSB list can be included in paging message for CU/DU split case.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=981037,981137,981237

[1] TR 38.864, Study on network energy savings for NR.
[2] RP-230566, WID revision: Network energy savings for NR.
[3] RP-233655, Status report for WI: Network energy savings for NR; rapporteur: Huawei.

7.3 Smart Energy and Infrastructure

See section 10.3, under Verticals

8 Uncrewed Aerial Vehicles (UAV), UAS, UAM

8.1 Architecture for UAV and UAM Phase 2

990107	**Further Architecture Enhancement for UAV and UAM**	**UAS_Ph2**		SP-221323	**Faccin, Stefano, Qualcomm**
940051	*Study on Phase 2 of UAS, UAV and UAM*	FS_UAS_Ph2	S2	SP-211632	**Stefano Faccin**
980012	**(Stage 2 of UAS Ph2) Further Architecture Enhancement for UAV and UAM**	UAS_Ph2	S2	SP-230091	**Faccin, Stefano, Qualcomm**
960034	*Study on Security of Phase 2 for UAS, UAV and UAM*	FS_UAS_Ph2_SEC	S3	SP-220532	**Escott, Adrian, Qualcomm,**
990036	Security of UAV and UAM Phase 2	UAS_Ph2	S3	SP-230149	**Escott, Adrian, Qualcomm**
990012	CT1 aspects of UAS Ph2	UAS_Ph2	C1	CP-230330	**Kim, Sunghoon, Qualcomm**
990063	CT3 aspects of UAS Ph2	UAS_Ph2	C3	CP-230330	**Kim, Sunghoon, Qualcomm**
990064	CT4 aspects of UAS Ph2	UAS_Ph2	C4	CP-230330	**Kim, Sunghoon, Qualcomm**
990105	CT6 aspects of UAS Ph2	UAS_Ph2	C6	CP-230330	**Kim, Sunghoon, Qualcomm**
930012	*Study on enhanced architecture for UAS Applications*	FS_eUASAPP	S6	SP-220465	**Monrad, Atle, InterDigital**

Summary based on the input provided by Qualcomm in SP-240889.

The support of UAS (Unmanned Aircraft System) by the 3GPP system was introduced in Rel-17 under the Work Item “UAS”.

Release 18 Phase 2 enhancements define new system enhancements required by the proliferation of UAV (Uncrewed Aerial Vehicles) and UAM (Urban Air Mobility) vehicles and use cases, as to provide reliable and safe communication for UAV/UAM. In particular, mechanisms are defined to support:

- Broadcast Remote Identification for UAV identification, to satisfy North American regulations;
- C2 (Command and Control) communications for direct C2 between a UAV controller and the UAV;
- aviation applications such as Detect And Avoid (DAA) to provide tactical deconfliction mechanisms to be deployed in order to complement existing strategical deconfliction solutions based on flight planning and monitoring, i.e. Traffic Management between UTM (UAS Traffic Management) and UAV.

A new functionality called A2X (Aircraft-to-anything) is added to enable the support of Broadcast Remote Identification, Direct C2 communications, Direct Detect And Avoid, and Ground-based Detect And Avoid for an area. A2X is based on concepts and mechanisms defined in previous releases for Cellular V2X (Vehicle-to-Anything).

A2X provides two modes of operation over, namely A2X communication over PC5 reference point over both LTE and NR (for Broadcast Remote Identification, Direct C2, and Direct Detect And Avoid) and A2X communication over Uu reference point (i.e. cellular communication with the mobile network) for NR connected to 5G core network (for Detect And Avoid). The two operation modes may be used by a device independently for different A2X services. A2X communication over Uu may use Multicast Broadcast System.

A2X service is based on configuration information provided to the device to indicate how A2X application should use the communication resources. A2X supports both devices that utilize cellular connectivity to the mobile network, and devices that do not utilize cellular connectivity to the mobile network (i.e. either devices that may or may not be capable of cellular connectivity to the network), with specific QoS levels defined for A2X over PC5 so that separate radio resource pools can be allocated to different services. For devices that do not utilize cellular connectivity to the mobile network, configuration of the A2X device may take pace over a transport outside the scope of 3GPP.

A2X can be supported by both devices with a subscription to a mobile operator (i.e. provisioned with an UICC) and devices without subscription to a mobile operator. The latter would use PC5 over a spectrum that does not belong to the mobile operator.

Authorization and configuration of A2X services may be based on A2X Policies configured in the device, in case of devices without a subscription with a mobile operator, and may be authorized by the mobile operator via the authentication/authorization procedures defined in Release 17 for devices with a subscription with a mobile operator. A2X Policies also configure the device on how to use the A2X transport based on either PC5 or cellular connectivity with the MNO. A2X Policies may be defined with input from an application function in the aviation domain, e.g. the UTM or an external UAV operator, via Network Exposure Function (NEF) services.

For Broadcast Remote ID, A2X provides transport of BRID messages defined by standards outside 3GPP via broadcast PC5 messages or via Multicast Broadcast Service, using broadcast only, with frequency defined via A2X Policy.

For Direct C2, a UAV that supports Direct C2 Communication may establish direct NR PC5 communication with a UAV controller based on application layer information (e.g. information regarding the identity of the serving UAV controller). The UAV that is engaged in Direct C2 Communication may or may not be capable of connection with the mobile network. The UAV is authorized by the USS for establishing Direct C2 Communication with the UAV controller either via pre-configuration information (e.g. when the UAV is not connected to a mobile network) or via the UUAA procedure (i.e. when the UAV is connected to a mobile network).

For Direct Detect And Avoid, the detection and deconfliction of potential collisions between UAVs is locally performed between UAVs using direct UAV to UAV communication over PC5. The UTM may be informed of the potential collision situation. DAA communications leverage broadcast PC5 to advertise DAA information, defined in standards and regulations outside of 3GPP, to other devices and to ground receivers. In case of a potential conflict is detected between two UAVs, the two devices can use unicast PC5 communications to exchange DAA information for flight deconfliction, based on application layer mechanisms defined outside of 3GPP.

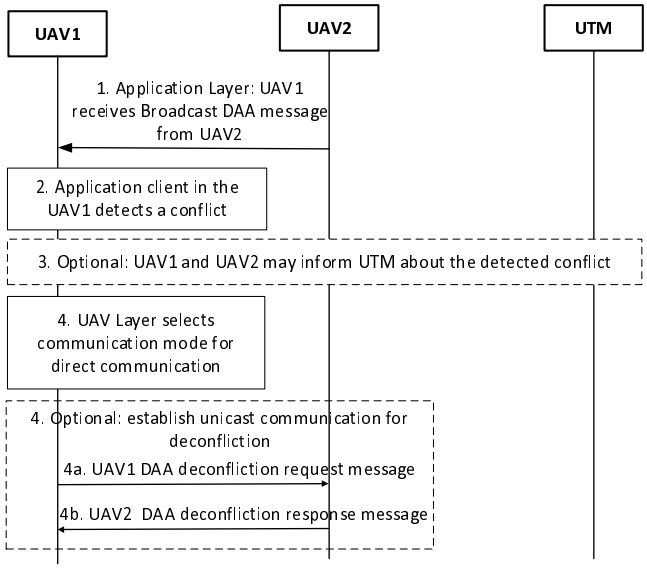

Figure 1: Information flow for Direct Detect And Avoid

For Ground-based DAA for an Area, a network-assisted DAA mechanism applicable for a specific area is defined (e.g. for a stadium or arena where UAVs are used). It is based on a ground-based entity, Area Airspace Manager (AAM), that is able to detect UAVs in the specific area and provide local steering policies (according to A2X mechanisms) to the individual UAVs in order to avoid the UAVs crashing into each other, structures, etc. The policy may e.g. include allowed flying zones and positions allowed for the specific UAV. The policy may also apply to a specific outdoor area, e.g. an event, where specific measures to avoid collision between drones are established locally. The AAM is one or more UEs using PC5, and they may also have a direct connection to the UTM.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990107,980012,990036,990012,990063,990064,990105

[1] TR 23.700-58: “Study of further architecture enhancements for uncrewed aerial systems and urban air mobility”
[2] TS 23.256: “Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2”

8.2 Architecture for UAS Applications, Phase 2

980126	**Architecture for UAS Applications, Phase 2**	**UASAPP_Ph2**		SP-220915	**Monrad, Atle, InterDigital**
970038	**Stage 2 of UASAPP_Ph2**	**UASAPP_Ph2**	**S6**	SP-221228	**Monrad, Atle, InterDigital**
980055	CT1 aspects of UASAPP_Ph2	UASAPP_Ph2	C1	CP-230189	**Taimoor Abbas, InterDigital**
980056	CT3 aspects of UASAPP_Ph2	UASAPP_Ph2	C3	CP-230189	**Taimoor Abbas, InterDigital**

Summary based on the input provided by InterDigital in SP-240930.

As part of Rel-17, the overall application layer architecture to enable application support for UAS applications over 3GPP networks was specified in TS 23.255 [1], also utilizing features in SEAL, specified in TS 23.434 [2]. In Rel-18, the UAS architecture has been enhanced to further extend functionality in 3GPP for improved support for the aviation industry.

In release 17, no work was done by 3GPP to support that the USS serving a UAV could change during flight. However, in wide and rural areas, the UAS could enter areas of responsibility of different USSes and experience both national as well as international roaming. Due to this, scenarios where a UAS could be served by multiple USSes during the same flight were studied and the impacts on the UAS application layer architecture and SEAL to support such scenarios were considered an improved.

The above could also impact location and support of PC5 versus the C2 switching. Due to this, new functionality for the UAS application due to location and support of PC5 versus C2 switching were considered.

Development of solutions for Detect And Avoid (DAA) was also studied, and new functionality for the UAS application to support such functionality has been implemented.

The study and its conclusions can be found in TS 23.700-55 [3].

The following three new functions are introduced.

UAE layer assisted change of USS during flight

The UAE layer assisted change of USS can be initiated from the server or from the client. Assistance from the network is provided by SEAL LMS due to UAV mobility to different geographical area covered by different edge clouds and is provided by the UAE server to initiate change of USS. Assistance from the client is provided when an emergency change of USS is deemed necessary by the UAE client.

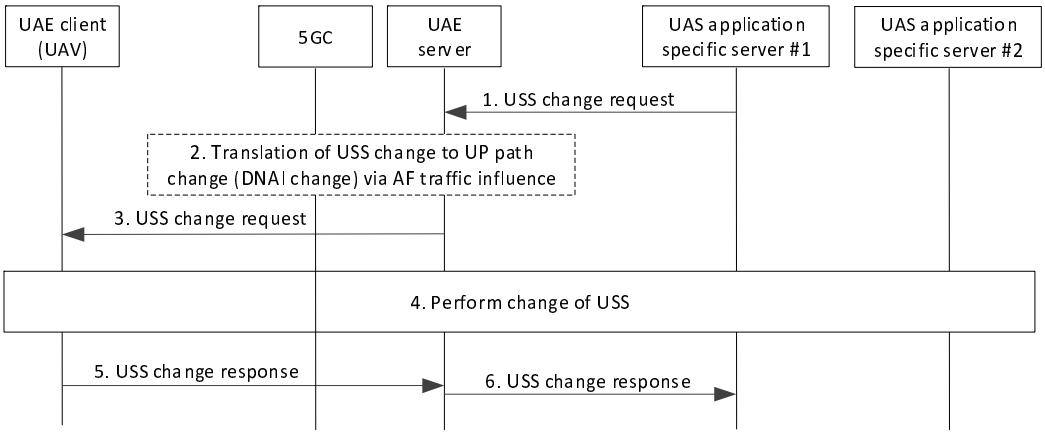

Figure 1: UAE server initiated change of USS

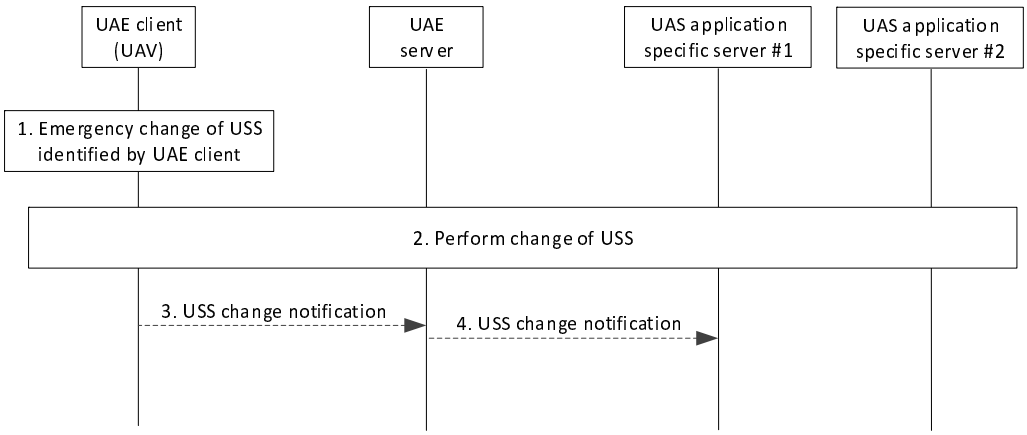

Figure 2: UAE client initiated change of USS

UAE layer assisted support for DAA services and applications

This feature enables the UAS application enablement services for assisting the UAS application with DAA handling. The UAE layer assisted support for detect and avoid can be initiated from the server or from the client.

NOTE 1: The Detect and Avoid operations are out of scope of the specification.

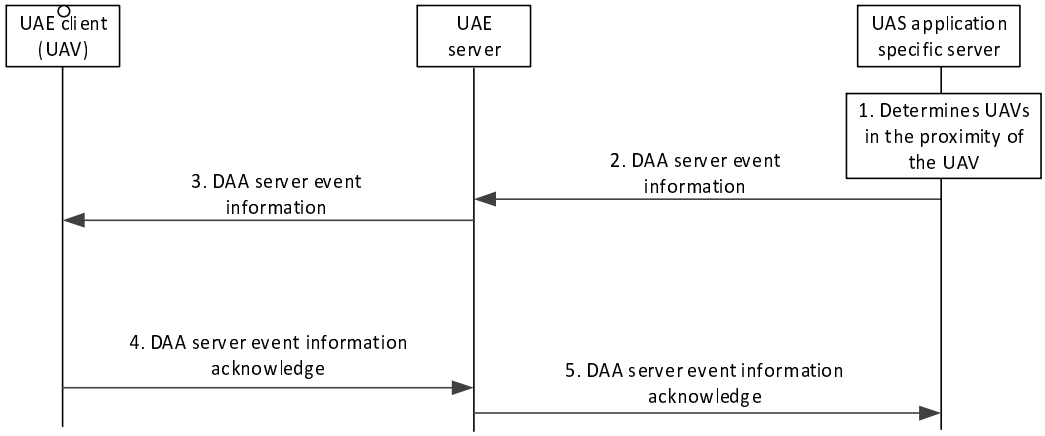

Figure 3: DAA support involving UAVs without U2X support (UAE server initiated)

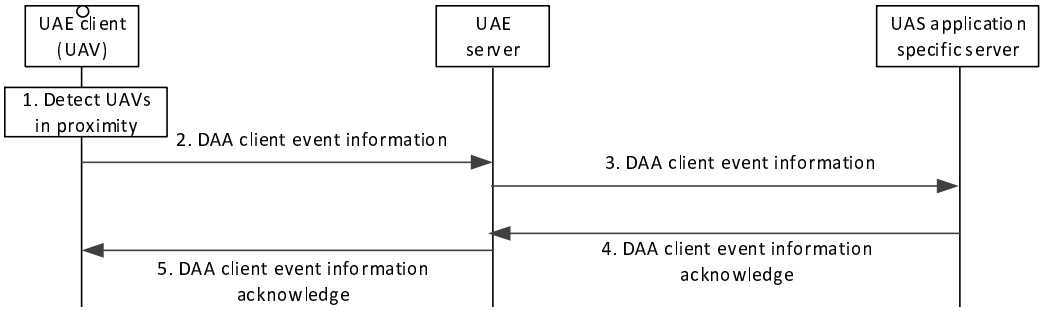

Figure 4: DAA support involving UAVs with U2X support (UAE client initiated)

Tracking dynamic UAVs in an application defined area relative to a host UAV

The UAE server can track a host UAV's dynamic information, i.e., information of other dynamic UAVs in an application defined area relative to a host UAV. As per a proximity range set by the application layer, the UAE layer supports providing dynamic information (i.e. other UAVs' location information) to the UAS Application Specific Server (UTM/USS) and/or to the host UAV. This feature can be utilized by UAS applications as input to (e.g. DAA, Dynamic maps).

This feature utilizes the following procedures:

- UAS Application Specific Server or the host UAV subscription for host UAV's dynamic information with UAE server.
- UAE server tracking host UAV's UE location with support from SEAL's location management server.
- UAE server management of dynamic UE location based group.
- UAE server obtaining dynamic information from the UAVs in application defined proximity range of the host UAV.
- UAE server notification of host UAV's dynamic information to the UAS Application Specific Server and/or to the host UAV.

NOTE 2: The details of the usage of dynamic information of host UAV by UAS Application Specific Server or by the host UAV is out of scope of the specification.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980126,970038,980055,980056

[1] TS 23.255: "Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows; Stage 2"
[2] TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows, stage 2"
[3] TR 23.700-55: "Study on enhanced Application Architecture for UAS applications"

8.3 NR support for UAV

941005	**NR support for UAV (Uncrewed Aerial Vehicles)**	**NR_UAV**	**R2**		**Jedrzej Stanczak, Nokia, Nokia Shanghai Bell**
941105	Core part: NR support for UAV (Uncrewed Aerial Vehicles)	NR_UAV-Core	R2	RP-230782	**Jedrzej Stanczak, Nokia, Nokia Shanghai Bell**

Summary based on the input provided by Nokia in RP-233387.

In the recent years, the global interest for uncrewed aerial vehicles based services has dramatically increased, including e.g. for multiple drone operation, personal entertainment for flight experience, cargo delivery, etc. As the basis of these applications, the capability for remote control and data transmission are key aspects for enhancements, which are of interest for service providers/operators as well as drone manufacturers.

Consequently, corresponding SI and WI based on LTE were established in previous releases, mainly focusing on aerial vehicles with an altitude up to 300m. According to the study, the feasibility and required enhancements have been verified for the support aerial vehicles via terrestrial cellular systems, e.g. in terms of UL and DL interference as well as mobility. However, since LTE was designed for terrestrial UEs, without considering aerial UEs at the very beginning, some inherent limitations, e.g. higher latency, reduced MIMO capabilities imply that some requirements for aerial services still cannot be met.

Compared to LTE, NR enables more diversified applications for aerial vehicles, with the lower latency for control and higher data rate for multi-media services.

While the advanced NR features generally improve performance with respect to basic LTE, it is clear that further improvements are needed, due to the fact that the NR system didn't take aerial vehicles into account when it was initially designed. Moreover, the interference issues that may be generated by aerial UEs have to be considered in order not to disrupt the operation of a network designed for terrestrial UEs.

Further element to comply with regulatory requirements is to address the additional out-of-band requirements from the ECC decision (22)07 on "harmonised framework on aerial UE usage in MFCN harmonised bands".

Mobility and Interference Reporting: The core features supporting event triggered reporting of altitude, i.e., events H1 and H2, and measurement events, i.e., measurement events A3, A4, and A5, triggered by multiple cells for interference reporting were ported to NR from LTE. Altitude reporting was enhanced with an increased maximum altitude (~10km). Support was added for altitude-dependent measurement report triggering through the introduction of new events A3H1, A3H2, A4H1, A4H2, A5H1, and A5H2, which enable altitude dependency for events A3, A4, and A5. Additionally, the altitude-dependent events can be configured to be triggered only for the altitude-dependent event of the same type, e.g., altitude-dependent A3 with an H1 threshold, as to implement altitude regions. Eventually, the measurement object (MO) was enhanced to support altitude-dependent SSBs (i.e. ssb-ToMeasure) through the introduction of a list of ssb-ToMeasure configurations accompanied by a height range and hysteresis.

Flight Path Information: Flight path information reporting was ported from LTE, and NR supports all of the core UAV LTE features. Enhancements support a flight path availability indication through UE assistance information (UAI) based on: initial flight path availability; the addition of a new waypoint or removal of an outdated waypoint; waypoint location and timestamp delta triggers. Additionally, a flight path can be invalidated by transmitting an empty flight path. Transmission of the flight path from the source to the target gNB is supported during handover.

Broadcast Remote Identification (BRID) and Detect and Avoid (DAA) : NR Sidelink can be used for A2X communications via NR Sidelink Mode 2. Sidelink resource pool can be configured to support aerial UE transmissions for BRID and DAA (i.e. A2X). The resource pool can indicate support for BRID only, DAA only, or both BRID and DAA.

Aerial UE-Specific NS Values: To comply with out of band emission (OOBE) requirements, NR supports the aerial UE-specific NS values.

Subscription-based Aerial UE identification: The Aerial UE's subscription information can be provided by the AMF to the NG-RAN node via the NGAP. Additionally, the source NG-RAN node can include the Aerial UE subscription information in the XnAP message sent to the target NG-RAN.

UE Capabilities: In NR, a mandatory capability indicates a UE's support for Release 18 UAV enhancements, and further requires support for altitude event triggers, i.e., events H1 and H2, and for multi-cell measurement report triggering. Support for the remaining features discussed in previous sections (e.g. flight path information reporting) is optional. Subscription-based aerial-UE identification is also supported as it is in LTE.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941005,941105

8.4 Enhanced LTE Support for UAV

991035	**Enhanced LTE Support for UAV (Uncrewed Aerial Vehicles)**	**LTE_UAV_enh**	**R2**	RP-230783	**Jedrzej Stanczak, Nokia, Nokia Shanghai Bell**
991135	Core part: Enhanced LTE Support for UAV (Uncrewed Aerial Vehicles)	LTE_UAV_enh-Core	R2	RP-230783	**Jedrzej Stanczak, Nokia, Nokia Shanghai Bell**

Summary based on the input provided by Nokia in RP-233390.

In the recent years, the global interest for uncrewed aerial vehicles based services has dramatically increased, including e.g. for multiple drone operation, personal entertainment for flight experience, cargo delivery, etc. As the basis of these applications, the capability for remote control and data transmission are key aspects for enhancements, which are of interest for service providers/operators as well as drone manufacturers.

Consequently, corresponding SI and WI based on LTE were established in previous releases, mainly focusing on aerial vehicles with an altitude up to 300m. According to the study, the feasibility and required enhancements have been verified for the support aerial vehicles via terrestrial cellular systems, e.g. in terms of UL and DL interference as well as mobility. However, since LTE was designed for terrestrial UEs, without considering aerial UEs at the very beginning, some inherent limitations, e.g. higher latency, reduced MIMO capabilities imply that some requirements for aerial services still cannot be met.

To comply with regulatory requirements which include UAV UE identification and avoiding the collisions with other UAV UEs, the support of Broadcasting UAV ID (BRID) and potentially Detect and Avoid (DAA) via LTE PC5 interface is needed.

Further element to comply with regulatory requirements is to address the additional out-of-band requirements from the ECC decision (22)07 on “harmonised framework on aerial UE usage in MFCN harmonised bands”

Broadcast Remote Identification (BRID) and Detect and Avoid (DAA): LTE Sidelink can be used for A2X communications via LTE Sidelink Mode 1. Sidelink resource pool can be configured to support aerial UE transmissions for BRID and DAA (i.e. A2X). The resource pool can indicate support for BRID only, DAA only, or both BRID and DAA.

Aerial UE-Specific NS Values: To comply with out of band emission (OOBE) requirements, LTE supports the aerial UE-specific NS values.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=991035,991135

9 Sidelink, Proximity, Location and Positioning

9.1 5GC LoCation Services - Phase 3

980111	**5GC LoCation Services - Phase 3**	**5G_eLCS_Ph3**		SP-220811	**Ming Ai, CATT**
940058	*Study on Enhancement to the 5GC LoCation Services-Phase 3*	FS_eLCS_Ph3	S2	SP-220069	**Ming Ai, CATT**
970021	**(stage 2 of) 5GC LoCation Services - Phase 3**	5G_eLCS_Ph3	S2	SP-230093	**Ming Ai, CATT**
980057	CT1 aspects of 5G_eLCS_Ph3	5G_eLCS_Ph3	C1	CP-232029	**Wang, Baixiao, CATT**
980058	CT3 aspects of 5G_eLCS_Ph3	5G_eLCS_Ph3	C3	CP-232029	**Wang, Baixiao, CATT**
980059	CT4 aspects of 5G_eLCS_Ph3	5G_eLCS_Ph3	C4	CP-232029	**Wang, Baixiao, CATT**

Summary based on the input provided by Intel Corporation, CATT, Ericsson in RP-240303.

As to enhance the 5G location services, the work item "5G Location Services – Phase 3" specifies the mechanisms presented below.

A dedicated study (FS_eLCS_Ph3) on support of Enhancement to the 5GC Location services is conducted. The outcome of the study is captured in the TR 23.700-71[1], the conclusion of the study supports a work item (5G_eLCS_Ph3), which standardizes some identified solutions by updating specifications TS 23.273 [2], TS 23.501[3], TS 23.401[4].

The corresponding stage 3 is provided by updates of CT1, CT3 and CT4 specifications TS 29.518[5], TS 29.515[6], TS 29.572[7], TS 29.510[8], TS 29.503[9], TS 29.504[10], TS 29.505[11], TS 29.172[12], TS 29.571[13], TS 24.080[14], TS 29.274[15], TS 24.171[16], TS 29.122[17], TS 29.522[18], TS 29.591[19], TS 29.517[20] ,TS 24.571[21], TS 24.501[22].

Positioning signalling transmission via user plane

To support more efficient communication between LMF and UE, and to reduce the positioning latency, an user plane between the UE and the LMF is used to transfer the positioning signalling including supplementary services messages and LPP messages.

The following new procedures are introduced:

- LMF initiated user plane connection: LMF decides to use the user plane connection establishment based on UE user plane positioning capability, control plane congestion status and other implementation factors. Then LMF provides user plane information including a user plane positioning address of the LMF to UE, to trigger UE to establish a secured user plane connection with the LMF.

- UE initiated user plane connection: UE triggers the user plane connection establishment by sending initiation message to LMF. LMF then provides user plane information including a user plane positioning address of the LMF to UE. UE establishes a secured user plane connection with the LMF.

- Modification of User Plane Connection between UE and LMF: this procedure is triggered by LMF when LMF relocation or AMF relocation occurs, or the LMF determines to terminate the user plane connection. The (source) LMF is responsible to terminate connection with UE.

Location service signalling optimisation in PNI-NPN

To support security of location service in PNI-NPN, LMF and GMLC are deployed in the PNI-NPN where the NG-RAN belongs to. The positioning messages between LMF and NG-RAN is transferred via the serving AMF of the target UE located in the public network. To optimize the signalling routing path, the local AMF is deployed in the PNI-NPN to transfer the DL NON UE associated NRPPa signalling between NG-RAN and LMF located in the same PNI-NPN. To support this optimisation, the LMF and NG-RAN deployed in the PNI-NPN are pre-configured with local AMF address. The NG-RAN needs to establish TNL association with local AMF.

Support of GMLC and LMF restricted to supporting location services in a local area

In some scenarios, a GMLC and an LMF might be restricted to supporting location services in a local area, i.e. the LMF needs to be selected within the same local area of the GMLC. To support the scenarios, the GMLC determines the LMF ID based on pre-configured LMF information or LMF ID received from UDM, and then provides the LMF ID to AMF. The AMF uses the received LMF ID to select the LMF.

Interaction between location services and NWDAF

To support interaction between location services and NWDAF, the following aspects are introduced:

- To assist location services by NWDAF: LMF is enhanced to request the Location Accuracy analytics from NWDAF to determine a location estimate (indoor or outdoor), to select positioning methods for the requested location accuracy.

- To assist network data analytics by location services: NWDAF interacts with the LCS system via Ngmlc services or NL9 interface to request location information.

GNSS assistance data collection and provisioning

The GNSS assistance data is collected by LMF from AF. The LMF may provide the GNSS assistance data via AMF to UE during a positioning procedure, or send the data to an NG-RAN node for broadcasting by the NG-RAN node to target UEs. In this latter case, the LMF may also provision one or more cyphered key(s) to UE from the AMF, and each cyphered key corresponds to a certain GNSS assistance data.

LMF may generate multiple sets of GNSS assistance data for the same location area, and each of them corresponds to certain location accuracy.

UE unaware positioning

To support the regulatory requirement that an UE should not aware there is a positioning procedure targeting it, the AF/LCS Client may request UE unaware positioning by including the UE awareness positioning indication in the location request message to GMLC. GMLC provides the indication in the location request to AMF. Based on the indication, the AMF returns the latest stored UE location to GMLC without paging UE if the UE is in CM-IDLE state or RRC-INACTIVE state (if known by AMF) or sends the indication to LMF if the UE is in CM-CONNECTED state. When LMF receives the UE unaware positioning indication, it selects the uplink positioning method and includes the indication in the network positioning message to NG-RAN. When NG-RAN receives the network positioning message, if the UE is in RRC-INACTIVE state, NG-RAN rejects the message with appropriate rejection cause.

Support of positioning reference units

Positioning Reference Units (PRU) with known locations can be used to enhance the positioning performance, mainly to improve the accuracy.

To support the introduction of the PRU into the LCS system, the following procedures are introduced:

- PRU association procedure: PRU sends PRU association request which is a supplementary services message to LMF via AMF. The request includes PRU positioning capabilities, location information or PRU ON/OFF state. Then LMF is responsible for storing the received PRU information.

- LMF initiated PRU disassociation procedure: When LMF becomes unavailable or during LMF relocation, the LMF disassociates already associated PRU(s) by invoking this procedure.

- PRU initiated PRU disassociation procedure: When PRU becomes unavailable or during LMF relocation, the serving LMF by invokes this procedure.

- Positioning of one target UE using location information provided by PRU(s): when the LMF decides to use PRUs for one target UE, the LMF selects one or more PRUs to obtain location information of those selected PRUs which is used to determine the location of the target UE.

Location service continuity in case of UE mobility

For commercial location service, in particular the use case that UEs in a vehicle, it is very likely that UE moves between EPS and 5GS. The following procedures are introduced to ensure the continuity of two kinds of location procedures::

- Location service continuity between EPS and 5GS for the Immediate Location Request Procedure:

- From 5GS to EPS with N26: when AMF detects 5GS to EPS handover happens during the immediate location request procedure, it cancels the on-going LCS session in 5GS and notifies the 5GC-GMLC the failure cause of handover to EPC. The 5GC-GMLC forwards the location request to EPC-GMLC to re-trigger the immediate location request procedure in EPS.

- From EPS to 5GS with N26: when MME detects EPS to 5GS handover happens during the immediate location request procedure, it cancels the on-going LCS session in EPS by notifying the handover related information to EPC-GMLC which is responsible to re-trigger the immediate location request procedure in 5GS by sending the location request to 5GC-GMLC.

- From 5GS to EPS without N26 Interface: when the 5GC-GMLC receives the CN type change event report from UDM, it forwards the location request to EPC-GMLC to re-trigger the immediate location request procedure in EPS.

- From EPS to 5GS without N26 Interface: when the EPC-GMLC receives the CN type change event report from 5GC-GMLC, it re-triggers the immediate location request procedure in 5GS by sending the location request to 5GC-GMLC.

- Location service continuity between EPS and 5GS for the deferred MT-LR procedure:

- From 5GS to EPS: this intersystem mobility from 5GS to EPS happens after the deferred MT-LR is triggered in 5GS, when UE detects the event happens in EPS, the UE sends the event report via EPC by invoking LCS MO-LR procedure. When the EPC-GMLC receives the event report, it sends the event report to 5GC-GMLC.

- From EPS to 5GS: this intersystem mobility from EPS to5GS happens after the deferred MT-LR is triggered in EPS, when UE detects the event happens in 5GS, the UE sends the event report via 5GC.

Support of positioning requirements related to satellite access

AMF may request assistance for UE location verification for NR satellite access by requesting or subscribing to UE mobility analytics from NWDAF. With NWDAF-based UE location statistics and predictions and UE location estimated by LMF, AMF can further assist UE location verification for NR satellite access.

Event report allowed area

Event report allowed area is used to reduce UE power consumption: i.e. when UE detects the triggered or periodic event happens, the UE only report such event when it is inside the event report allowed area. The event report allowed area is determined by GMLC and sent to UE during the deferred 5GC-MT-LR procedure.

Low Power and High Accuracy Positioning

To support Low Power and High Accuracy Positioning (LPHAP), the LMF is enhanced to determine the appropriate positioning method, e.g. network-based positioning method, or to trigger the low power periodic and triggered 5GC-MT-LR procedures based on the LPHAP indication received from AMF or GMLC. The LCS related subscription data in the UDM may include an LPHAP indication.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980111,940058,970021,980057,980058,980059

[1] TR 23.700-71: "Study on enhancement to the 5GC LoCation Services (LCS); Phase 3".
[2] TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".
[3] TS 23.501: "System Architecture for the 5G System; Stage 2".
[4] TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".
[5] TS 29.518: "5G System; Access and Mobility Management Services; Stage 3".
[6] TR 29.515: "5G System; Gateway Mobile Location Services; Stage 3".
[7] TS 29.572: "5G System; Location Management Services; Stage 3".
[8] TS 29.510: "5G System; Network function repository services; Stage 3".
[9] TS 29.503: "5G System; Unified Data Management Services; Stage 3".
[10] TS 29.504: "5G System; Unified Data Repository Services; Stage 3".
[11] TS 29.505: "5G System; Usage of the Unified Data Repository services for Subscription Data; Stage 3".
[12] TS 29.172: "Location Services (LCS); Evolved Packet Core (EPC) LCS Protocol (ELP) between the Gateway Mobile Location Centre (GMLC) and the Mobile Management Entity (MME); SLg interface".
[13] TS 29.571: "Common Data Types for Service Based Interfaces; Stage 3".
[14] TS 24.080: "Mobile radio interface layer 3 supplementary services specification; Formats and coding".
[15] TS 29.274: "3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".
[16] TS 24.171: "Control Plane Location Services (LCS) procedures in the Evolved Packet System (EPS)".
[17] TS 29.122: "T8 reference point for Northbound APIs".
[18] TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".
[19] TS 29.591: "5G System; Network Exposure Function Southbound Services; Stage 3".
[20] TS 29.517: "5G System; Application Function Event Exposure Service; Stage 3".
[21] TS 24.571: "5G System (5GS); Control plane Location Services (LCS) procedures; Stage 3".
[22] TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

9.2 Expanded and improved NR positioning

981038	**Expanded and improved NR positioning**	**NR_pos_enh2**		RP-233382	**Debdeep Chatterjee, Intel Corporation**

940081	*Study on expanded and improved NR positioning*	FS_NR_pos_enh2	R1	RP-222616	**Debdeep Chatterjee, Intel Corporation**
981138	Core part: Expanded and improved NR positioning	NR_pos_enh2-Core	R1	RP-233382	**Debdeep Chatterjee, Intel Corporation**
981238	Perf. part: Expanded and improved NR positioning	NR_pos_enh2-Perf	R4	RP-233382	**Debdeep Chatterjee, Intel Corporation**

Summary based on the input provided by Intel Corporation, CATT, Ericsson in RP-240303.

The Release 18 work item (WI) on expanded and improved NR positioning introduced multiple features to expand the scope of NR positioning and to enable various improvements to support of high accuracy positioning in NR systems [1].

The expansion of the scope of NR positioning involved support of Sidelink (SL) positioning for which the initial target scenarios, targeting V2X, public safety, IIoT, and commercial use-cases and their corresponding requirements for in-coverage, partial coverage, and out-of-coverage NR positioning use-cases were identified as part of a 3GPP RAN-level study during Release 17 that were captured in TR 38.845 [2]. Additionally, requirements defined in TS 22.261 [3] for "Ranging based services" and in TS 22.104 [4] for IIoT use cases in out-of-coverage scenarios were taken into consideration. These initial target requirements were refined further to develop RAN-level target requirements as part of the study item (SI) on expanded and improved NR positioning during Release 18 and captured in TR 38.859 [5]. Following from the studies reported in [5], as part of the current Release 18 WI, RAN WGs introduced support of SL positioning and ranging features with various positioning methods for in-coverage, partial coverage, and out-of-coverage NR positioning use-cases.

The improvements to high accuracy positioning in NR systems was three-fold and considered: (1) positioning integrity improvements for RAT-dependent positioning methods, (2) positioning accuracy improvements by introducing NR carrier phase measurements and reporting and by leveraging use of larger bandwidths within the NR spectrum based on PRS (Positioning Reference Signal) and SRS (Sounding Reference Signal) bandwidth aggregation for intra-band contiguous carriers, and (3) power efficiency of NR positioning via support of LPHAP (Low Power High Accuracy Positioning) use-cases and high accuracy positioning for RedCap (Reduced Capability) NR UEs.

Sidelink Positioning

A new SL reference signal, SL PRS, has been introduced to support SL positioning and ranging for in-coverage, partial coverage, and out-of-coverage scenarios. Transmission of SL PRS via unicast, broadcast, and groupcast modes are supported. Protocol and procedures for SL positioning between UEs and LMF, involving SL Target UE, SL Anchor UE(s), and Location Server (SL Server UE or LMF) are introduced as part of SLPP (SL Positioning Protocol) and specified in TS 38.355 [6]. A SL Target UE is a UE whose distance, direction and/or position is measured with the support from one or multiple SL Anchor UEs using Sidelink in the Ranging based service and Sidelink positioning. A SL Anchor UE is a UE that supports positioning of a target UE, e.g., by transmitting and/or receiving reference signals for positioning, providing positioning-related information, etc. over the SL interface. A Location Server is an entity or UE providing location and/or ranging services to one or more target UE(s), including facilitating transfer of assistance information and coordination with one or more anchor UE(s).

Different SL positioning methods have been introduced to support SL positioning and ranging. These include: (i) SL-RTT (Round Trip Time) that utilize SL Rx-Tx time difference measurements between a target and anchor UE, (ii) SL-AoA (Angle of Arrival), (iii) SL-TDOA (Time Difference of Arrival) method that utilizes SL RSTD (Reference Signal Time Difference) measurements corresponding to SL PRSs received at a target UE from multiple anchor UEs, and (iv) SL-TOA (Time Of Arrival) method that utilizes SL RTOA (Relative Time of Arrival) measurements corresponding to reception of SL PRS transmitted by a target UE at multiple anchor UEs. In addition, SL PRS-RSRP (Reference Signal Received Power) and SL PRS-RSRPP (Reference Signal Received Power per Path) have been introduced.

SL PRS is designed based on DL PRS, utilizing a comb-based mapping to frequency resources and pseudorandom sequence generation. Different comb-sizes and numbers of symbols of SL PRS are supported by the specifications, depending on whether the SL PRS are transmitted in a dedicated or a shared SL PRS resource pool. A dedicated SL PRS resource pool is a SL resource pool which can be used for transmission of one or more SL PRS and associated PSCCH (Physical Sidelink Control Channel) without transmission of PSSCH (Physical Sidelink Shared Channel), while a shared SL PRS resource pool is a SL PRS resource pool which can be used for transmission of both SL PRS and PSSCH and is backward compatible to legacy (pre-Release 18) SL communications. Within a SL carrier, a UE may be configured with one or more dedicated or one or more shared SL PRS resource pools. Both fully staggered SL PRS patterns, where the comb size equals the number of symbols of SL PRS, and partially staggered SL PRS patterns, where the comb size is larger than the number of symbols of SL PRS, are supported.

In a dedicated SL PRS resource pool, SL PRS and its associated PSCCH are multiplexed in time domain while multiple SL PRS resources may be multiplexed via comb-based or TDM (Time Division Multiplexing)-based multiplexing. For

a given SL slot, a one-to-one mapping is defined between a SL PRS resource and its associated PSCCH. In contrast, in a shared SL PRS resource pool, a single SL PRS resource can be multiplexed with associated PSCCH, PSSCH, and their associated DMRS (Demodulation Reference Signals) within a single sub-channel. As for the case of SL communication, multiple SL PRS with their associated PSCCH and PSSCH may be multiplexed in frequency at the granularity of sub-channels.

Specifications for transmit power control for SL PRS transmissions follow approaches defined for SL communication, with OLPC (open loop power control) defined for SL PRS transmissions in dedicated SL PRS resource pool based on one or both of SL and DL pathloss measurements with SL PRS as a reference for SL pathloss measurements. For SL PRS transmission in shared SL PRS resource pool, the same transmit power level as determined for PSSCH transmission is used.

In terms of resource allocation for SL PRS, similar to SL communication, two resource allocation modes are supported: (i) network-centric resource allocation, whereby a UE transmits SL PRS using resources as indicated dynamically by the serving gNodeB (gNB) or via SL configured grants types 1 or 2 by the serving gNB, and (ii) UE-autonomous SL PRS resource selection. For dynamic resource allocation for SL PRS, a new DCI (Downlink Control Information) format 3_2 has been introduced. For UE-autonomous SL PRS resource selection, both random resource selection and sensing-based resource selection methods have been defined. While, for shared SL PRS resource pools, congestion control and IUC (inter-UE coordination) methods are reused from SL communication, for dedicated SL PRS resource pools, separate congestion control methods, that are based on those for SL communication, are defined.

For indication of SL PRS resource allocation, a new single stage SCI (Sidelink Control Information) format 1-B is introduced for dedicated SL PRS resource pool, while a new second stage SCI format 2-D is introduced for shared SL PRS resource pool. No second stage SCI is included in a slot of a dedicated SL PRS resource pool.

SLPP is used point-to-point between Endpoints, e.g. Location Server (SL Server UE or LMF) and SL Target UE in order to obtain absolute position, relative position, or ranging information of SL Target UE using sidelink measurements obtained by one or more reference sources. Each SLPP transaction involves the exchange of one or more SLPP messages between Endpoint A and Endpoint B. The general format of an SLPP message consists of a set of common fields followed by a body. The body (which may be empty) contains information specific to a particular message type. Each message type contains information specific to one or more positioning methods and/or information common to all positioning methods. The following message types are defined:

- Request Capabilities;
- Provide Capabilities;
- Request Assistance Data;
- Provide Assistance Data;
- Request Location Information;
- Provide Location Information;
- Abort;
- Error.

Positioning integrity for RAT-dependent positioning methods

Positioning integrity is a measure of the reliability in the accuracy of the position-related data and the ability to provide timely warnings based on assistance data provided by the network. During Release 17, specification support for GNSS integrity was introduced. This is being extended in Release 18 to RAT-dependent positioning methods to address relevant integrity aspects of mission critical use-cases that rely on positioning estimates and corresponding uncertainty estimates.

For integrity operation, Integrity Principle of Operation in AGNSS in Rel-17 is reused for RAT-dependent positioning methods in Release 18.

UE-based and LMF-based integrity of RAT-dependent positioning methods including Multi-RTT, DL-AoD, DL-TDOA, UL-TDOA, and UL-AoA are supported via error modeling parameters. On the error source for RAT-dependent positioning methods, there are different error sources such as location errors, timing errors which are estimated and provided in the corresponding assistance data. Only those TRPs for which the integrity assistance data are provided are monitored by the network and can be used for integrity related applications. The mapping between the integrity fields and the assistance data are specified per positioning method.

For UE-based integrity of DL-AoD positioning method, TRP (Transmission Reception Point) location, boresight direction of DL PRS resource and beam information of DL PRS are the error sources. Therefore, the mean and standard deviation of TRP/ARP (Antenna Reference Point) location error, mean and standard deviation of Azimuth/Elevation

error of DL PRS resource boresight direction, and mean and standard deviation of beam power error per direction are provided as integrity bounds to UE.

For UE-based integrity of DL-TDOA positioning method, TRP location and inter-TRP synchronization are the error sources. Therefore, the mean and standard deviation of TRP/ARP location error and mean and standard deviation of RTD (Round Trip Delay) error are provided as integrity bounds to UE. All error sources share the same residual risks in each positioning method.

For LMF-based integrity, there is no protocol impact for the relevant positioning methods.

NR Carrier Phase Positioning

Inspired by the support of GNSS carrier phase positioning that is primarily limited to outdoor applications, NR CPP (Carrier Phase Positioning) has been introduced to enable support of cm-level positioning accuracy that can be utilized in both outdoor and indoor applications. NR CPP is supported via introduction of new carrier phase (CP) measurements that may be reported along with existing positioning measurements, viz., DL RSTD or UE Rx-Tx time difference measurements for DL positioning methods and UL RTOA or gNB Rx-Tx time difference measurements for UL positioning methods.

For DL, two types of CP measurements are defined: (i) DL RSCP (Reference Signal Carrier Phase) measurements that may be reported along with UE Rx-Tx time difference measurements; and (ii) DL RSCPD (Reference Signal Carrier Phase Difference) measurements that may be reported along with DL RSTD measurements. Further, DL CP measurements may be reported by a UE in RRC_CONNECTED state using measurement gaps for the measurements, or in RRC_INACTIVE or RRC_IDLE states. The reported carrier phase is associated with the centre frequency of the DL PFL (Positioning Frequency Layer) to which the DL PRS is mapped, with DL RSCP being defined as the phase of the channel response at the first path delay derived from the REs (resource elements) that carry the DL PRS configured for the measurement.

For UL, UL RSCP measurements are introduced that may be reported by an NG-RAN node (e.g., gNB) along with UL RTOA or gNB Rx-Tx time difference measurements. The reported carrier phase is associated with the centre frequency of the UL SRS for positioning resource, with UL RSCP being defined as the phase of the channel response at the first path delay derived from the REs (resource elements) that carry the UL SRS for positioning configured for the measurement. For UE-based CPP, the LMF can forward, either one time (aperiodic) or periodically, the carrier phase measurements together with the legacy measurement associated with the carrier phase measurement to UE.

Release 17 LOS/NLOS (Line of Sight/Non-Line of Sight) indication for UE RSTD/Rx-Tx time difference measurements applies for the RSCP/RSCPD measurement(s) in the same report. For both DL and UL, reporting of phase quality indication for the RSCP/RSCPD measurements have been introduced.

The accuracy and efficacy of carrier phase measurements are impacted by multiple factors, especially the timing and frequency errors impacting initial phases at both the Tx (transmitter) and Rx (receiver). These errors must be removed to achieve high accuracy CPP. PRUs (Positioning Reference Units) with known location coordinates have been introduced for supporting double-differential (DD) CPP to eliminate these errors. For DL DD-CPP, it is essential that the DL measurements are made by a target UE and a PRU simultaneously or very close in time. Similarly, for UL DD-CPP, it is critical that I SRS for positioning are transmitted from a target UE and a PRU and measured by the gNB(s) simultaneously or very close in time. Accordingly, Release 18 has introduced signalling support to enable the following:

(i) Simultaneous measurements of DL PRS at a target UE and a PRU within indicated time window(s).

(ii) Configuration of SRS transmissions from a target UE and a PRU within indicated time window(s).

(iii) Requests to the serving gNB and neighboring gNBs of a UE to measure the UL SRS for positioning resources from the UE within indicated time window(s).

It should be noted that the above features for enabling simultaneous DL/UL measurements are applicable for UE in RRC_CONNECTED, RRC_INACTIVE, and RRC_IDLE states, and are not restricted to NR CPP but can be used for other NR DL/UL positioning methods as well.

Bandwidth Aggregation for DL PRS and SRS for positioning

To enable high accuracy positioning, bandwidth aggregation for DL PRS and SRS for positioning have been introduced whereby DL PRS and SRS for positioning, respectively, are aggregated across intra-band contiguous carriers for single Tx/Rx architectures at gNB and UE. Further detailed conditions for aggregating DL PRS resources and SRS for positioning have been specified. Up to two or three DL PFLs and up to two or three UL carriers can be aggregated.

Further, up to two DL PFL combinations (e.g., PFL1 aggregated with PFL2 and PFL3 aggregated with PFL4) can be configured where different combinations are expected to be measured at different time instances, i.e., multiplexed in time domain.

For DL PRS bandwidth aggregation across DL PFLs, the DL PRS to be aggregated are linked on a per-TRP- and per-DL PRS resource set-basis. For SRS for positioning bandwidth aggregation across UL carriers, the UL carriers to be aggregated are linked on a per SRS for positioning resource set-basis. Further, SRS for positioning bandwidth aggregation may be supported independent of the UE's support of UL CA (Carrier Aggregation) for communication. Accordingly, SRS resource configured within a CC (Component Carrier) without PUSCH/PUCCH can be linked for bandwidth aggregation with an SRS resource configured within an UL active BWP of a UL communication CC.

For DL, support of DL PRS measurements across multiple aggregated DL PFLs for a UE in RRC_CONNECTED, RRC_INACTIVE, and RRC_IDLE states are specified. For RRC_CONNECTED state, measurements for DL PRS bandwidth aggregation are limited to configured measurement gaps. For UL, support of SRS for positioning bandwidth aggregation is supported for a UE in RRC_CONNECTED and RRC_INACTIVE states. Periodic, semi-persistent, and aperiodic SRS for positioning configurations are supported for SRS bandwidth aggregation. For semi-persistent SRS for positioning with bandwidth aggregation, a single MAC (Medium Access Control) CE (Control Element) can activate or deactivate one or more of the aggregated carriers. Similarly, for aperiodic SRS for positioning with bandwidth aggregation, in addition to triggering based on separate DCIs for the respective carriers, a single DCI (e.g., DCI format 0_3 or 1_3 for multi-cell PDSCH/PUSCH scheduling or Rel-17 single DCI scheduling positioning SRS resource sets across the linked carriers) can trigger the aperiodic SRS transmission across the linked carriers.

The aggregated measurements may be used for different timing-based positioning measurements, including DL RSTD, UE Rx-Tx time difference, UL RTOA, and gNB Rx-Tx time difference measurements. Additionally, RSRP and RSRPP measurements in DL and UL may be reported where the measurements are based on aggregated DL PRS or aggregated SRS for positioning resources, respectively.

LMF (Location Management Function) can request a UE or NG-RAN node to report aggregated measurements based on bandwidth aggregation across multiple configured DL PFLs or carriers, respectively. When configured for DL PRS bandwidth aggregation, TRP(s) and/or PRS resource set(s) that include PRS aggregation have higher priority than TRP(s) and/or PRS resource set(s) that do not include PRS aggregation. A UE or NG-RAN node may also indicate in a measurement report as to whether and which measurements are based on bandwidth aggregation. To enable reporting of timing measurements with finer timing resolution, the reporting granularity factor for both DL and UL positioning have been enhanced to include the new values of k = {-1, -2, -3, -4, -5, -6}. Further, use of the new reporting granularity factor values is not limited to the configuration of bandwidth aggregation feature.

Low Power High Accuracy Positioning (LPHAP)

The SA1 requirements for high accuracy and extremely low power consumption with battery lifetimes of up to one or more years have been identified for IIoT (Industrial Internet of Things) use-cases such as massive asset tracking, AGV tracking in industrial factory and person localization in danger zones. A typical scenario of interest is use-case #6 as defined TS 22.104, which corresponds to tracking of workpiece (in- and outdoor) in assembly area and warehouse with a target accuracy of <1m, a positioning interval of 15-30 seconds, and a battery lifetime of 6-12 months.

To support LPHAP, multiple enhancements have been introduced in Release 18, including: (i) enhancement of SRS for positioning configurations in RRC_INACTIVE state for UL and UL+DL positioning based on SRS for positioning validity area to avoid frequent reconfiguration of SRS for positioning upon serving cell changes; (ii) introduction of (e)DRX cycles longer than 10.24 seconds in RRC_INACTIVE state; (iii) alignment of (e)DRX cycles in RRC_INACTIVE state and DL PRS configurations, and (iv) support of measurements on DL PRS resources in RRC_IDLE state with reporting of the corresponding measurements when in RRC_CONNECTED state.

An SRS for positioning validity area consists of cells, which are configured in the same carrier, with common values of BWP (Bandwidth Part) parameters, viz., locationAndBandwidth, subcarrierSpacing, and cyclicPrefix, and in which the SRS for positioning configuration in RRC_INACTIVE state is valid. Further, various parameters for the SRS for positioning configuration (via srs-PosConfig) and SRS for positioning resource configuration (via SRS-PosResource) are commonly configured across these cells. Furthermore, methods for determination of UL timing and TA (timing advance) values, spatial relation for SRS for positioning, and pathloss RS (reference signal) for transmit power control within an SRS for positioning validity area have been specified.

When configured with an SRS for positioning configuration along with SRS for positioning validity area, if a UE reselects to another cell within the SRS positioning validity area during SRS transmission, the UE continues the SRS transmission, subject to validation for SRS transmission. When the UE reselects out of the SRS for positioning Validity Area during SRS transmission, the UE may send an "RRC Resume Request" message to the network for SRS configuration request.

The SRS for positioning configuration in RRC_INACTIVE state may be preconfigured in the target device. The target device may send an "RRC Resume Request" message to the network when a configured periodic or triggered location event has been detected to request activation of the pre-configured SRS for positioning. For preconfigured multiple SRS configurations, the UE is configured with only one SRS for positioning configuration for each validity area.

The (e)DRX cycles longer than 10.24 seconds in RRC_INACTIVE state which are introduced as part of eRedCap WI is reused for LPHAP. Legacy UE-initiated on-demand PRS request procedure can also be used to align DL PRS to fixed (e)DRX in order to reduce the power consumption of UE for LPHAP.

For LPHAP, positioning measurements may be performed when a UE is in RRC_IDLE state and reported when in RRC_CONNECTED state to reduce the power consumption. A UE may utilize the positioning assistance data received via broadcast or the positioning assistance data received while in RRC_CONNECTED state when performing positioning measurements in RRC_IDLE state.

Positioning for RedCap UEs

RedCap (Reduced Capability) NR UEs, with reduced maximum UE bandwidth of 20 MHz and 100 MHz in FR1 and FR2 respectively and reduced numbers of Rx antennas have been introduced in Release 17. As a consequence of reducing the maximum UE bandwidth, the achievable positioning accuracy was observed to be degraded compared to regular NR UEs. Such observations were documented in [5] and motivated the consideration of enhancements in Release 18 involving reception of DL PRS with Rx (receiver) frequency hopping and transmission of SRS for positioning with Tx (transmitter) frequency hopping to enable measurements spanning a wider bandwidth than maximum UE bandwidth for RedCap or Release 18 eRedCap UEs.

Frequency hopping-based reception and transmission are defined within a DL PRS resource and within an SRS for positioning resource, with switching times between frequency hops that are shorter than typical BWP switching times specified in Release 15. For DL Rx frequency hopping, a single instance of a configured measurement gap is used for receiving all the hops for DL PRS with Rx frequency hopping. For UL Tx frequency hopping, the frequency hopping pattern can be configured with overlapping or non-overlapping hops and following a wrapped staircase pattern. Further, the SRS for positioning resource is be configured outside of the active UL BWP configuration of the UE. In time domain, a frequency hopping pattern for SRS for positioning with Tx frequency hopping may be contained within a single slot or may span multiple slots and can be configured for periodic, semi-persistent, and aperiodic SRS for positioning.

An LMF may include an explicit request via the location request signaling for DL PRS Rx hopping measurements and reporting. The location information request can also optionally include the total bandwidth of all hops. For reporting of measurements, for DL Rx frequency hopping or UL Tx frequency hopping, a UE or NG-RAN node may report a single measurement based on receiving multiple hops of the DL PRS or UL SRS for positioning or a measurement associated with one received hop, with optional reporting of whether the measurement is based on a single-hop or multiple hops.

DL Rx frequency hopping for DL PRS reception is supported for a UE in RRC_CONNECTED state within configured measurement gaps, or in RRC_INACTIVE, or RRC_IDLE states. UL Tx frequency hopping for SRS for positioning transmission is supported for a UE in RRC_CONNECTED state or in RRC_INACTIVE state. New collision rules between SRS for positioning with frequency hopping and other UL and DL signals/channels have been introduced. In addition to the new collision rules, for UL Tx frequency hopping-based transmissions, a periodically occurring UTW (Uplink Time Window) may be optionally configured to a UE within which the UE is not expected to transmit other signals/channels and is only expected to transmit FH SRS for positioning. When UTW is configured, collision rules are applied outside the UTW.

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List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=981038,940081,981138,981238

[1] RP-233382, “Revised WID on Expanded and Improved NR Positioning,” Intel Corporation, CATT, Ericsson, December 2023.
[2] TR 38.845: "Study on scenarios and requirements of in-coverage, partial coverage, and out-of-coverage NR positioning use cases".
[3] TS 22.261, "Service requirements for the 5G system".
[4] TS 22.104: "Service requirements for cyber-physical control applications in vertical domains".
[5] TR 38.859, “Study on expanded and improved NR positioning (Release 18)”.
[6] TS 38.355, “NR; Sidelink Positioning Protocol (SLPP); Protocol Specification”.

9.3 NR sidelink evolution

940097	**NR sidelink evolution**	**NR_SL_enh2**		RP-230077	**Kevin Lin, OPPO**
940197	Core part: NR sidelink evolution	NR_SL_enh2-Core	R1	RP-230077	**Kevin Lin, OPPO**
940297	Perf. part: NR sidelink evolution	NR_SL_enh2-Perf	R1	RP-230077	**Kevin Lin, OPPO**

Summary based on the input provided by OPPO in RP-233982.

In accordance to the approved WID for NR sidelink evolution (SL-evo) in Release 18 [1], the WI introduced specification support for a number of new features that are needed for enhanced support of NR based V2X deployment in the ITS spectrum and to expand the usage of NR sidelink technology to commercial applications.

Firstly, the introduction of carrier aggregation (including packet duplication) for NR sidelink communication in the ITS band (i.e., Band n47) is to primarily enhance the data rate and the reliability of NR sidelink transmissions for applications such as sensor information (video) sharing between vehicles with high degree of driving automation.

Secondly, with WI also introduced support for NR sidelink communication to operate over FR1 unlicensed spectrum (SL-U) in Band n46 and Band n96/n102, targeting commercial applications and enabling new carrier frequencies and larger bandwidths for higher data rates.

Thirdly, in order to provide enhanced support of LTE-based and NR-based V2X to operate using the same frequency channel in the 5.9GHz spectrum (Band n47) dedicated to ITS usage, LTE sidelink and NR sidelink co-channel coexistence feature is introduced in this WI to minimize interference and cross-RAT impacts.

Objective #1: NR sidelink carrier aggregation

Carrier aggregation (CA) in SL is supported for mode 2 and in V2X case only. It applies to both in coverage UEs and out of coverage UEs. Each resource pool (pre)configured for SL is associated to a single carrier. A UE using mode 2 resource allocation performs carrier (re)selection and may select one or more carriers used for SL. The Rel-16/17 SL resource (re)selection procedure is independently performed for each SL carrier.

The carrier(s) that can be used for transmitting data are provided by the V2X layer per QoS flow, and LCP ensures that data from a SLRB is transmitted on a carrier for which all mapped QoS flows are allowed to use the carrier. For groupcast and broadcast, when the V2X layer provides multiple carriers in QoS flow to carrier mapping information to the AS, TX profile is used to indicate whether the transmission corresponding to the QoS flow is backward compatible or not. When backward compatibility is needed, the TX UE uses only the legacy carrier without PDCP duplication, or uses PDCP duplication with at least the legacy carrier.

For groupcast and broadcast, carrier selection is performed at MAC layer, depending on the CBR of the configured carriers and logical channel priority. Carrier (re)selection may be performed when resource (re)selection is triggered, or when there is no SL grant for a SL process on any allowed carrier, and is triggered for each SL process. In order to avoid frequent switching across different carriers, the UE may keep using a carrier already selected for transmission, if the measured CBR on this carrier is lower than a (pre)configured threshold. For a UE using mode 2 resource allocation, logical channel prioritization is performed for a SL resource on a carrier depending on the CBR measured on the carrier and the logical channel priority. For unicast, SL CA related capability is exchanged between the TX UE and RX UE, and the TX UE delivers the carrier configuration to the RX UE in PC5-RRC. For unicast, carrier selection and logical channel prioritization is performed similar to groupcast and broadcast among the carriers delivered in the carrier configuration. SL CA for unicast is not applied until the carrier configuration signalling is complete. Carrier (re)selection may be performed and a new carrier configuration is sent to the RX UE when the TX UE detects carrier failure on a specific carrier.

SL packet duplication is supported for SL CA and is performed at PDCP layer. For SL packet duplication for transmission, a PDCP PDU is duplicated at the PDCP entity. The duplicated PDCP PDUs of the same PDCP entity are submitted to two different RLC entities and associated to two different SL logical channels respectively. The duplicated PDCP PDUs of the same PDCP entity are only allowed to be transmitted on different carriers. For a SL DRB, SL packet duplication is (pre)configured in the bearer configuration. For applicable SL SRBs, whether to use duplication is decided by the TX UE. In unicast, the TX UE sends the duplication configuration to the RX UE in PC5-RRC. There are specified logical channel identities which apply to the SL logical channel used for SL packet duplication exclusively.

Rel-16/17 PSFCH power control and PSFCH TX/TX prioritization rule are performed across carriers for all PSFCH transmissions over all the aggregated carriers at the same time. When PSFCH transmission(s) and PSFCH reception(s) are overlapping in time at the same UE over multiple carriers, Rel-16/17 PSFCH TX/RX prioritization rule is used for determining either PSFCH transmission(s) or PSFCH reception(s) over all the aggregated carriers.

In determining the power of multiple PSFCH transmissions for SL CA, the UE does not expect to be provided with a (pre)configuration that would result in different transmit power per PSFCH on different carriers. When UE performs multiple S-SSB transmissions over multiple carriers by following LTE SL CA synchronization procedure and if the total power of multiple S-SSB transmissions over multiple carriers exceeds PCMAX, it is up to UE implementation how to adjust the transmit power of each S-SSB transmission so that its total transmit power does not exceed PCMAX.

To avoid AGC problems caused by time resources of different lengths between different carriers, subcarrier spacing, CP length, SL starting symbol within a slot, and SL symbol length within a slot are (pre)configured to be the same among multiple carriers. Also, from a UE perspective, the time resources for PSFCH are aligned across aggregated carriers (e.g., by (pre)configuring that the period of PSFCH resources and the time resource of resource pool with PSFCH resources are the same across the aggregated carriers).

Objective #2: NR sidelink operation on unlicensed spectrum

To support NR sidelink operation in FR1 unlicensed spectrum bands (n46, n96 and n102), the principle and framework of channel access mechanisms adopted in Release 16 for NR-U are reused for a UE operating in sidelink resource allocation mode 1 and mode 2 to transmit SL signals and channels in one or more unlicensed spectrum channels (RB sets). The support of NR sidelink in unlicensed band in Rel-18 does not include gNB performing Type 1 channel access to initiate and share a channel occupancy, neither Type 2 channel access to share an initiated channel occupancy, nor semi-static channel access procedures to access an unlicensed channel. Existing mode 2 resource allocation mechanisms for partial sensing, random resource selection and IUC, and SL-DRX operation are supported in SL-U. The supported UE power class for SL-U in bands n46, n96 and n102 is 20dBm (PC5).

SL-U channel access mechanisms

Several channel access procedures are supported for SL-U operation, including Type 1 LBT, Type 2 LBT and multi-channel access procedures. In Type 1 LBT, a UE initiates a channel occupancy based on the SL CAPC level (p) associated with the SL transmission(s), where p=1 for PSFCH and S-SSB transmissions and p is determined by the associated SL TB for PSCCH/PSSCH transmission. The contention window size to be used in Type 1 LBT is maintained according to SL HARQ-ACK feedback within a reference duration and whether the SL transmission is associated with explicit HARQ-ACK feedback.

In Type 2 channel access procedures, Type 2A, Type 2B and Type 2C LBTs are supported, and a UE can access the channel to perform a SL transmission within its own initiated or shared channel occupancy according to Type 2A, Type 2B or Type 2C LBT depending on a transmission gap.

Type 2A LBT is applicable to a SL transmission when the gap to the previous SL transmission is at least 25μs. Type 2A is also supported for a UE transmitting only S-SSB without a channel occupancy, subject to a time duration and a duty cycle restriction.

Type 2B LBT is applicable to a SL transmission when the gap to the previous SL transmission is 16μs.

Type 2C LBT is applicable to a SL transmission when the gap to the previous SL transmission is up to 16μs and the SL transmission is at most 584us.

UE-to-UE COT sharing from a channel occupancy initiating UE is supported in SL-U. When performing S-SSB transmission, a responding UE can utilize a COT shared by a COT initiating UE when the responding UE intends to transmit S-SSB in the shared COT. When performing PSFCH transmission, a responding UE can utilize a COT shared by a COT initiating UE when at least one of the responding UE's PSFCH transmissions is intended for the COT initiating UE. When performing PSSCH/PSCCH transmission, a responding UE can utilize a COT shared by a COT initiating UE when the responding UE's transmission is intended for the COT initiating UE based on source/destination ID and additional source/destination ID (if present) matching indicated in SCI. In order to satisfy COT sharing requirements, a responding UE may perform an enhanced LCP procedure by taking into account the CAPC value of corresponding LCH. When receiving multiple COT sharing indications from different COT initiators, it is up to UE implementation which shared COT is used.

In SL-U, a UE transmits a CPE from a CPE starting position before a PSCCH/PSSCH, PSFCH or S-SSB transmission. For PSCCH/PSSCH transmission in a slot, the CPE starting position within one or two symbols prior is determined based on L1 priority of the PSCCH/PSSCH if no a resource reservation is transmitted or detected for the slot; or based on a (pre-)configured default starting position otherwise. A single CPE starting position in the symbol prior to PSFCH and S-SSB transmission is always used.

Multi-channel access procedures are supported if a UE is scheduled to transmit or intends to transmit on configured or selected resources over multiple channels (RB sets) at the same time.

Type A and Type B multi-channel access procedures are supported for PSFCH or S-SSB transmission over multiple channels (RB sets), where if the channel access procedures fail on part of the RB set(s) but succeed on other part of the RB set(s), the UE may transmit the SL transmission(s) on the part of the RB set(s) where the corresponding channel access was successful.

An UL-based multi-channel access procedures is also supported in SL-U and it is applicable for PSCCH/PSSCH, S-SSB and PSFCH transmissions, where if the channel access procedures fail on any part of the RB sets, the UE shall not transmit the SL transmissions on all of the RB sets where the channel access procedures is performed.

Enhanced resource selection schemes

For supporting a SL UE to transmit continuously within an initiated or shared channel occupancy, an enhanced resource selection feature for multiple consecutive slots transmission (MCSt) in SL resource allocation mode 2 is introduced in Release 18. In MCSt, resources in consecutive slots can be selected for transmitting one or more TBs.

In order to avoid blocking of Type 1 LBT among different SL UEs, a UE may prioritize and select a resource for PSCCH/PSSCH transmission before a reserved resource if the transmission is able to share its initiated COT to the reservation. Otherwise, a UE may avoid selection of N consecutive resources before and/or M consecutive resources after a reserved resource.

SL-U Physical channel design

To meet OCB/PSD requirement and to address LBT uncertainty on unlicensed spectrum, Rel-18 NR SL enhanced physical channels and procedures, which are elaborated in followings.

Same as legacy NR SL, only one SL BWP is (pre-)configured within a carrier and it includes one or multiple SL resource pools. One SL resource pool can be (pre-)configured to include integer number of RB sets.

To address LBT failure, 2 candidate starting symbols within a slot for a PSCCH/PSSCH transmission is supported to provide UE more transmission opportunities. When a UE initiates a COT, for the 1st slot of a COT, the Tx UE chooses the earliest starting symbol for PSCCH/PSSCH transmission after clearing LBT. In the same slot, Tx UE can use the 2nd starting symbol only if LBT fails at the 1st starting symbol.

SL-U PSCCH/PSSCH supports both interlaced RB-based (IRB) and contiguous RB-based (CRB) transmission structures, and sub-channel is used as the frequency domain resource allocation granularity for PSSCH transmission. In IRB structure, 1 sub-channel equals to 1 or 2 interlace(s) according to different sub-carrier spacing (15kHz/30kHz SCS). In CRB structure, the mapping of sub-channel starts from the first PRB of the resource pool and mapped sequentially within the resource pool according to the sub-channel size.

To meet the OCB requirement, two PSFCH transmission schemes in RB-based interlace format are supported. In scheme 1, a PSFCH transmission occupies a common interlace and a (pre-)configurable number of dedicated PRBs. In scheme 2, a PSFCH transmission occupies a dedicated interlace, with PRB-level cyclic shift hopping. To address potential LBT failure for PSFCH transmissions, each PSCCH/PSSCH transmission has a (pre-)configurable number of candidate PSFCH occasion(s). The first candidate PSFCH occasion is determined as in Rel-16 sidelink, while other candidate PSFCH occasion(s) are sequentially allocated in the following slot(s) with PSFCH resources. A PSCCH/PSSCH receiver UE attempts to transmit PSFCH on a candidate PSFCH occasion only if it fails to transmit on previous PSFCH occasion(s), e.g., due to LBT failure, uplink/sidelink prioritization, etc.

To meet the OCB requirement, the SL-U S-SSB reuses the Rel-16 S-SSB and allows S-SSB repetition(s) in the frequency domain. Per RB-set, the center frequency of the 1st S-SSB is indicated by the absolute frequency, and the number of S-SSB repetitions and the gap RBs between S-SSB repetitions are (pre-)configured. To ensure robust S-SSB transmission, additional candidate S-SSB occasions following the legacy S-SSB occasion(s) can be (pre-)configured. No matter the LBT fails at legacy S-SSB occasion or not, a UE can retry S-SSB transmissions at later candidate S-SSB occasions.

Objective #3: void

Objective #4: LTE sidelink and NR sidelink co-channel coexistence

To support co-channel coexistence for LTE SL and NR SL, TDM-based semi-static resource pool partitioning based on Rel-16/17 specification is supported. In addition, dynamic resource pool sharing between LTE SL and NR SL is introduced. For devices which contain both LTE SL and NR SL modules, there is support for the NR SL module to make use of information obtained from the LTE SL module's mode 4 resource allocation procedure in the NR mode 2 resource allocation procedure, when the subcarrier spacing (SCS) of NR SL is 15 or 30 kHz. To be specific, for the dynamic resource pool sharing, NR SL module can use the information shared by the LTE SL module including the

LTE SL reserved resources by other LTE SL UEs, the LTE SL resources selected to be used for LTE SL module's own LTE SL transmission, and the LTE SL resources associated with non-monitored subframe (in which the UE has not monitored due to its transmission) in LTE SL module in NR SL resource (re)selection procedure. NR SL module can exclude NR SL candidate resources overlapping with the LTE SL resources according to relative priority between LTE SL and NR SL, SL-RSRP, periodicity of LTE SL resources. Furthermore, to mitigate additional AGC issue due to overlapping with the LTE SL reserved resources and NR PSFCH, the NR SL module can further exclude NR SL candidate resources where the corresponding PSFCH transmission occasions overlap with LTE SL reserved resources by other LTE SL UE in time domain. To support 30kHz SCS for NR SL for the dynamic resource pool sharing, it is supported that NR SL module selects at least the first of NR SL slots overlapping with an LTE SL subframe, and can select the subsequent overlapping NR SL slot while the power level of the NR PSCCH/PSSCH transmission in the first of NR SL slots overlapping with an LTE SL subframe is always larger than or equal to the power level(s) of the NR PSCCH/PSSCH transmission in the subsequent NR SL slot overlapping with the LTE SL subframe.

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List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941000,941100

[1] RP-232864, Status report for WI: Core part: NR Timing Resiliency and URLLC enhancements, Nokia

9.4 NR sidelink relay enhancements

941002	**NR sidelink relay enhancements**	**NR_SL_relay_enh**		RP-223501	**Youngdae LEE, LG Electronics**
941102	Core part: NR sidelink relay enhancements	NR_SL_relay_enh-Core	R2	RP-223501	**Youngdae LEE, LG Electronics**
941202	Perf. part: NR sidelink relay enhancements	NR_SL_relay_enh-Perf	R2	RP-223501	**Youngdae LEE, LG Electronics**
960083	UE Conformance - NR Sidelink Relay	NR_SL_relay-UEConTest	R5	RP-221447	**Xiaozhong CHEN, CATT**

Summary based on the input provided by LG Electronics in RP-232973.

This WI specified solutions to enable single-hop, sidelink-based, L2 and L3 based U2U relay, enhance service continuity for single-hop Layer-2 U2N relay, and enable multi-path operation using both direct path and PC5 or N3C indirect path.

This WI specified solutions to enable single-hop Layer-2 and Layer-3 UE-to-UE (U2U) relay for unicast, enhance service continuity for single-hop Layer-2 UE-to-Network (U2N) relay, and enable multi-path operation in which a remote UE is connected to the same gNB using one direct path and one indirect path via 1) Layer-2 U2N relay UE using PC5 link, or 2) via N3C (Non-3GPP Connection) relay UE.

UE-to-UE Relay

5G ProSe UE-to-UE Relay (U2U Relay) function is introduced to provide connectivity between U2U Remote UEs. For the coverage extension, the U2U Remote UE can communicate with the peer U2U Remote UE(s) which are not reachable within the sidelink coverage. A U2U Relay UE provides coverage extension of the sidelink transmissions between two U2U Remote UEs. For U2U Relay, NR sidelink is supported between U2U Relay UE and U2U Remote UEs.

The U2U Relay UE and U2U Remote UE can be in any RRC state. The U2U Relay UE and the U2U Remote UEs can be in the coverage of different cells, partially in-coverage, or out-of-coverage. Both L2 and L3 U2U Relay architectures are supported. The L3 U2U Relay architecture is transparent to the AS layer of the U2U Relay UE.

In order to enable remote UE and relay UE to identify each other and to establish sidelink connection, sidelink discovery is used. The U2U Remote UE and U2U Relay UE can perform Relay discovery message transmission or DCR message with integrated discovery transmission and may monitor for Relay discovery message or DRC message with integrated discovery while in coverage (i.e. RRC_IDLE, RRC_INACTIVE, or RRC_CONNECTED) or out-of-coverage. The U2U Remote UE performs radio measurements (i.e., SD-RSRP and/or SL-RSRP) at PC5 interface and uses them for U2U Relay selection and reselection along with higher layer criteria.

After NR sidelink establishment between U2U Relay UE and U2U Remote UEs, end-to-end PC5 unicast link connection establishment is performed between U2U Remote UEs. Only unicast is supported between U2U Relay UE and U2U Remote UEs.

L2 U2U Relay: Protocol Architecture

In order to support bearer mapping between sidelink connection between remote UEs via relay UE, the SRAP sublayer is placed above the RLC sublayer in each hop-by-hop PC5 link. The header of SRAP sublayer carries remote UE identification and bearer identification, in order for relay UE to perform packet forwarding between the two remote UE sides. The sidelink SDAP, PDCP and RRC are terminated between two L2 U2U Remote UEs (i.e., end-to-end), while SRAP, RLC, MAC and PHY are terminated in each hop-by-hop PC5 link.

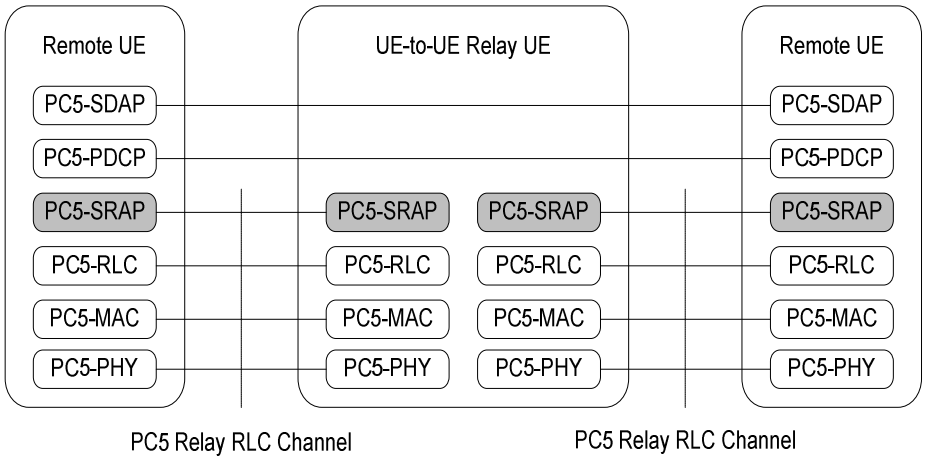

Figure 1: User plane protocol stack for L2 UE-to-UE Relay

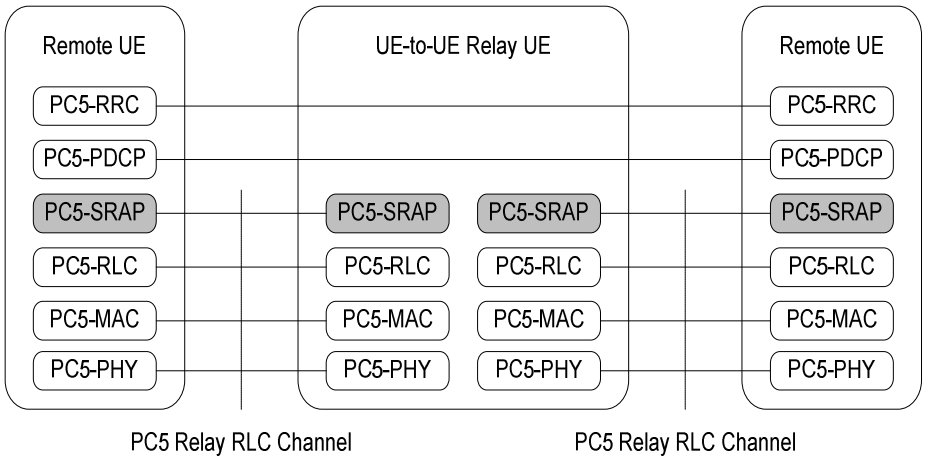

Figure 2: Control plane protocol stack for L2 UE-to-UE Relay

L2 U2U Relay: Control Plane Procedure

The L2 U2U Remote UE, L2 U2U Relay UE, and peer L2 U2U Remote UE perform discovery procedure or integrated discovery procedure. The L2 U2U Remote UE establishes end-to-end PC5-RRC connection and end-to-end SL-SRB/DRBs with the peer L2 U2U Remote UE via the selected L2 U2U Relay UE before user plane data transmission.

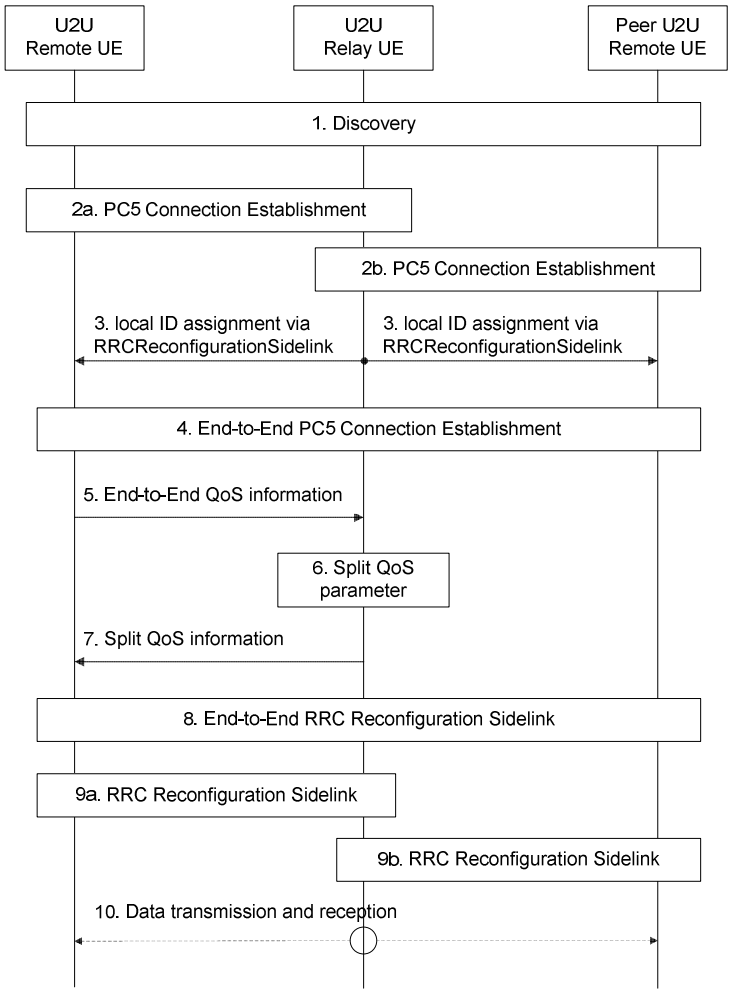

Figure 3: Procedure for L2 U2U Remote UE connection establishment

Service Continuity for L2 U2N relay

The single-hop Layer-2 UE-to-Network (U2N) relay function is enhanced to support the following additional service continuity scenarios:

A. Inter-gNB indirect-to-direct path switching

B. Inter-gNB direct-to-indirect path switching

C. Intra-gNB indirect-to-indirect path switching

D. Inter-gNB indirect-to-indirect path switching

For inter-gNB path switching, it is the source gNB that selects the target path type (i.e. direct or indirect). For inter-gNB path switching to the indirect path, the source gNB sends a list of candidate relay UEs belonging to the same target cell to the target gNB, and the target gNB can select an L2 U2N Relay UE in any RRC state i.e., RRC_IDLE, RRC_INACTIVE, or RRC_CONNECTED, as a target L2 U2N Relay UE.

Multi-path Relay

In multi-path relay, a MP Remote UE is connected to a single gNB via one direct path and one indirect path while the MP Remote UE is in RRC_CONNECTED state. For the indirect path, the interface between MP Remote UE and MP Relay UE can be either PC5 or N3C (Non-3GPP Connection). When the interface between MP Remote UE and MP Relay UE is N3C interface, the relationship of MP Remote UE and MP Relay UE is pre-configured or static, and it is up to implementation how to pre-configure or make it static. The MP Relay UE and MP Remote UE should be served by the same cell or different intra/inter-frequency cells of the same gNB.

For the indirect path, both L2 and L3 MP Relay architectures are supported. The L3 MP Relay architecture is transparent to the serving NG-RAN of the MP Relay UE, except for controlling sidelink resources.

From L2 MP Remote UE perspective, three bearer types exist: direct bearer, indirect bearer, and MP split bearer. For direct bearer, only Uu radio resources are involved, and for indirect bearer, only PC5 or N3C radio resources are involved. For MP split bearer, both Uu and PC5/N3C radio resources are involved. Packet duplication is supported for a MP split bearer. If PDCP PDU duplication is activated, duplicated PDCP PDUs are delivered via both direct path and indirect path.

L2 MP Relay using PC5 indirect path: Protocol Architecture

For multi-path relay operation by using PC5 indirect path, the SRAP sublayer is placed above the RLC sublayer for both CP and UP at both PC5 interface and Uu interface of the indirect path.

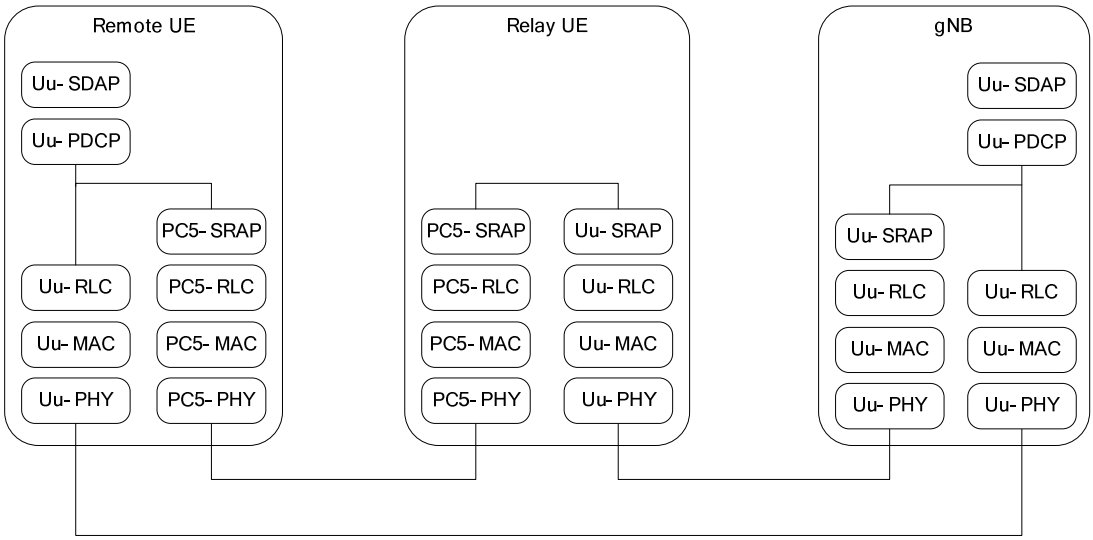

Figure 4: User plane protocol stack for L2 Multi-path Relay using PC5 indirect path

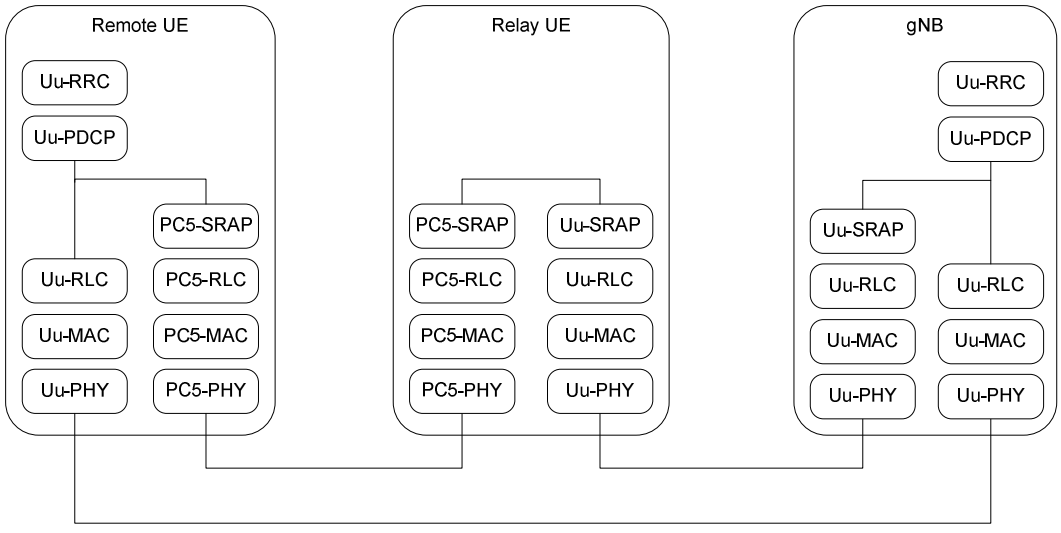

Figure 5: Control plane protocol stack for L2 Multi-path Relay using PC5 indirect path

In the case of MP Remote UE using PC5 indirect path, mode 1 resource allocation is supported at least only for intra-DU case, with the SR/BSR and grant sent on the direct path.

L2 MP Relay using N3C indirect path: Protocol Architecture

In the multi-path relay using N3C indirect path, the SRAP sublayer does not exist on the protocol stack. More than one RB over the Uu link of the L2 MP Relay UE can be supported by configuring 1:1 bearer mapping between the Radio bearer in the L2 MP Remote UE and Uu Relay RLC channel in the L2 MP Relay UE.

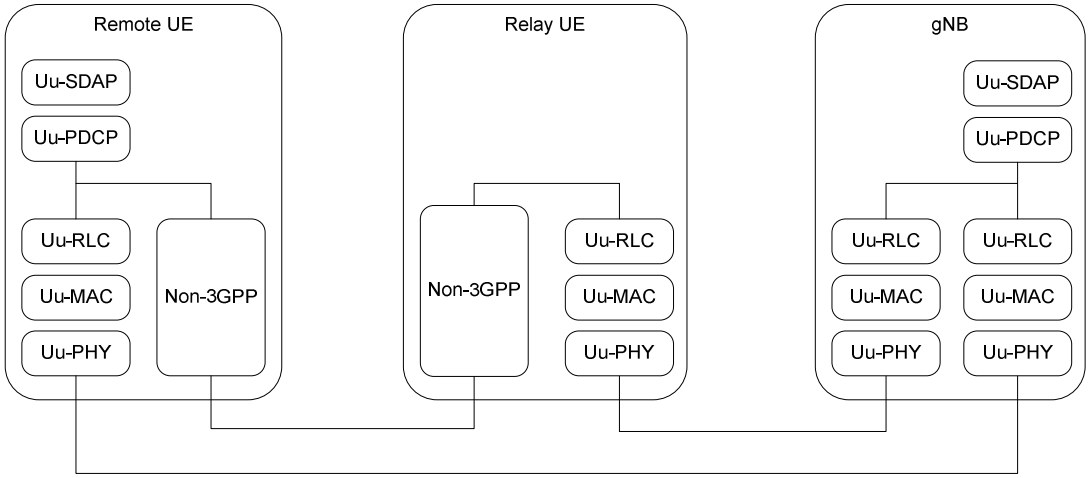

Figure 6: User plane protocol stack for L2 Multi-path Relay using N3C indirect path

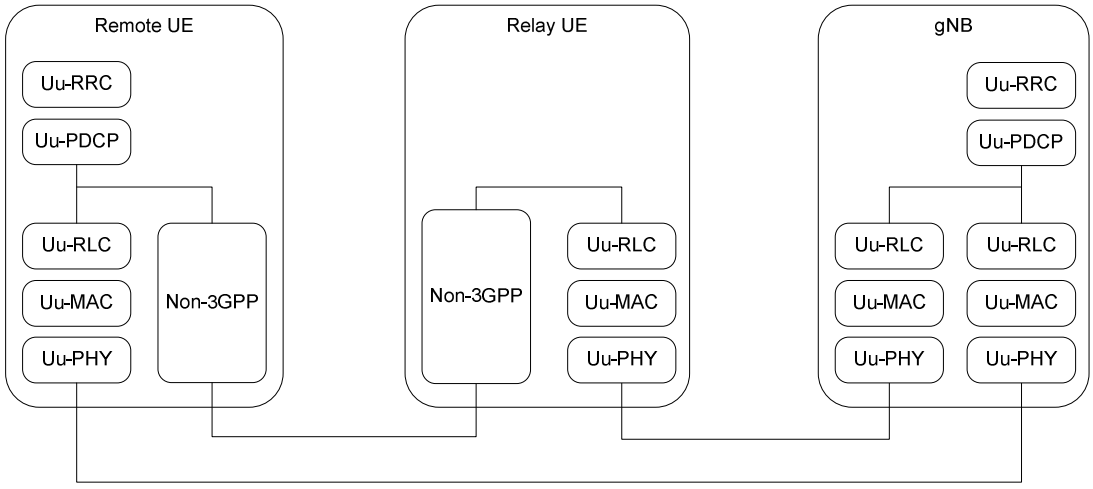

Figure 7: Control plane protocol stack for L2 Multi-path Relay using N3C indirect path

L2 MP Relay: Control Plane Procedure

The L2 MP Remote UE establishes both a direct path and an indirect path for multi-path relaying. For L2 MP Remote UE, only a single cell group is configured (i.e., only MCG is configured for the direct path and indirect path). PCell is always on the direct path. The primary path of split SRB1 and SRB2 is always configured on direct path. In the L2 MP Remote UE, non-split SRB1/2 is allowed to be configured only on direct path.

For L2 MP Relay using PC5 indirect path, the control plane procedure supports addition of the indirect path on top of the only direct path under the same gNB and addition of the direct path on top of the only indirect path under the same gNB.

For L2 MP Relay using N3C indirect path, the control plane procedure supports addition of the indirect path on top of the only direct path under the same gNB. But, addition of the direct path on top of the only N3C indirect path is not supported.

When the L2 MP Remote UE detects Uu Radio Link Failure (RLF) on the direct path, the L2 MP Remote UE triggers path failure reporting through the indirect path via a RRC message if split SRB1 is configured and the indirect path is not suspended. Otherwise, RRC connection re-establishment is initiated. On the other hand, the L2 MP Remote UE detects PC5 Radio Link Failure (RLF) on the indirect path, the L2 MP Remote UE triggers path failure reporting through the direct path via a RRC message if split SRB1 or non-split SRB1 is configured and the direct path is not suspended. The PC5 RLF detection includes PC5 link failure and/or Uu link failure on the indirect path.

The L2 MP Remote UE can acquire any necessary SIB(s) over Uu interface or indirect path, or the system information via dedicated RRC signalling via SRB1.

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941002,941102,941202,960083

9.5 Proximity-based Services in 5GS Phase 2

980112	**Proximity-based Services in 5GS Phase 2**	**5G_ProSe_Ph2**		SP-220806	**Deng Qiang, CATT**
970016	**(stage 2 of) Proximity-based Services in 5GS Phase 2**	5G_ProSe_Ph2	S2	SP-230097	**Deng Qiang, CATT**
980060	CT1 aspects of 5G_ProSe_Ph2	5G_ProSe_Ph2	C1	CP-223110	**Duan, Xiaoyan, CATT**
980061	CT3 aspects of 5G_ProSe_Ph2	5G_ProSe_Ph2	C3	CP-223110	**Duan, Xiaoyan, CATT**
980062	CT4 aspects of 5G_ProSe_Ph2	5G_ProSe_Ph2	C4	CP-223110	**Duan, Xiaoyan, CATT**
980063	CT6 aspects of 5G_ProSe_Ph2	5G_ProSe_Ph2	C6	CP-223110	**Duan, Xiaoyan, CATT**
990045	**Security Aspects of Proximity-based Services in 5GS Phase 2**	5G_ProSe_Ph2	S3	SP-230158	**Wei Zhou, CATT**

Summary based on the input provided by CATT in SP-240387.

Based on the conclusions reached within clause 8 of TR 23.700-33 [1], the enhancements of 5G System to support Proximity based Services (5G ProSe) Phase 2 are specified in TS 23.304 [2]. They consist of 5G ProSe UE-to-UE Relay, 5G ProSe UE-to-Network Relay enhancements and path switching between PC5 and Uu reference points.

5G ProSe UE-to-UE Relay enables indirect communication between two 5G ProSe End UEs. Both 5G ProSe Layer-3 UE-to-UE Relay and 5G ProSe Layer-2 UE-to-UE Relay are specified to relay unicast traffic between the 5G ProSe End UEs, supporting IP, Ethernet or Unstructured traffic type. The 5G ProSe UE-to-UE Relay supports 5G ProSe UE-to-UE Relay Discovery (including Model A discovery, Model B discovery and Candidate Relay discovery) procedure, 5G ProSe UE-to-UE Relay Communication with integrated Discovery procedure, 5G ProSe UE-to-UE Relay Communication procedure, and 5G ProSe UE-to-UE Relay reselection procedure.

Based on the 5G ProSe **UE-to-Network Relay** architecture specified in Rel-17, the 5G ProSe UE-to-Network Relay is enhanced in Rel-18 to support the features on path switching between two 5G ProSe UE-to-Network Relays, multi-path communication via Uu and via 5G ProSe UE-to-Network Relay and emergency service from 5G ProSe Remote UE via 5G ProSe UE-to-Network Relay.

The **path switching between PC5 and Uu reference points** enables a UE switches between Uu communication path and direct PC5 communication path when it is communicating with another UE. The path switching between PC5 and Uu reference points is performed at ProSe service level, and UE takes the path selection policy into account to determine whether and for which ProSe service(s) to switch the communication path.

The corresponding Stage 3 is specified in TS 24.554 [3], TS 24.555 [4], TS 29.555 [5], TS 29.557 [6] and TS 29.559 [7], while the Security normative work is specified in TS 33.503 [8].

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941002,941102,941202,960083

[1] TR 23.700-33: "Study on system enhancement for Proximity based Services (ProSe) in the 5G System (5GS); Phase 2".
[2] TS 23.304: "Proximity based Services (ProSe) in the 5G System (5GS)".
[3] TS 24.554: "Proximity based services (ProSe) in 5G system (5GS) protocol aspects; Stage 3".
[4] TS 24.555: "Proximity based services (ProSe) in 5G system (5GS); User Equipment (UE) policies; Stage 3".
[5] TS 29.555: "5G System; 5G Direct Discovery Name Management Services; Stage 3".
[6] TS 29.557: "5G System; Application Function ProSe Service; Stage 3".
[7] TS 29.559: "5G System; 5G ProSe Key Management Services; Stage 3".
[8] TS 33.503: "Security Aspects of Proximity based Services (ProSe) in the 5G System (5GS)".

9.6 Ranging-based Service and sidelink positioning

910040	**Ranging-based Service and sidelink positioning**	**Ranging**		SP-210212	**Xiaowei jiang, Xiaomi**

880039	*Study on Ranging*	FS_Ranging	S1	SP-200575	**Xiaowei jiang**
910034	**Stage 1 for Ranging**	Ranging	S1	SP-210212	**Xiaowei jiang, Xiaomi**
940069	*Study on Ranging based services and sidelink positioning*	FS_Ranging_SL	S2	SP-211647	**Shen, Sherry (Yang), Xiaomi,**
980015	**Stage 2 of Ranging_SL**	Ranging_SL	S2	SP-230106	**Shen, Sherry (Yang), Xiaomi**
960036	*Study on Security Aspects of Ranging Based Services and Sidelink Positioning*	FS_Ranging_SL_Sec	S3	SP-220534	**Wei Lu, Xiaomi,**
990046	**Security Aspects of Ranging_SL**	Ranging_SL_Sec	S3	SP-230769	**Lu, Wei, Xiaomi**
990014	CT1 aspects of Ranging_SL	Ranging_SL	C1	CP-230331	**Tingfang Tang, Xiaomi**
990066	CT3 aspects of Ranging_SL	Ranging_SL	C3	CP-230331	**Tingfang Tang, Xiaomi**
990067	CT4 aspects of Ranging_SL	Ranging_SL	C4	CP-230331	**Tingfang Tang, Xiaomi**
1000009	**Charging Aspects of Ranging and Sidelink Positioning**	**FS_Ranging_SL_CH**	**S5**	SP-230622	**Zhiwei Mo, China Telecom,**

Summary based on the input provided by Xiaomi in SP-240907.

Ranging-based service provides the distance between two UEs or more UEs and/or the direction of one UE (i.e. Target UE) from another UE (i.e. SL Reference UE) via PC5 operations.

Sidelink Positioning provides absolute location, relative position, or Ranging information of a UE by using PC5 for the positioning. A Located UE can be used to determine the absolute location of a Target UE using Sidelink Positioning.

The operation of Ranging/Sidelink Positioning can be performed with Network-assisted Operation, Network-based Operation or UE-only Operation:

- In the Network-based Operation, 5GC NF(s) is involved for the service request handling and result calculation.
- In the UE-only Operation, the service request handling and result calculation are performed by UE.
- In the Network-assisted Operation, 5GC NF(s) is involved for the service request handling and assist UE for the result calculation.

The Ranging/Sidelink Positioning service request can be initiated by a UE (i.e. SL Positioning Client UE, Target UE, SL Reference UE), a 5GC NF, an LCS Client or an AF.

Ranging based services and sidelink positioning in 5G System are applied for commercial, V2X and public safety use cases in in-coverage, partial coverage, and out-of-coverage of 5G network using 5G NR PC5 RAT, which includes the following functionality and features:

- Authorization and Provisioning for Ranging/SL positioning service
- Ranging/Sidelink Positioning UE Discovery & Selection
- Ranging/SL Positioning control
- UE Positioning assisted by Sidelink Positioning and involving 5GC
- UE-only Operation for SL Positioning using Located UE
- Ranging/SL Positioning service exposure
- QoS Handling
- Subscription to Ranging/SL Positioning
- Support of Concurrent Ranging/Sidelink Positioning Requests
- Security
- Charging

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910040,910034,980015,990046,990014,990066,990067,1000009

[1] TS 23.586: "Architectural Enhancements to support Ranging based services and Sidelink Positioning".
[2] TS 23.501: "System architecture for the 5G System (5GS)".
[3] TS 23.502: "Procedures for the 5G System (5GS)".
[4] TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2".

[5] TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".
[6] TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".
[7] TS 23.222: "Common API Framework for 3GPP Northbound APIs".
[8] TS 33.122: "Security aspects of Common API Framework (CAPIF) for 3GPP northbound APIs".
[9] TS 38.355: "NR; Sidelink Positioning Protocol (SLPP); Protocol Specification".
[10] TS 33.533: "Security aspects of ranging based services and Sidelink positioning".
[11] TS 23.032: "Universal Geographical Area Description (GAD)".
[12] TS 38.300: "NR; NR and NG-RAN Overall Description; Stage 2".
[13] TS 24.080: "Supplementary services specification; Formats and coding".
[14] TS 24.514: "Ranging based services and sidelink positioning in 5G system (5GS); Stage 3".

9.7 Mobile Terminated-Small Data Transmission (MT-SDT) for NR

941000	**Mobile Terminated-Small Data Transmission (MT-SDT) for NR**	**NR_MT_SDT**		RP-222993	**Eswar Vutukuri, ZTE Corporation**
941100	Core part: Mobile Terminated-Small Data Transmission (MT-SDT) for NR	NR_MT_SDT-Core	R2	RP-222993	**Eswar Vutukuri, ZTE Corporation**
950048	***Study on Proximity based Services Phase 2***	**FS_5G_ProSe_Ph2**	**S2**	SP-211653	**Deng, Qiang, CATT**
940077	*Study on Stage 2 for Proximity based Services Phase 2*	FS_5G_ProSe_Ph2	S2	SP-211653	**Deng, Qiang, CATT**
950024	*Study on Security Aspects of Proximity Based Services Phase 2*	FS_5G_ProSe_Ph2	S3	SP-220202	**Wei Zhou, CATT**

Summary based on the input provided by ZTE in RP-232943.

In Rel-17, the work item for small data enhancements (NR_SmallData_INACTIVE) enabled transmission of small signalling and/or data packets whilst the UE remains in RRC_INACTIVE state. These Rel-17 enhancements supported only the Mobile Originated Small Data Transmissions (MO-SDT). In Rel-18 the Mobile Terminated Small Data Transmissions are supported with the completion of the MT-SDT WI. For DL, MT-SDT (i.e. DL-triggered small data) allows similar benefits as MO-SDT i.e. 1) reducing signalling overhead and UE power consumption by avoiding unnecessary transitions to RRC_CONNECTED and reducing latency by allowing fast transmission of (small and infrequent) packets, e.g. for positioning.

For a UE in RRC_INACTIVE state, MT-SDT is initiated by the network with an indication to the UE in the paging message when DL data awaits transmission for radio bearers configured for SDT; based on the indication, the UE initiates the MT-SDT only if the DL RSRP is above a configured threshold. When MT-SDT is initiated by the UE, a resume cause indicating MT-SDT is included in the RRCResumeRequest/RRCResumeRequest1 message. It is possible for the network to enable MO-SDT or MT-SDT or both MO-SDT and MT-SDT in a cell. MT-SDT procedure can be initiated with either a transmission over RACH or over Type 1 Configured Grant (CG) resources (configured via dedicated signalling in RRCRelease).

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941000,941100

9.8 5G-enabled fused location service capability exposure

990108	**5G-enabled fused location service capability exposure**	**5GFLS**		SP-221234	**Liping Wu, CATT**
920015	*Study on 5G-enabled fused location service capability exposure*	FS_5GFLS	S6	SP-220097	**Zhang, Ling, CATT**
980109	**Stage 2 of 5GFLS**	5GFLS	S6	SP-221234	**Liping Wu, CATT**
990016	CT1 aspects of 5GFLS	5GFLS	C1	CP-230195	**Zhao, Xiaoxue, CATT**
990069	CT3 aspects of 5GFLS	5GFLS	C3	CP-230195	**Zhao, Xiaoxue, CATT**

Summary based on the input provided by CATT in SP-240867.

The work item "5G-enabled fused location service capability exposure" specifies the following function/mechanism to enhance the 5G location services in the application enabled layer:

- Architecture enhancement of application enablement for location;
- Support of LCS QoS;
- Location service differentiation; and
- Initialization and configuration for fused location service.

A dedicated study (FS_5GFLS) on support of fused location services for 5G in the application enabled layer is performed. The outcome of the study is captured in the TR 23.700-76[1], and the conclusion of the study supports a work item (5GFLS), which standardizes some identified solutions by updating the specification of TS 23.434 [2].

CT1 and CT3 also update specifications of TS 24.545 [3] and TS 29.549 [4] to implement the solutions identified by Stage 2 in SA6.

Architecture enhancement of application enablement for location

To specify how the SEAL location-related architecture can be enhanced to support the combined use and fusion of different location technologies at the application enabled layer

The current SEAL-LM architecture should be enhanced to include the Fused Location Function (FLF) which is part of Location Management Server (LMS), and support the LM-3P interface to interact with 3rd party location server. The LM-3P interface is out of the scope of 3GPP.

When the Fused Location Function is present, the Location Management Server may use the location information from multiple sources to determine a more accurate UE location. The fused location function may select one or more location sources and location methods based on the requested location QoS which obtained from the location management server.

Support of LCS QoS

As different location sources can provide different location information with different location QoS, the Fused Location Function takes the advantages of these different location sources and decides to select the most proper location sources based on the required location QoS and fuses the location information from the selected location sources to generate the final location information to meet the requested location QoS.

Location service differentiation

To distinguish the location service via different dimensions in the application enabled layer, the creation of location profiles at a fused location service is introduced and the Fused Location Function (FLF) which is part of the Location Management Server(LMS) could enable the translation/mapping of the vertical request to a location profile, derive the requested location report, and then fetch the aggregated/fused location data from more data sources in an iterative manner to ensure that the vertical requirement is met and send the final fused location report to the VAL server at last.

Initialization and configuration for fused location service

To support how to initiate and start the fused location service such that the location capabilities of target UE, the following aspects are introduced:

- What configurations are needed for the initialization of fused location service and how: The Location Management Client (LMC) can provide its UE IDs and the location capabilities to the Fused Location Function (FLF) through the LM-UU interface, and the FLF can generate and store this information as the UE location context, and also can use these UE location contexts in the service flow for the fused location service.

- What application layer sessions are established for the fused location service and how: The location service is initiated at the Location Management Server (LMS) and triggered by an application. The FLF in the LMS may query the location management client of the target UE, and invoke the location service and/or SUPL service with 5GC, and/or the 3rd party location server, etc.

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990108,980109,990016

[1] TR 23.700-96: "Study on 5G-enabled fused location service capability exposure ".
[2] TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL) ".
[3] TS 24.545: "Location Management - Service Enabler Architecture Layer for Verticals (SEAL)".
[4] TS 29.549: "Service Enabler Architecture Layer for Verticals (SEAL); Application Programming Interface (API) specification; Stage 3".

10 Verticals, Industries, Factories, Northbound API

10.1 Low Power High Accuracy Positioning for industrial IoT scenarios

910036	**Low Power High Accuracy Positioning for industrial IoT scenarios**	LPHAP	S1	SP-210216	**Yuan Wang, Huawei**

Summary based on the input provided by Huawei in SP-231582.

Energy efficient provision of positioning services allows battery-constrained UEs to sustain a long lifetime without changing battery. Such a UE may have low communication capability with highly accurate positioning capability.

Low power high accuracy positioning is an important requirement for industrial applications. 3GPP Rel-17 mainly enhances the accuracy and reduces the latency of position estimation for IIoT scenarios, e.g. reaching accuracy of 0.2 m at 90 % availability and at a latency of position estimation of 10~100 ms, but the device power consumption aspects are not properly addressed.

The Release 17 version of 3GPP SA1 TS 22.261 (v17.4.0) captures in clause 7.3.2.3 low power requirements for asset tracking and use cases of this sort as:*"The 5G system shall support positioning technologies that allow the UE to operate at Service Level 1 for at least 12 years using less than 1800 mWh of battery capacity, assuming multiple position updates per hour."*

This requirement came from an industry scenario, and two accompanying notes in the same clause further explain the expected quantitative KPI to achieve the expected low power performance as 20 mJ per positioning fix.

As more industries continue to explore the adoption of positioning service in their environment, it becomes more important that using the 5G positioning services should not entail significant change in the primary process (e.g. OPEX to accommodate manual replacement of batteries) in the long run. This makes the longevity of a positioning device paramount, especially for use cases requiring more frequent positioning. Low power high accuracy positioning addresses power efficiency and battery lifetime aspects for positioning services for industries. The outcome is captured in Annex A.7.2 of TS 22.104 [1] (Rel-18). Table A.7.2-1 [1] contains the low power aspects per use-case category in terms of battery lifetime, accompanied by the required positioning service level as defined in TS 22.261 [2] and expected positioning update frequency (also in Table 1 below).

It is important low power consumption should be achieved not at the cost of positioning accuracy. Low power high accuracy positioning should satisfy both power efficiency and positioning accuracy aspects, so that many industrial applications are covered, e.g. use case #6 (Flexible modular assembly area: tracking of workpiece (indoor and outdoor) in assembly area and warehouse) in TS 22.104 [1] Annex A.7.2 (also in Table 1 and Table 2 below). Therefore, 5G NR should support low power consumption while keeping high positioning accuracy, for example:

- Horizontal accuracy <1 m, vertical accuracy <2 m, positioning service availability at 99%
- 15-30 s positioning interval
- 6-12 months battery life

The table below includes the identified use cases that require low-power high accuracy positioning (TS 22.104 [1], Table A.7.2-1). Further positioning KPIs can be derived from the corresponding positioning service levels provided for each use case in Table 1.

Table 1: Low power high accuracy positioning KPIs (from TS 22.104 , Table A.7.2-1)

Use Case #	Horizontal accuracy	Corresponding positioning service level (TS 22.261)	Positioning interval/ duty cycle	battery life time/ minimum operation time
1	10 m	Positioning Service Level 1	on request	24 months
2	2 m to 3 m	Positioning Service Level 2	< 4 s	> 6 months
3	< 1 m	Positioning Service Level 3	no indication	1 work shift - 8 hours (up to 3 days, 1 month for inventory purposes)
4	< 1 m	Positioning Service Level 3	1 s	6 - 8 years
5	< 1 m	Positioning Service Level 3	5 s to 15 min	18 months
6	< 1 m	Positioning Service Level 3	15 s to 30 s	6 - 12 months
7	30 cm	Positioning Service Level 5	250 ms	18 months
8	30 cm	Positioning Service Level 5	1 s	6 - 8 years (no strong limitation in battery size)
9	10 m	Positioning Service Level 1	20 min	12 years (@20 mJ/position fix)

Table 2: Use cases for low power high accuracy positioning (cf. TS 22.104 , clause A.7.2)

Use Case #	Use Case Name / Brief Description
1	Dolly tracking (outdoor) (process automation)
2	Asset tracking (process automation)
3	Tool tracking in flexible, modular assembly areas in smart factories
4	Sequence container (Intralogistics) (process automation)
5	Palette tracking (e.g. in turbine construction) (process automation)
6	Tracking of workpiece (indoor/outdoor) in assembly area and warehouse (flexible modular assembly area)
7	Tool assignment (assign tool to vehicles in a production line, left/right) in flexible, modular assembly area in smart factories (flexible modular assembly area)
8	Positioning of autonomous vehicles for monitoring purposes (vehicles in line, distance 1.5 m) (flexible modular assembly area)
9	Asset Tracking ((Intra-)logistics)

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910036

[1] TS 22.104: “Service requirements for cyber-physical control applications in vertical domains”
[2] TS 22.261: “Service requirements for the 5G system”

10.2 Application enablement aspects for subscriber-aware northbound API access

990117	**Application enablement aspects for subscriber-aware northbound API access**	**SNAAPP**		SP-220469	**Suzuki, Yuji, NTT DOCOMO**
960012	**Stage 2 of SNAAPP**	SNAAPP	S6	SP-220469	**Suzuki, Yuji, NTT DOCOMO**
960028	*Study on SNAAPP securitY*	FS_SNAAPPY	S3	SP-220526	**Zugenmaier, Alf, NTT DOCOMO,**
990048	**Security aspects of SNAPP**	SNAAPPY	S3	SP-230161	**Zugenmaier, Alf, NTT DOCOMO**

1010002	**CT3 aspects of SNAAPP**	SNAAPP	C3	CP-232128	**Eitoku, Haruka, NTT**
890024	**Subscriber-aware Northbound API access**	SNA	S1	SP-200797	**Minokuchi, Atsushi, NTT DOCOMO**

Summary based on the input provided by NTT DOCOMO, INC. in SP-240337.

3GPP specified the CAPIF(Common API Framework) in Rel-15 to provide a framework for accessing 3GPP northbound APIs. To enhance CAPIF, the "SNAAPP(Application Enablement Aspects for Subscriber-aware Northbound API Access)" work item in Rel-18 specifies the authorization of API invokers when access to protected resources are granted by resource owners (e.g., UE users or an MNO subscribers) and the APIs are invoked. In SA6, it has been defined that 'SNAAPP' should be referred to as 'RNAA (Resource owner-aware Northbound API Access).

The SA1 requirements in TS 22.261 [1] specified to authenticate and authorize 3rd parties and UEs for secure access to APIs and information sharing, to protect the confidentiality of user personal information, and provide network information. Specifically, it should allow the UE to provide/revoke consent for sharing information (e.g., location, presence) with the third-party.

Figure 1 below shows the architectural model for the RNAA which allows the resource owner to provide authorization to the API invocation. This is Figure 6.2.3-1 of TR 23.700-92 [2] in SA6.

CT3 has specified the APIs (e.g., CAPIF_Security API) based on the RNAA scenario and OAuth authorization code grant in TS 29.222 [3].

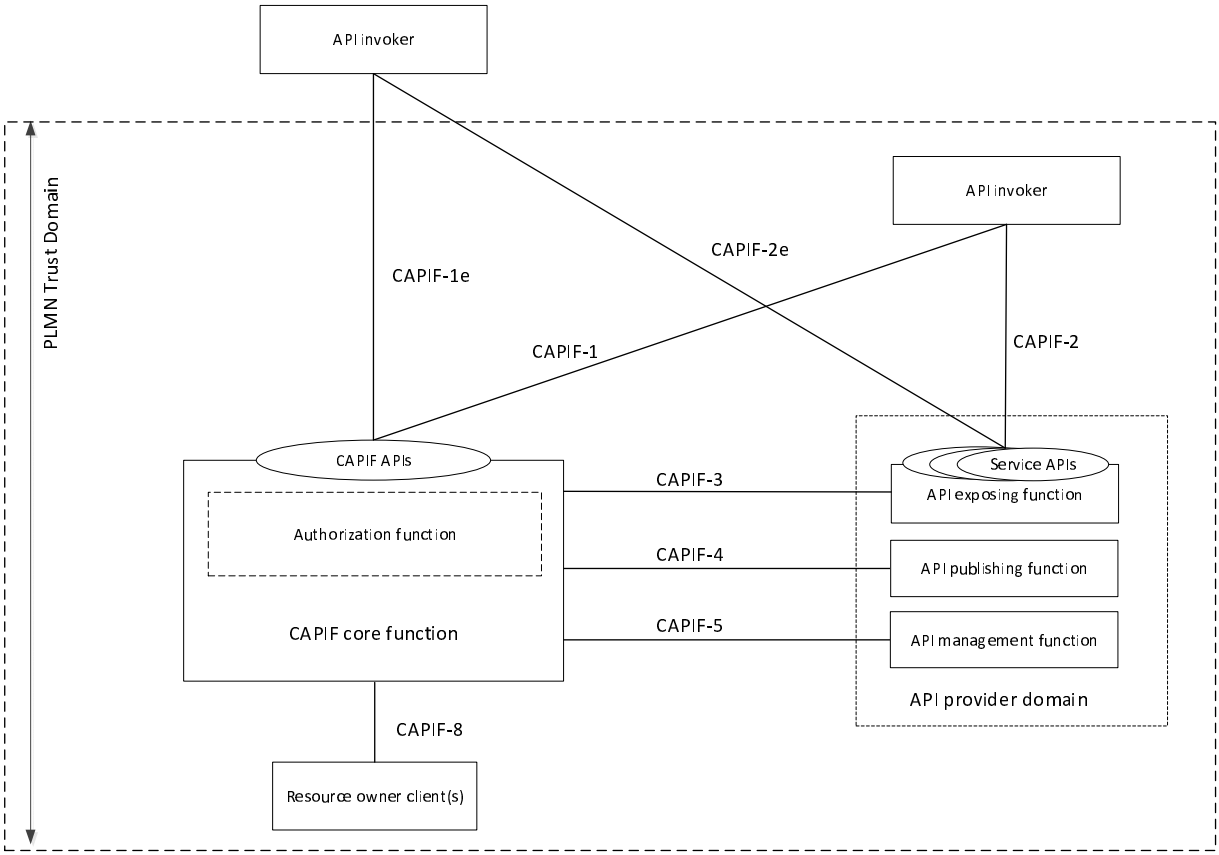

Figure 1: High level functional architecture for CAPIF supporting RNAA

RNAA Security Aspects

SA1 has developed Stage 1 requirements for subscriber-aware northbound API access (TS 22.261 [1]), in clause 6.10.2. A detailed Stage 2 study FS_SNAAPP in (TR 23.700-92 [2]) followed, identifying key issues and solutions for SNA, allowing the CAPIF framework to support northbound API invocations requiring authorization from the resource owner.

SA6 has developed stage 2 normative work for CAPIF (TS 23.222[4]), focusing on security enhancements specified in SNAAPP and supporting normative work in SA6 and CT3. SA6 studied to enhance CAPIF (TS 23.222[4]) to support the “SNAAPP” as the “RNAA”, which enables the authorization of API invokers when the APIs are invoked. Authorization by the resource owner is crucial for API invocations to access protected resources, with a need for dynamic and near real-time authorization.

Based on SA1 requirements and SA6 normative work, SA3 has specified security procedures for RNAA (TR 33.884[5]). The SA3 objectives include enhancing CAPIF with resource owner awareness retaining existing mechanisms without resource owner awareness.

In CT3, based on the normative stage 2 technical specifications of RNAA from SA6 and SA3, the RNAA scenario based on OAuth authorization code grant to CAPIF_Security API has been specified in TS 29.222[6].

RNAA Use cases

3GPP has introduced various northbound APIs exposed to API invokers inside and outside the PLMN trust domain. For example, Service Capability Exposure Function (SCEF) and Network Exposure Function (NEF) expose the 3GPP network capabilities via APIs, and Service Enabler Architecture Layer (SEAL) APIs offer commonly used functionalities among different vertical applications.

The API invoker accesses the resources exposed by 3GPP northbound APIs and some of these resources may directly impact end user's service experience (e.g., modify QoS) or may handle end user specific information (e.g., obtain user location).

Up to Rel-17, if the API is invoked on behalf of the end user, the end user is not aware of the API invocation or does not have any control over which APIs can be executed on their behalf. RNAA aims to protect users against such unintended access to their resources via APIs.

An example use case of RNAA is QoS modification while consuming gaming services. Assume that an end user (also a subscriber of the MNO in this case) is playing a game provided by a game provider and the gaming experience of the end user has to be improved. In such a scenario, two potential use cases are elaborated below.

Use case 1: The application on the UE directly invokes the NEF API to modify the end user's QoS. The end user, acting as an API invoker and a resource owner, authorizes this API invocation with NEF.

Use case 2: The end user triggers the gaming server for enhanced gaming experience. Based on the trigger from gaming application on the end user's UE, the gaming server, which is acting as an API invoker, invokes the NEF API to modify the end user's QoS and the end user authorizes this API invocation with NEF.

In both use cases, the end user, acting as a resource owner, can control whether API invoker can change their QoS before the end user is potentially charged for the high-quality service.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=910036

[1] TS 22.261: “Service requirements for the 5G system”
[2] TR 23.700-92: “Study on enablers for network automation for the 5G System (5GS)”
[3] TS 29.222: “Common API Framework for 3GPP Northbound APIs”
[4] TS 23.222: “Common API Framework for 3GPP Northbound APIs”
[5] TR 33.884: “Study on Security of Application enablement aspects for Subscriber-aware Northbound API access”

10.3 Smart Energy and Infrastructure

920039	**Smart Energy and Infrastructure**	**SEI**		SP-210523	**XIA Xu, China Telecom**
880038	*Study on 5G Smart Energy and Infrastructure*	FS_5GSEI	S1	SP-200574	**XIA Xu, China Telecom**
920032	Stage 1 of Smart Energy and Infrastructure	SEI	S1	SP-210523	**XIA Xu, China Telecom**
940040	*Study on Network and Service Operations for Energy Utilities*	FS_NSOEU	S5	SP-211622	**Erik Guttman, Samsung**

1000014	**Network and Service Operations for Energy Utilities**	NSOEU	S5	SP-230632	**Erik Guttman, Samsung;**
920014	*Study on application enablement aspects for subscriber-aware northbound API access*	FS_SNAAPP	S6	SP-220094	**Suzuki, Yuji, NTT DOCOMO**

Summary based on the input provided by China Telecom in SP-240326 for the service aspects and by Samsung in SP-240380 for OAM aspects.

Service aspects

Smart Grid is a term that refers to enhanced cyber-physical control of electrical grids and to related application. Smart Grid operation can cover power generation, transmission, distribution, and consumption, which can require high communication service availability and communication service reliability, and in some cases a low end-to-end latency with more accurate clock synchronization. 5G system functionalities can be used for Smart Grid control, monitoring, availability assurance, service security, isolation and etc. Communication for cyber-physical control applications supports operation in various vertical domains, for instance industrial automation and energy automation.

The 5G system supports the communication services for cyber-physical control applications in the vertical domains of factories of the future (smart manufacturing), electric power distribution, smart grid, central power generation, and rail-bound mass transit. The associated requirements are described in TS 22.104.

- NSOEU (refer to that feature, specified in TS 28.318)
- GMEC (supports the requirements below) – 22.261 6.26.2.3 monitoring of LAN-VN performance

Based on MNO policy, the 5G network shall provide suitable means to allow an authorised third party to

- monitor changes in QoS policy that pertains to LAN-VN performance;
- configure and receive information regarding the achieved performance for a specific UE;
- configure and receive information regarding the achieved performance for a specific network;
- receive notification of changes in specific configuration aspects of the UE in the VN (e.g., changes in group membership information.)

OAM aspects

Network and Service Operations for Energy Utilities is a feature that exposes management information and capabilities from the 5G system to energy utility operators to achieve higher service availability, and also to enable the exchange of information used to coordinated recovery of energy service outages - of benefit to both energy service and mobile telecommunication service availability.

There is a cross-dependency between the power supply provided to the MNO's network infrastructure by the energy utility, and the telecommunications connectivity service provided to the DSO's network infrastructure by the MNO. Diverse applications are used to operate and manage energy systems. These applications require very high communication service availability. High availability of the energy system directly benefits the availability of the 5G system.

Network Services and Operations for Energy Utilities exposes specific capabilities that allow an energy utility operator to obtain information from a mobile network operator's network, to monitor network performance of cells. This information enables the energy utility operator to identify performance trends that could motivate use of a 'back up communication service' and thereby achieve greater availability for smart energy services.

A further capability introduced by this feature is to enable the energy utility operator and mobile network operator to share information with each other concerning where the energy utility operator supplies energy to the mobile network. This allows coordination of recovery from energy system outages. The energy utility operator can share information concerning when and where outages will occur (when planned) and when recovery is expected (for both planned and unplanned energy outages.) The mobile network operator can expose the autonomous power supply capacity of their sites, e.g. Uninterruptable Power Supply, to the energy utility operator. This enables better planning for energy system recovery, so as to avoid interruption of service at mobile network sites. This can increase the availability of the 5G system.

The following illustrates a use case supported by TS 28.318 [2].

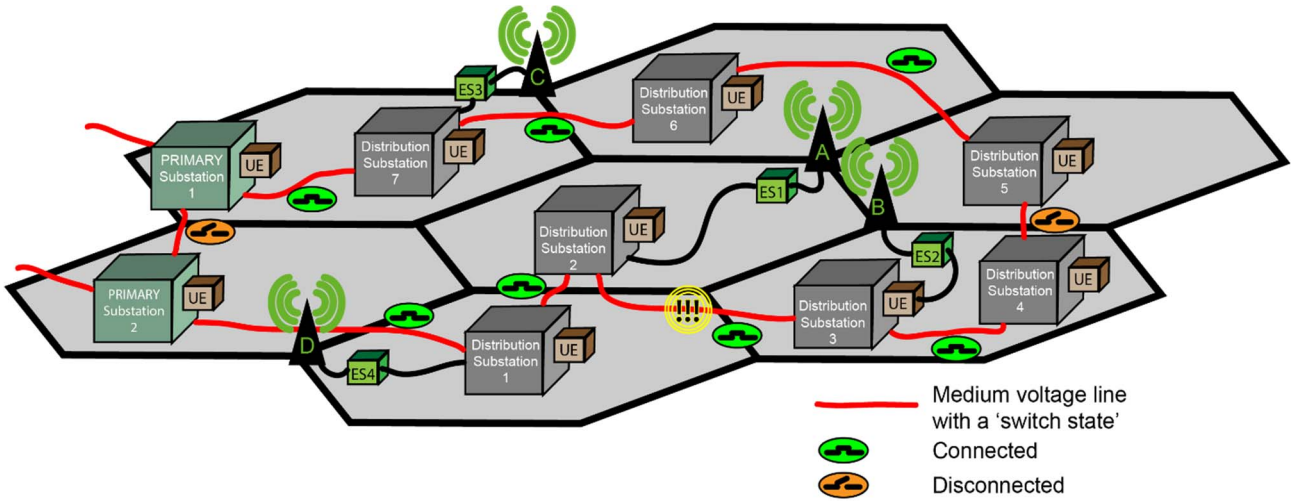

Figure 1: Local failure event

The figure above shows a redundant energy distribution topology between Distribution Substations. Each receives energy through a connection to a Primary Substation, shown on the left. When one of the feeder lines is disconnected, the topology can be adjusted so all secondary substations receive energy supply. Effectively, the switch between Distribution Substation 5 and 6 (on the right) can be closed. This action, if it can be remote controlled, can be accomplished in a matter of minutes. However, in order to support remote control of this action through smart energy services, telecommunication service is required. The disconnection of Distribution Substation 2 and 3 means that Distribution Substation 3 has no ability to supply energy to 'B' (the site providing service to the cell in which Distribution Substation 3 and 4 are located.) The operation to restore the topology has to occur before site 'B' exhausts its autonomous energy supply.

The functionality defined for this feature was studied in TR 28.829 [5] and specified in TS 28.318 [6], including stage 1, 2 and 3 aspects.

Network and Service Operations for Energy Utilities satisfies the stage 1 requirements defined in 22.261 [4], clause 6.23.2:
The 5G system shall provide a means by which an MNO informs a third party of network events (failure of network infrastructure affecting UEs in a particular area, etc.).

Based on MNO policy, the 5G system shall provide a mechanism to automatically report service degradations, communications loss, and sustained connection loss in a specific geographic area (e.g., a cell sector, a cell or a group of cells) to a third party.

NOTE 3: These reports use a standard format. The specific values, thresholds, and conditions upon which alarms occur can include the measured values for end-to-end latency, service bit rate, communication service availability, end-to-end latency jitter, etc. for a UE, the UE's location, and the time(s) during which the degradation occurred.

and 22.104 [1], all of clause 8, Recovery of infrastructure for electrical distribution.

Some aspects required to support the functionality above are not specified in this release. In TS 28.318, Annex D a list of unspecified aspects, including configuration, are provided. These will require implementation specific support.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920039,920032,1000014

[1] TS 22.104: "Service requirements for cyber-physical control applications in vertical domains".
[2] TS 22.261: "Service requirements for 5G system: Stage 1".
[3] TS 28.318: "Management and Orchestration; Network and services operations for energy utilities".
[4] TS 22.261: "Service requirements for 5G system: Stage 1".
[5] TR 28.829: " Study on network and service operations for energy utilities".
[6] TS 28.318: "Management and Orchestration; Network and services operations for energy utilities".

10.4 Generic group management, exposure and communication enhancements

990109	**Generic group management, exposure and communication enhancements**	**GMEC**		SP-221339	**Qianghua Zhu, Huawei**
940061	*Study on generic group management, exposure and communication enhancements*	FS_GMEC	S2	SP-211603	**Qianghua Zhu, Huawei**
970069	**Stage 2 of GMEC**	GMEC	S2	SP-230101	**Qianghua Zhu, Huawei**
990009	CT3 aspects of GMEC	GMEC	C3	CP-232135	**El Moatamid, Abdessamad, Huawei**
990071	CT4 aspects of GMEC	GMEC	C4	CP-232135	**El Moatamid, Abdessamad, Huawei**
990072	CT1 aspects of GMEC	GMEC	C1	CP-232135	**El Moatamid, Abdessamad, Huawei**

Summary based on the input provided by Samsung in SP-241297.

The GMEC enables group management, exposure and communication enhancements for a group of UEs (e.g., 5G VN group and a group configured by OA&M). For group management and exposure, the GMEC allows the AF to exchange the information about vertical domain with 5GS to fulfil certain goals. The information for a group of UEs now contains service area, default QoS, group status event for group member list changes, traffic characteristics and performance characteristics. Addition to 5G VN group, it can further contain indication that the 5G VN group is associated with 5G VN group communication, Maximum Group Data Rate. For group communication enhancements, the GMEC allows multiple serving SMFs (SMF instances in single SMF Set or different SMF Sets) for a 5G VN group to support wide area 5G VN group communication, and allows the UE to simultaneously send data to different groups with different QoS policy.

The GMEC specification includes:
- the support of provisioning and enforcement of service area, default QoS applicable to each UE within the group
- the support of group status event reporting on group member list changes
- the support of provisioning of traffic characteristics and monitoring of performance characteristics (e.g., 5G QoS parameters, change of the PDU Session Type, temporal invalidity condition)
- the support of UE to simultaneously send data to different groups with different QoS policy
- Specific enhancements for 5G VN group: the support of provisioning and enforcement of the indication that the 5G VN group is associated with 5G VN group communication, the support of provisioning and enforcement of the Maximum Group Data Rate for a 5G VN group, and the support of Multiple SMFs (a single SMF Set or different SMF Sets) for a 5G VN group to enable wide area 5G VN group communication

3GPP has specified many enablers for vertical use, for example the features defined by IIOT, NPN and URLLC. Among them, Rel-16's 5G LAN-type service offers private communication using IP and/or non-IP type communications for UE and devices behind UE, using an optimized communication path controlled by a single SMF. However, the number of SMF per 5G VN is limited to one in Rel-16, even if the 5G VN is very large. Multiple SMFs should be supported, for instance for administrative domains or a large multi-site company or a large-scale industrial setting that spans multiple countries. And at the same time, the SMFs need to support single/common 5G VN wide area.

In Rel-18, SA1 study on 5G Smart Energy and Infrastructure "5SEI" has concluded new requirement (clause 6.13.2, 6.28 of TS 22.261 and clause 5.2, 5.6 and 9 of TS 22.104) including that the 5G system shall allow a UE to request a communication service to send data to different groups of UEs at the same time and the 5G system shall allow different QoS policy for each group the UE communicates with.

The 5G Alliance for Connected Industries and Automation (5G-ACIA) has provided to 3GPP a whitepaper (S2-2102128) including a set of functional requirements that the 5GS has to satisfy in terms of supporting certain information exchange between 5GC and industrial application domain, and exposure of 5G capabilities. The main goal is to enable the management, operation, monitoring and use of such networks and network services from an enterprise perspective easily without having to rely on sophisticated, heavy-weight tools and in-depth knowledge on the underlying 5G technology. Some requirements regarding device management, e.g., connectivity management, connectivity monitoring, group management etc. have not yet been fulfilled and need further studies.

The GMEC enables the group management, exposure and communication enhancements for a group of UEs (e.g., 5G VN group and a group configured by OA&M).

1) Enhance group attribute management for groups created by an AF using the 5G VN API as well as groups other than 5G VN groups configured by O&M as in clause 5.6.5a, 5.20b and 5.29.2 of TS 23.501, clause 4.15.6.2, 4.15.6.3b and 4.15.6.3e of TS 23.502, clause 6.1.5 and 6.2.1.11 of TS 23.503, including the support of:

- provisioning of service area applicable to each UE within the group (clause 5.20b of TS 23.501, clause 4.15.6.2 and 4.15.6.3e of TS 23.502)
- LADN per DNN and S-NSSAI for enforcement of service area applicable to each UE within the group (clause 5.6.5a and 5.20b of TS 23.501)
- provisioning and enforcement of default QoS applicable to each UE within the group (clause 5.20b of TS 23.501, clause 4.15.6.2 and 4.15.6.3e of TS 23.502)
- AF indication that the group is associated with 5G VN group communication (clause 5.29.2 of TS 23.501, clause 4.15.6.2 and 4.15.6.3b of TS 23.502)
- Maximum Group Data Rate for a 5G VN group using Slice-MBR (clause 5.29.2 of TS 23.501, clause 4.15.6.2 and 4.15.6.3b of TS 23.502, clause 6.1.5 and 6.2.1.11 of TS 23.503)

2) Enhance group status event reporting on group member list changes for groups created by an AF using the 5G VN API as well as groups other than 5G VN groups configured by O&M as in clause 5.20 of TS 23.501, clause 4.15.3.2.3c of TS 23.502.

3) NEF exposure framework for provisioning of traffic characteristics and monitoring of performance characteristics for a UE or a group of UEs as in clause 5.20c of TS 23.501, clause 4.15.6.10 and 4.15.6.14 of TS 23.502, and clause 6.1.3.28 of TS 23.503, including:
- support mapping the request targeting a group to requests targeting each group member within the group, and further handling request for traffic characteristics and performance characteristics based on 5G QoS parameters for both TSCTSF case and non-TSCTSF case (clause 5.20c of TS 23.501, clause 4.15.6.14 of TS 23.502, and clause 6.1.3.28 of TS 23.503)
- handle AF-requested change of PDU Session Type associated with a group of UEs (clause 4.15.6.10 of TS 23.502)
- manage temporal invalidity condition (clause 5.20c of TS 23.501, and clause 6.1.3.28 of TS 23.503)

4) Support Multiple SMFs for VN group communication (clause 5.29.2 and 5.29.3 of TS 23.501):
- multiple SMFs serving a same 5G VN group can belong to a single SMF Set or different SMF Sets:
  - associations between one or more SMF Sets and the DNN, S-NSSAI of the associated 5G VN group is registered and discovered in NRF per existing mechanisms
  - service area of the 5G VN group in KI#1 can span across multiple SMFs
- For UPFs served by a single SMF Set:
  - N19-based forwarding, N6-based forwarding and local switch can be used, implementation dependent mechanism can be used for the SMF set or SMF instances in SMF set to support functionality for 5G VN group communications across SMFs
- For UPFs controlled by different SMF Sets:
  - Static connectivity (configured via OA&M) between PSA UPFs controlled by different SMF sets can be used, and how to implement the static connectivity is up to network operator.

5) Allowing UE to simultaneously send data to different groups with different QoS policy as in Annex O of TS 23.501.
- use different QoS Flows of single PDU Session to transfer the data copy sent to different groups (Annex O.1 of TS 23.501)
- use different PDU Sessions to transfer the data copy sent to different groups (Annex O.2 of TS 23.501)
- or, associate each group and group combination with separate multicast address to allow application to send data to different groups using the multicast address associated with the group(s) it wants to target, and support provisioning of QoS applicable to service flow corresponding to a multicast address for each group member within the group (Annex O.3 of TS 23.501)

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990109,940061,970069,990009,990071,990072

[1] TR 23.700-74: “Study on generic group management, exposure and communication enhancements (GMEC)”
[2] TS 23.501: "System architecture for the 5G System (5GS)"
[3] TS 23.502: "Procedures for the 5G System; Stage 2".
[4] TS 23.203: "Policies and Charging control architecture; Stage 2".

10.5 Service Enabler Architecture Layer for Verticals Phase 3

980131	**Service Enabler Architecture Layer for Verticals Phase 3**	**SEAL_Ph3**		SP-211518	**Basavaraj (Basu) Pattan, Samsung**

940024	**Stage 2 of SEAL_Ph3**	**SEAL_Ph3**	**S6**	SP-230276	**Basavaraj (Basu) Pattan, Samsung**
980064	CT1 aspects of SEAL_Ph3	SEAL_Ph3	C1	CP-232170	**Vijay Sangameshwara (Samsung Electronics)**
980065	CT3 aspects of SEAL_Ph3	SEAL_Ph3	C3	CP-232170	**Vijay Sangameshwara (Samsung Electronics)**
990047	Security aspects of SEAL_Ph3	SEAL_Ph3	S3	SP-230365	**Rajavelsamy Rajadurai, Samsung**

Summary based on the input provided by Samsung in SP-241297.

A set of common capabilities have been specified by 3GPP, like Group Management, Configuration Management, Key Management, Identity Management, Location Management and Network Resource Management. These capabilities are utilized by V2X applications and potential usage by multiple vertical industry applications known as service enabler architecture layer (SEAL) in Rel-16 TS 23.434 [1]. Security aspects for SEAL are specified in TS 33.434 [2], and Stage 3 aspects for SEAL are specified in TS 24.544 [3], TS 24.545 [4], TS 24.546 [5], TS 24.547 [6], TS 24.548 [7] and TS 29.549 [8]. Rel-16 summary is available in clause 9.4 of TR 21.916 [17].

In Rel-17, enhancements are made to all common services of the SEAL, defined Light Weight Protocol (LWP) for constrained devices and a new service called Network Slice Capability Enablement (NSCE) is defined in TS 24.549 [10]. Rel-17 summary is available in clause 6.2.1.1 of TR 21.917 [18].

In Rel-18, new SEAL service Notification Management and other enhancements to the existing SEAL services are specified in TS 23.434 [2] and related stage 3 aspects are specified in TS 24.544 [3], TS 24.545 [4], TS 24.547 [6], TS 24.548 [7], TS 23.435 [9], TS 24.549 [10] and TS 24.542 [11]. Additionally new SEAL services Application Data Analytics Enablement and Data Delivery are specified in TS 23.436 [12] and TS 23.433 [14] respectively and related Stage 3 aspects are specified in TS 23.559 [13], TS 29.548 [16] and TS 24.543 [15].

In Rel-18, the following enhancements are made:

1) New SEAL service called Notification Management is defined which enables the VAL (Vertical Application Layer) applications in the VAL UE to subscribe and receive notification messages from their VAL Server. Procedures and information flows are defined for creation of notification channel, receiving notifications from the notification management server and deletion of notification channel.

2) The "Network resource management" service is enhanced to introduce the MBS services in 5G, by defining the SIP and HTTP based MBS procedures like MBS announcement, MBS de-announcement, MBS listening status, MBS UE join notification, Application coordinated UE-to-UE communication requirements management etc.

3) The "Group management" service is enhanced to address the group deletion procedure and minor enhancements.

4) The "Location Management" service is enhanced to address the location client initiated trigger deletion procedure, VAL service area support, fused location and minor enhancements. When the VAL service area configurations in place the VAL server may use the VAL service area ID as part of the location information in the SEAL APIs requiring location information. With the fused location function, the location management server, may use the location information from multiple sources to determine a more accurate UE location.

5) Service-based interface representation of the functional model for SEAL services.

6) Identity management capability is enhanced to support VAL server provisioning through which the VAL servers can provide configuration information to the identity management server.

7) The “Network Slice Capability Exposure for Application Layer Enablement” service is enhanced to support additional capabilities. More details of NSCALE features can be found under WI UID # 960013.

8) New SEAL service called Data Delivery is defined which eases the application content and delivery for vertical applications and also provides storage capabilities to vertical applications. More details of SEAL DD features can be found under WI UID # 970037.

9) New SEAL service called Application Data Analytics Enablement is defined offering value-add application data analytics capabilities which cover stats/predictions for the end-to-end application service. More details of ADAE features can be found under WI UID # 970036.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980131,940024,980064,980065,990047

[1] TS 23.434: "Service Enabler Architecture Layer for Verticals; Functional architecture and information flows".
[2] TS 33.434: "Security aspects of Service Enabler Architecture Layer (SEAL) for verticals".
[3] TS 24.544: "Group Management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification".
[4] TS 24.545: "Location Management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification".
[5] TS 24.546: "Configuration management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification".
[6] TS 24.547: "Identity management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification".
[7] TS 24.548: "Network Resource Management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification".
[8] TS 29.549: "Service Enabler Architecture Layer for Verticals (SEAL); Application Programming Interface (API) specification".
[9] TS 23.435: "Procedures for Network Slice Capability Exposure for Application Layer Enablement Service"
[10] TS 24.549: "Network slice capability enablement- Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification; Stage 3".
[11] TS 24.542: "Notification management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol specification".
[12] TS 23.436: "Functional architecture and information flows for Application Data Analytics Enablement Service".
[13] TS 24.559: "Application Data Analytics Enablement Service (ADAES); Stage 3".
[14] TS 23.433: "Service Enabler Architecture Layer for Verticals (SEAL); Data Delivery enabler for vertical applications".
[15] TS 24.543: "Data delivery management - Service Enabler Architecture Layer for Verticals (SEAL); Protocol Specification".
[16] TS 29.548: "Service Enabler Architecture Layer for Verticals (SEAL); SEAL Data Delivery (SEALDD) Server Services; Stage 3".
[17] TR 21.916: "Release 16 Description; Summary of Rel-16 Work Items"
[18] TR 21.917: "Release 17 Description; Summary of Rel-17 Work Items"

10.6 SEAL data delivery enabler for vertical applications

980124	**SEAL data delivery enabler for vertical applications**	**SEALDD**		SP-220914	**Niranth Amogh, Huawei Telecommunications India**
930013	*Study on SEAL data delivery enabler for vertical applications*	FS_SEALDD	S6	SP-220467	**Niranth Amogh, Huawei Telecommunications India**
970037	**(Stage 2 of Seal DD) SEAL data delivery enabler for vertical applications**	**SEALDD**	**S6**	SP-221232	**Niranth Amogh, Huawei Telecommunications India**
980066	CT1 aspects of SEALDD	SEALDD	C1	CP-231284	**Herrero Veron, Christian (Huawei)**
980067	CT3 aspects of SEALDD	SEALDD	C3	CP-231284	**Herrero Veron, Christian (Huawei)**
1000006	Security aspects of SEAL Data Delivery enabler	SEALDD	S3	SP-230560	**Ao Lei, Huawei**

Summary based on the input provided by Huawei in SP-241342 for the general aspects and in in SP-240884 for the security aspects.

This feature specifies the Service Enabler Architecture Layer for Verticals Data Delivery (SEALDD) enabler to provide the application data distribution and delivery over 3GPP network, which enables the vertical application to use the mobile network (e.g. 5G network) feature to optimize the data transmission. The SEALDD architecture and procedures is specified in TS 23.433 [1], and the SEALDD is part of the SEAL services specified in TS 23.434 [2].

The application layer architecture of SEALDD is introduced as shown in figure 1.

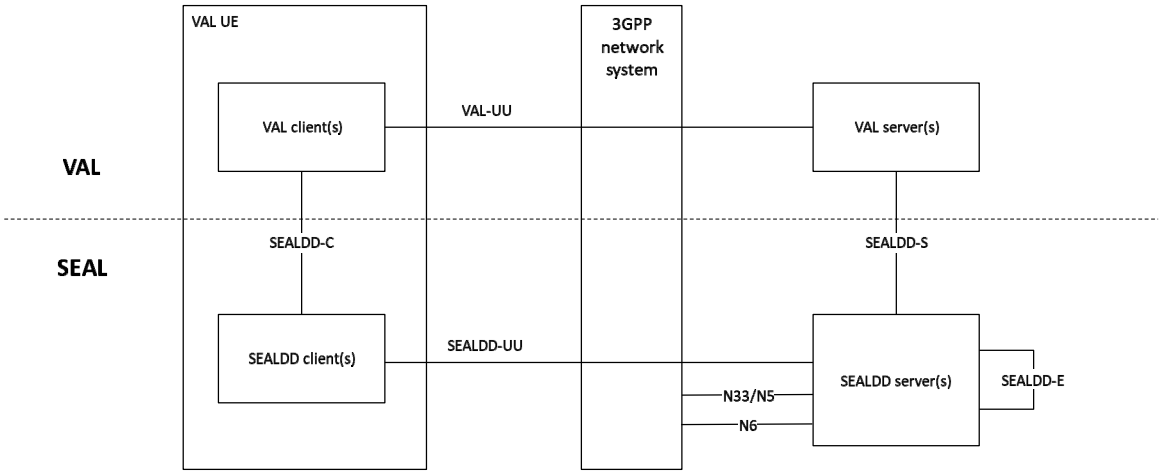

Figure 1: The application layer architecture of SEALDD

The SEALDD server can communicate with the control plane of 3GPP core network via N33/N5 interface with the SEALDD control plane functionality, and can support the user plane interaction with 3GPP core network via N6 interface. The SEALDD server can provide the 5G network enabled transmission optimization and expose the related service APIs (e.g. regular transmission, URLLC transmission) to vertical applications by reusing CAPIF framework. The applictaion data originated from vertical applications can be transmitted by using the SEALDD layer via SEALDD-UU interface.

In relase 18, the SEALDD layer provides the following features:

a) E2E URLLC transmission enablement to provide the reliable transmission, by supporting the redundant transmission session establishment, packet duplication, and packet elimination.
b) Service continuity optimization for edge deployment by managing and interacting the transport layer context
c) E2E transmission quality measurement and exposure, including the transmission delay, packet loss rate, etc.
d) Transmision quality optimization and guarantee, such as URLLC transmission triggering, SEALDD server switching
e) IoT message transmission support by utlizing MSGin5G functionalities
f) Application data storage and management to support the vertical application data stores, update, deletes, etc.

Security aspects

The SEALDD enabler is specified in TS 23.433 [3] as one of the functionalities of SEAL services specified in TS 23.434 [4]. The intention of SEALDD is to offer a data delivery enabler to satisfy diverse application content distribution and delivery requirements from various vertical applications using 3GPP systems, including functionalities of connection management, E2E redundant transmission, data storage, data transmission quality measurement, etc.

Based on the functionalities of SEALDD services as specified in TS 23.433 [3], this work item delivered security features of SEALDD.

Using existing SEAL security mechanisms in TS 33.434 [5] as cornerstone, the security of SEALDD covers the following SEALDD scenarios:

- Security aspects for End-to-End data transmission in SEALDD.
- the authentication and authorisation for SEALDD functionalities.

The above security features have been specified in TS 33.434 [5].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990109,940061,970069,990009,990071,990072,1000006

[1] TS 23.433: "Service Enabler Architecture Layer for Verticals (SEAL); Data Delivery enabler for vertical applications, stage 2"
[2] TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows, stage 2"

[3] TS 23.433: "Service Enabler Architecture Layer for Verticals (SEAL); Data Delivery enabler for vertical applications"
[4] TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows"
[5] TS 33.434: "Security aspects of Service Enabler Architecture Layer (SEAL) for verticals"

10.7 Rel-18 Enhancements of 3GPP Northbound and Application Layer interfaces and APIs

960022	**Rel-18 Enhancements of 3GPP Northbound and Application Layer interfaces and APIs**	**NBI18**		CP-231190	**Abdessamad El Moatamid, Huawei**
960053	CT1 aspects of NBI18	NBI18	C1	CP-231190	**Abdessamad El Moatamid, Huawei**
960054	CT3 aspects of NBI18	NBI18	C3	CP-231190	**Abdessamad El Moatamid, Huawei**

Summary based on the input provided by Huawei in CP-241275.

The 3GPP Northbound Interfaces and APIs are specified in 3GPP in order to enable external entities and third-party Application Servers/Functions to access a set of exposed 3GPP network services and capabilities in a secure and controlled manner (via the SCEF/NEF).

The 3GPP application layer APIs are defined by 3GPP so as to allow the support of various applications/services (e.g., CAPIF, V2X, UAS, EDGE, SEAL, MSGin5G, etc.) over 3GPP networks and ensure the efficient use and deployment of these applications/services over 3GPP systems via an optimized application layer framework.

3GPP northbound interfaces/APIs as well as application layer APIs, which are accessed by various external entities including third party Application Servers/Functions, should be continuously maintained and optimized.

Therefore, the main work carried out was to introduce pure stage 3 (i.e., there are no related stage 1 nor stage 2 requirements) technical improvements and enhancements, i.e., improvement of the overall efficiency, reliability and flexibility, enhancement of the signalling efficiency, consolidation of the common protocol aspects, alignment with the 5GC service based principles and guidelines when relevant, corrections/changes missed in the previous 3GPP Releases, etc., especially that such enhancements may not be covered by the other more dedicated and functionality-driven work items.

A new TS template/skeleton for technical specifications documenting 3GPP northbound interfaces/APIs as well as application layer APIs was also established and used under this work item.

References

List of related CRs:select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960022,960053,960054

[1] TS 29.122: "T8 reference point for Northbound APIs"
[2] TS 29.222: "Common API Framework for 3GPP Northbound APIs"
[3] TS 29.255: "Uncrewed Aerial System Service Supplier (USS) Services; Stage 3"
[4] TS 29.257: "Application layer support for Uncrewed Aerial System (UAS); UAS Application Enabler (UAE) Server Services; Stage 3"
[5] TS 29.343: "Proximity-services (ProSe) function to ProSe application server aspects (PC2); Stage 3"
[6] TS 29.486: "V2X Application Enabler (VAE) Services; Stage 3"
[7] TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3"
[8] TS 29.538: "Enabling MSGin5G Service; Application Programming Interfaces (API) specification; Stage 3"
[9] TS 29.549: "Service Enabler Architecture Layer for Verticals (SEAL); Application Programming Interface (API) specification; Stage 3"
[10] TS 29.558: "Enabling Edge Applications; Application Programming Interface (API) specification; Stage 3"
[11] TS 24.558: "Enabling Edge Applications; Protocol specification"

10.8 Charging Aspects of B2B

Moved to 29.2 by the pCR in SP-241858.

10.9 NRF API enhancements to avoid signalling and storing of redundant data

960002	*Study on NRF API enhancements to avoid signalling and storing of redundant data*	FS_NRFe	C4	CP-231022	**Wiehe, Ulrich, Nokia**
1020001	**NRF API enhancements to avoid signalling and storing of redundant data**	NRFe	C4	CP-233025	**Wiehe, Ulrich, Nokia**

Summary based on the input provided by Nokia in CP-240303.

This work item introduces enhancements to the NRF APIs in order to avoid signalling and storing of redundant data.

The following enhancements have been implemented in TS 29.504 [1], 29.510 [2] and 29.571 [3]:

- Optional and backwards compatible extension to the Nnrf_NFManagement service, allowing NRF consumers to register NF profiles containing shared data IDs.
- Optional and backwards compatible extensions to the Nnrf_NFDiscovery service, allowing NRF consumers to discover NF providers having registered profiles containing shared data IDs.
- Optional and backwards compatible extension to the Nnrf_NFManagement service, allowing NRF consumers to retrieve shared data from the NRF, and to subscribe, unsubscribe and get notified for shared data change notifications.
- For service discovery between VPLMN and HPLMN reduced information based on operator policy may be conveyed.
- Extensions to the Nudr_GroupIDmap service allowing UDR consumers (NRF) to request mapping from RID to NF Group ID.

All these enhancements are pure Stage 3 subjects, i.e. not requiring any Stage 1 or Stage 2 specification.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1020001

[1] TS 29.504 : “5G System; Unified Data Repository Services; Stage 3”
[2] TS 29.510 : “5G System; Network function repository services; Stage 3”
[3] TS 29.571 : “5G System; Common Data Types for Service Based Interfaces; Stage 3”
[4] TR 29.831: "Study on NRF API enhancements to avoid signalling and storing of redundant data"

10.10 GBA_U Based APIs

1000003	GBA_U Based APIs	GBA_U_APIs	C6	CP-231353	**Huo Weijing(China Mobile)**
960004	*Study on GBA_U Based APIs*	FS_GBA_U_API	C6	CP-221185	**Huo Weijing, China Mobile**

Summary based on the input provided by China Mobile in CP-241268.

This WI specifies GBA_U_APIs based on Ks_int_NAF which is derived from the Long Term Key of ISIM/USIM applications on the UICC

The prior study on GBA_U Based APIs” proved the feasibility of GBA_U Based APIs with candidate solutions [1]. “GBA_U Based APIs” [2] [3] [4]specifies the methods of GBA_U_APIs and the Access Control scheme to GBA_U Based APIs.

GBA_U Based APIs include 2 classes: GBAUCipher and GBAUSignature.The GBAUCipher class is the abstract base class for Cipher algorithms.The GBAUSignature class is the base class for Signature algorithms. Ks_int_NAF keys, internal keys generated during GBA_U process (see TS 31.102 and TS 33.220), are the only ones used in this class. Those keys are 256 bits symmetric keys then all asymmetric key algorithms are not supported.

There difines an Access Control scheme, when an applet is authorized to use the Ks_int_NAF, the NAF_ID associated to the applet should be included in EFAC_GBAUAPI as defined in USIM or ISIM.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000003

[1] TR 31.822: “Study on GBA_U Based APIs”.
[2] TS 31.102: "Characteristics of the Universal Subscriber Identity Module (USIM) application".
[3] TS 31.103: "Characteristics of the IP Multimedia Services Identity Module (ISIM) application".
[4] TS 31.130: "(U)SIM Application Programming Interface (API); (U)SIM API for Java™ Card".

10.11 Application layer support for Factories of the Future (FF)

820025	Study on application layer support for Factories of the Future in 5G network	FS_FFAPP	S6	SP-200836	Shao Weixiang, ZTE Corporation
930015	**Application layer support for Factories of the Future (FF)**	FFAPP	S6	SP-230751	**Shao Weixiang, ZTE Corporation**

Summary based on the input provided by ZTE in SP-241080.

The application layer support capabilities, illustrated by some solutions, can be utilized by the Factories of the Future (FF) application layer resident on UE(s) (e.g. AGV, robot) or on network (e.g. factory automation system) which enhances the interaction with the 3GPP system(s) mainly considering 3GPP system services enabled towards Factories of the Future.

As part of Rel-18, the overall application layer architecture to enable application support for FF applications over 3GPP networks was utilizing features in SEAL, specified in TS 23.434 [1].

The study and its conclusions can be found in TS 23.745 [2].

The following Factories of the Future (FF) application layer support functions are introduced, the related procedures and information flows are supported in SEAL specified in TS 23.434 [1]:

- Enhancements related to geographic location and positioning information support
- Enhancements for TSC services
- Establishing communication with FF application service requirements

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930015

[1] TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows, stage 2"
[2] TR 23.745: "Study on application layer support for Factories of the Future in 5G network"

10.12 Service exposure interfaces for industry

930023	**Service exposure interfaces for industry**	EXPOSE	S1	SP-211056	**Joachim W. Walewski**

Summary based on the input provided by Siemens in SP-241161.

This work item introduced new normative requirements in TS 22.261 [1] for combined and event-based QoS monitoring and exposure of position-related data, together with the accuracy of its position.

The new normative requirements for enhancing QoS monitoring, and the exposure of UE position information are based on the 5G-ACIA whitepaper “Exposure of 5G Capabilities for Connected Industries and Automation Applications” [2]. The work item addressed the outcome of the gap analysis in the whitepaper.

QoS Monitoring requirements are extended with:

- Combined QoS monitoring for a group of UEs, where the monitoring results for several UEs are reported together;
- Event-based monitoring, where the triggering event is, for example, a position change of the pertinent UE.

The exposure of position-related data of a UE is required to provide also the accuracy of this position information.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930023

[1] TS 22.261: “Service requirements for the 5G system”
[2] “Exposure of 5G Capabilities for Connected Industries and Automation Applications”, 5G-ACIA whitepaper, https://5g-acia.org/whitepapers/exposure-of-5g-capabilities-for-connected-industries-and-automation-applications-2/

11 Artificial Intelligence (AI)/Machine Learning (ML)

11.1 AI/ML model transfer in 5GS

920037	**AI/ML model transfer in 5GS**	**AIML_MT**		SP-210520	**Jia SHEN, OPPO, sj@oppo.com**
860009	*Study on traffic characteristics and performance requirements for AI/ML model transfer in 5GS*	FS_AIML_MT	S1	SP-220441	**Jia SHEN, Oppo .**
920030	Stage 1 of AMMT	AIML_MT	S1	SP-220440	**Jia SHEN, OPPO, sj@oppo.com**
940084	*Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface*	FS_NR_AIML_air	R1	RP-221348	**Juan Montojo Qualcomm**
989997	**Artificial Intelligence (AI)/Machine Learning (ML)**	**AIMLsys**		SP-221329	**Alla Goldner, OPPO**
960037	*Study on Security and Privacy of AI/ML-based Services and Applications in 5G*	FS_AIML	S3	SP-220687	**Marcus Wong, OPPO**
940071	*Study on 5G System Support for AI/ML-based Services*	FS_AIMLsys	S2	SP-220071	**Alla Goldner, OPPO**
980019	**(Stage 2 for AIML) System Support for AI/ML-based Services**	AIMLsys	S2	SP-230095	**Alla Goldner, OPPO**
990008	CT3 aspects of AIML	AIMLsys	C3	CP-230329	**Tangudu, Narendranath Durga, Samsung**
990074	CT4 aspects of AIML	AIMLsys	C4	CP-230329	**Tangudu, Narendranath Durga, Samsung**

Summary based on the input provided by Oppo in SP-240206.

The AMMT study (AI/ML Model Transfer) in stage-1 relates to how the 5GS supports the transmissions of AI/ML-based services over the application layer. The study addresses use cases and potential performance requirements for 5G system support of application layer Artificial Intelligence (AI)/Machine Learning (ML) model distribution and transfer (download, upload, updates, etc.), and identifies traffic characteristics of AI/ML model distribution, transfer and training for various applications, e.g. video/speech recognition, robot control, automotive, other verticals. Many of these requirements need 5GS transport solutions to support device-based application AI/ML training or inference services. Hence, 5GS is evolved to provide intelligent transmission support for application AI/ML-based services.

The outputs of the corresponding stage-2 study phase FS_AIMLsys are documented in the TR 23.700-80 [1].

The Feature enhances the following aspects:
- Monitoring of network resource utilization to support the Application AI/ML operations
- Exposure of 5GC information to authorized 3rd party for Application AI/ML operations
- Enhancement of external parameter provisioning in 5GC to assist the Application AI/ML operations
- Enhancement in 5GC to enable Application AI/ML traffic transport
- Enhancement of QoS and Policy control to support Application AI/ML data transport over 5GS
- 5GS assistance to federated learning operation

by introducing the following set of capabilities:

Planned Data Transfer with QoS: Planned Data Transfer with QoS is used to enable the AF to negotiate viable time window for the planned AI/ML operation e.g. application data transfer with specific QoS requirements and operational conditions via the support of the NEF as described in the TS 23.503 [4] and in the TS 23.502 [3]. The PDTQ policies are defined for a specific ASP and each PDTQ policy includes a recommended time window for the traffic transfer for

each of the AF sessions involved. The AF will select one of the PDTQ policy and inform the PCF about the selected PDTQ policy which will then be stored in the UDR. The PCF may, upon a request from AF/NEF for negotiation for Planned Data Transfer with QoS requirements (PDTQ), subscribe to the network analytics related to "Network Performance" or "DN Performance" from the NWDAF to assist in determination of PDTQ policies as described in the TS 23.288 [5]. Prior to the start of the selected time window for the planned data transfer, the AF requests the PCF to set up the AF session with required QoS. The PCF then determines the appropriate PCC rules according to the AF request.

Enhanced external parameter provisioning: An AF hosting an AI/ML based application may provision the Expected UE Behaviour parameters and/or the Application-Specific Expected UE Behaviour parameter(s) captured in TS 23.502 [3] to the 5GC enhanced corresponding confidence and/or accuracy levels, where confidence level indicates a probability assertion for the associated parameter and accuracy level indicates the performance of the estimator (e.g. AI/ML model) used for the prediction. In addition, a threshold for those confidence/accuracy levels may also be provided to the UDM by the NF (e.g. AMF or SMF) subscribing to such externally provisioned parameters as described in 23.502 [3].

Member UE selection assistance functionality for application operation: 5G System may support Member UE selection assistance functionality to assist the AF to select member UE(s) that can be used in application operations such as AI/ML based applications (e.g. Federated Learning) according to the AF's request including a list of target member UEs and a set of filtering criteria. The Member UE selection assistance functionality is hosted by NEF and a new NEF service allows the AF to request such assistance from the 5GC. See TS 23.501 [2] for the detailed member UE selection requirements and TS 23.502 [3] for the details of Member UE selection procedures.

Multi-member AF session with required QoS: Support of Multi-member AF session with required QoS for a set of UEs identified by a list of UE addresses. The NEF receives the request for a Multi-member AF session with required QoS for a set of UEs identified by their addresses. The NEF then maps the request for Multi-member AF session with required QoS to individual requests for AF session with required QoS (i.e., one request for individual AF session with required QoS per UE address) and interacts with each of the UE's serving PCFs on a per AF session basis. The NEF receives the outcome of the individual requests for AF session with required QoS corresponding to each UE's IP address and consolidates them into a single response before forwarding it to the AF based on a locally configured timer. Details are specified in the TS 23.502 [3].

End-to-end data volume transfer time analytics: The E2E data volume transfer time analytics may be used to assist an AF or NEF with AI/ML-based services, e.g. for member UE selection of federated learning. NWDAF can provide E2E data volume transfer time analytics, in the form of statistics or predictions or both, to a service consumer. NWDAF collects E2E data volume transfer time related input data from 5GC NFs, OAM and AF. The E2E data volume transfer time refers to a time delay for completing the transmission of a specific data volume from UE to AF, or from AF to UE. The detailed requirements are covered in the TS 23.288 [5].

NEF new monitoring events: The AF may subscribe to new NEF monitoring events relevant to the operation of AI/ML based operations as described in TS 23.502 [3]. The new monitoring events include session inactivity time in order to assist the AI/ML application server in scheduling available UE(s) to participate in the AI/ML operation, traffic volume exchanged between the UE and the AI/ML application server in order to assist the AF with the transfer of AI/ML data, and UL/DL data rate aggregated per PDU session.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920037,860009,920030,940084,989997,960037,940071,980019,990008,990074

[1] TR 23.700-80: "Study on 5G system support for AI/ML-based services"
[2] TS 23.501: "System architecture for the 5G System (5GS); Stage 2"
[3] TS 23.502: "Procedures for the 5G System; Stage 2"
[4] TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2"
[5] TS 23.288: " Architecture enhancements for 5G System (5GS) to support network data analytics services"

11.2 AI/ML for NG-RAN

941010	**Artificial Intelligence (AI)/Machine Learning (ML) for NG-RAN**	**NR_AIML_NGRAN**		RP-220635	**Fang Xie, Angelo Centonza, CMCC, Ericsson**

941110	Core part: Artificial Intelligence (AI)/Machine Learning (ML) for NG-RAN	NR_AIML_NGRAN-Core	R3	RP-220635	**Fang Xie, Angelo Centonza, CMCC, Ericsson**

Summary based on the input provided by Nokia in RP-232988.

The R18 Artificial Intelligence (AI)/Machine Learning (ML) for NG-RAN specifies the data collection enhancements and signalling support within existing NG-RAN interfaces and architecture (only limited to non-split architecture) for three use cases, including AI/ML-based Network Energy Saving, Load Balancing and Mobility Optimization.

This work item is based on the conclusions captured in TR37.817, and the objectives of Artificial Intelligence (AI)/Machine Learning (ML) for NG-RAN WI are included in [1].

Support of AI/ML for NG-RAN, as a RAN internal function, is used to facilitate Artificial Intelligence (AI) and Machine Learning (ML) techniques in NG-RAN. The objective of AI/ML for NG-RAN is to improve network performance and user experience, through analysing the data collected and autonomously processed by the NG-RAN, which can yield further insights, e.g., for Network Energy Saving, Load Balancing, Mobility Optimization.

Support of AI/ML in NG-RAN requires inputs from neighbour NG-RAN nodes (e.g., predicted information, feedback information, measurements) and/or UEs (e.g., measurement results).

Signalling procedures used for the exchange of information to support AI/ML in NG-RAN are use case and data type agnostic, which means that the intended usage of the data exchanged via these procedures (e.g., input, output, feedback) is not indicated. The collection and reporting of information are configured through the Data Collection Reporting Initiation procedure, while the actual reporting is performed through the Data Collection Reporting procedure.

Support of AI/ML in NG-RAN does not apply to ng-eNB.

For the deployment of AI/ML in NG-RAN, the following scenarios may be supported:

- AI/ML Model Training is located in the OAM and AI/ML Model Inference is located in the NG-RAN node.
- AI/ML Model Training and AI/ML Model Inference are both located in the NG-RAN node.

Network Energy Saving

AI/ML-based Network Energy Saving is to optimize the overall energy consumption in an area of the Operator's network by leveraging on the data collected in the RAN network. AI/ML based Energy Saving at a NG-RAN node essentially is for a trained AI model to make real-time decisions to either deactivate or activate a cell or a NG-RAN node to save network energy consumption.

In R18, the metric of Energy Cost (EC), which can be used e.g. for the Network Energy Saving use case, is introduced as the AI/ML metric and can be exchanged within the neighbouring NG-RAN nodes upon request, following the Data Collection Request Initiation and Reporting Initiation procedures. EC is represented as an index, which should be normalized and defined by OAM. The index value could be encoded as an integer from 0 to a maximum. The maximum value should guarantee enough accuracy. The "Energy Consumption – Energy Cost" mapping rule is defined by the Operator.

Load Balancing

Load balancing is to distribute load evenly among cells and among areas of cells, or to transfer part of the traffic from congested cells or from congested areas of cells, or to offload users from one cell, cell area, carrier or RAT to improve network performance. The AI/ML-based Load Balancing is introduced to improve the load balancing performance by using load predictions from AI/ML models and feedback information mirroring the performance of a UE after an offloading action.

For AI/ML-based Load Balancing, the predicted resource status information and UE performance feedback can be configured to be collected and measured by an NG-RAN node by using the Data Collection Reporting Initiation procedure, while the actual reporting is performed through the Data Collection Reporting procedure.

The UE performance feedback configuration is associated to the handed over UE(s) by using a set of measurement IDs. Such measurement IDs label the UE performance metrics and allow the source NG-RAN node to determine to which UE(s) the metrics correspond to. The collection of UE performance feedback is triggered at successful Handover execution. Both one-time and periodic UE performance feedback reporting are supported.

Mobility Optimization

Mobility management allows to guarantee service-continuity during mobility by minimizing call drops, radio link failures, unnecessary handovers, and ping-pong. AI/ML-based mobility optimization is introduced to improve successful handover rates and determine which is the best mobility target for maximisation of efficiency and performance.

To enable the target NG-RAN node to be aware of mobility related prediction information, which allows optimal allocation of resources for the handed over UE, a cell-based UE trajectory prediction is transferred to the target NG-RAN node via the Handover Preparation procedure to provide information for subsequent mobility decisions, e.g., the predicted NG-RAN cells the UE is expected to connect to. Cell-based UE trajectory prediction is limited to the first-hop target NG-RAN node.

For feedback information, i.e. the measured UE trajectory, the target NG-RAN node start s to collect the measured UE trajectory information at successful Handover execution, and one-time reporting is supported. The collection of the measured UE trajectory terminates when at least one of the following conditions is fulfilled: the UE moves to RRC_INACTIVE or RRC_IDLE, the UE is handed over to another cell of an NG-RAN node different from the first-hop target NG-RAN node, the configured measurement collection time duration expires or the configured number of visited cells within the same target NG-RAN node is reached.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941010,941110

11.3 AI/ML management

990119	AI/ML management	AIML_MGT	S5	SP-230335	**Yao, Yizhi, Intel**
950011	*Study on Artificial Intelligence (AI) and Machine Learning (ML) for Media*	FS_AI4Media	S4	SP-220328	**Eric Yip, Samsung**

Summary based on the input provided by NEC, Intel in SP-240204.

To support and facilitate the efficient deployment and operation of AI/ML capabilities/features with the suitable AI/ML techniques in 5GS (including management system, 5GC and NG-RAN), the ML model and AI/ML inference function need to be managed throughout their entire lifecycle.

The basic ML training capabilities and associated MnS have been defined in TS 28.105 [2] since Rel-17, while the other aspects of AI/ML management have been comprehensively studied in TR28.908 [1] which addressed a wide range of use cases, potential requirements, and possible solutions along with their evaluations for the additional AI/ML management capabilities.

Rel-18 specifications, documented in TS28.105 [2] addressed many aspects of AI/ML management that have been studied in TR 28.908 [1], including the development of terminology and definitions, a general framework for the operational workflow encapsulating various life cycle management operations for ML model (i.e., model training and testing, emulation, deployment, and inference), and a comprehensive number of detailed use cases for each phase of the operational workflow along with requirements and corresponding solutions.

The Rel-18 WID specified the AI/ML management capabilities (including use cases, requirements, and solutions (stage 2 NRMs and stage 3 OpenAPIs) for ML training (which also includes validation & testing), AI/ML emulation, ML model deployment and AI/ML inference phases of the AI/ML operational workflow as shown below for managing the entire lifecycle of the ML model and AI/ML inference function:

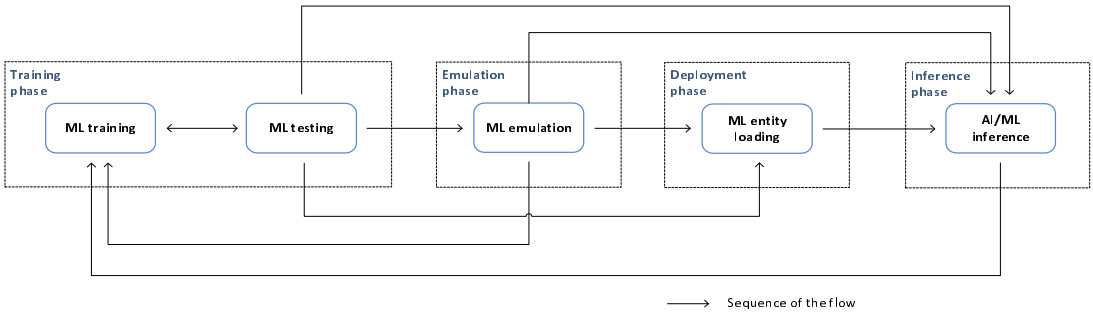

Figure 1: managing the entire lifecycle of the ML model and AI/ML inference function

Each operational phase in the workflow is supported by one or more AI/ML management capabilities as listed below:

- ML training Phase

  - ML training: Training requested by consumer or producer, ML entity selection, Managing ML training process, Handling errors in data and in ML decisions, ML entity joint training, ML entity validation performance reporting, training data effectiveness reporting.
  - Performance management for ML training and testing: Performance indicator selection for ML training and testing, ML entity performance indicators query and selection for ML training and testing, MnS consumer policy-based selection of ML entity performance indicators for ML training and testing.
  - ML testing: Consumer or producer-requested ML entity testing, Joint testing of multiple ML entities.

- AI/ML emulation phase: - AI/ML Inference emulation

- ML entity deployment phase: -ML entity loading: Consumer requested ML entity loading, Control of producer-initiated ML entity loading, ML entity registration.

- AI/ML inference Phase:

  - AI/ML inference performance management: AI/ML inference performance evaluation, AI/ML performance measurements selection based on MnS consumer policy.
  - AI/ML update control: Availability of new capabilities or ML entities, Triggering ML entity update.
  - AI/ML inference capabilities management: Identifying capabilities of ML entities, Mapping of the capabilities of ML entities.
  - AI/ML inference capability configuration management: Managing NG-RAN AI/ML-based distributed Network Energy Saving, Managing NG-RAN AI/ML-based distributed Mobility Optimization, Managing NG-RAN AI/ML-based distributed Load Balancing.
  - Executing AI/ML Inference: AI/ML Inference History - tracking inferences and context.

The Rel-18 WID also documented AI/ML functionalities management scenarios which describe the possible locations of ML training function and AI/ML inference function.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990119,950011

[1] TR28.908: “Study on Artificial Intelligence/Machine Learning (AI/ ML) management”
[2] TS28.105: “Management and orchestration; Artificial Intelligence/ Machine Learning (AI/ML) management”

11.4 NEF Charging enhancement to support AI/ML in 5GS

1020023	NEF Charging enhancement to support AI/ML in 5GS	AIMLsysNEF_CH	S5	SP-231706	OPPO, Alla Goldner

Summary based on the input provided by OPPO in SP-240207.

This work item covers the work related to the NEF charging enhancements introduced in order to support AIML in 5GC.

At the time or during the AI/ML operation. e.g., Federated Learning, the AF may request the serving NEF to provide QoS for a list of UEs, each UE identified by its UE IP addresses and also subscribe to QoS Monitoring which may also include Consolidated Data Rate monitoring. Then, the AF may eventually update the list of UE addresses and/or the QoS and/or the QoS monitoring and/or the Consolidated Data Rate monitoring and send it back to NEF. These procedures might assist the AF e.g. in order to decide which UEs are appropriate for AI/ML operation a.g. Federated Learning operation.

Therefore, under this WID, NEF Northbound APIs converged charging encompasses the NEF Northbound APIs specified to support AI/ML-based services:

- Member UE selection assistance functionality for application operation;
- Planned Data Transfer with QoS (PDTQ) requirements;
- Multi-member AF session with required QoS.

For the Multi-member AF session with required QoS, the list of UEs and Consolidated Data Rate are added in order to fulfil AI/ML service requests.

Such a NEF charging reporting enhancements will allow Charging Function to be aware of AI/ML service and support e.g. billing, credit control, statistics etc. for the purposes of appropriate engagement between e.g. the MNO and e.g. the provider of AI/ML Service.

One related CR: SP-231462: " AI/ML support for NEF based charging".

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1020023

[1] TS 32.254: " Charging management; Exposure function northbound Application Program Interfaces (APIs) charging".

11.5 Application Data Analytics Enablement Service

990115	**Application Data Analytics Enablement Service**	**ADAES**		SP-220913	**Pateromichelakis, Emmanouil (Manos)**
940019	*Study on Application Data Analytics Enablement Service*	FS_ADAES	S6	SP-211513	**Pateromichelakis, Emmanouil (Manos)**
970036	**Stage 2 of ADAES**	ADAES	S6	SP-230275	**Pateromichelakis, Emmanouil (Manos)**
990020	CT1 aspects of ADAES	ADAES	C1	CP-230333	**Atarius, Roozbeh, Lenovo**
990097	CT3 aspects of ADAES	ADAES	C3	CP-230333	**Atarius, Roozbeh, Lenovo**

Summary based on the input provided by Lenovo in SP-230275.

ADAES introduces a new SEAL functionality for application layer analytics and specifies the following analytics capabilities in the application enablement layer:

- application performance analytics.
- edge load analytics.
- performance analytics for UE-to-UE sessions.
- service experience to support application performance analytics, as well as application service management.
- slice related application data analytics.
- slice configuration recommendation.
- location accuracy analytics.
- service API analytics.

A dedicated study (FS_ADAES) has been conducted to identify key issues, architecture requirements, functional architecture model, and corresponding solutions that are relevant to the definition of the application layer support for data analytics enablement. The results of the study are captured in TR 23.700-36 [1] and the conclusions of the study are captured in the ADAES work item, which standardizes the analytics enablement services and identified solutions by updating the specification of TS 23.434 [2] (for the high level architecture as part of SEAL) and by introducing a new specification (TS 23.436 [3] for the functional architecture and information flows for ADAES .

CT1 and CT3 also update specifications of TS 24.559 [4] and TS 29.549 [5] to implement the solutions identified by Stage 2 in SA6.

Architecture enhancement for analytics enablement

ADAES is a new enablement service (which is part of SEAL) which introduces application data analytics services (stats/predictions) to optimize the application service operation by notifying the application specific layer (aka VAL layer) for expected/predicted application service parameters changes considering both on-network and off-network deployments (e.g., related to application QoS parameters).

Figure 1 illustrates the high-level reference-based architecture for ADAES. The ADAE client communicates with the ADAE server over the ADAE-UU reference point. The ADAE client provides the support for application data analytics enablement functions to the VAL client(s) over ADAE C reference point. The VAL server(s) communicates with the ADAE server over the ADAE-S reference point. The ADAE server, acting as AF, may communicate with the 5G Core Network functions (over N33 reference point to NEF and N6 reference point to UPF) and OAM. Additionally, in the vertical application layer, the VAL client of UE1 communicates with VAL client of UE2 over VAL-PC5 reference point, and ADAE clients of UE1 and UE2 interact with each other over ADAE-PC5 reference points.

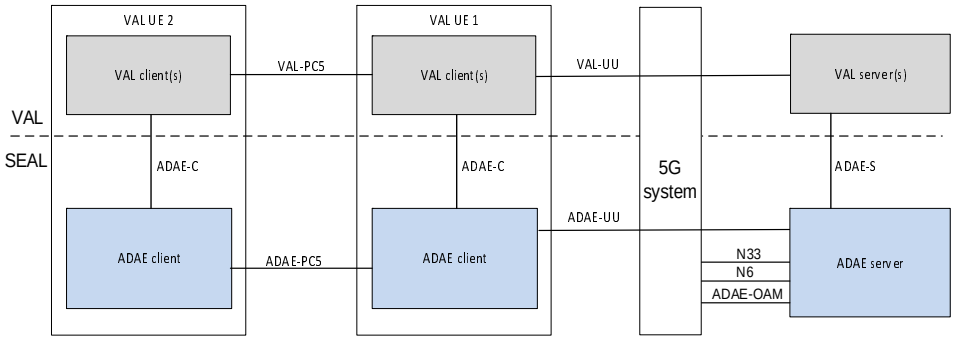

Figure 1. ADAE functional model

ADAE server in certain deployments can reuse the existing 3GPP data analytics framework for the data collection coordination, delivery and storage. Figure 2 illustrates the generic functional model for ADAE when re-using the existing data analytics model. In this model, an Application layer - Data Collection and Coordination Function (A-DCCF) is used to fetch data or put data into an Application level entity (e.g. A-ADRF, Data Source). Such A-DCCF coordinates the collection and distribution of data requested by ADAE server (over ADCCF-1, ADAE-X). ADAE server can also directly interact with the Data Sources/Producers. Also, Application layer – Analytics and Data Repository Function (A-ADRF) can be used to store historical data and/or analytics, i.e. data and/or analytics related to past time period that has been obtained by the ADAE server (via AADRF-1) or other NFs/NWDAF. ADAE server can also fetch historical data from A-ADRF.

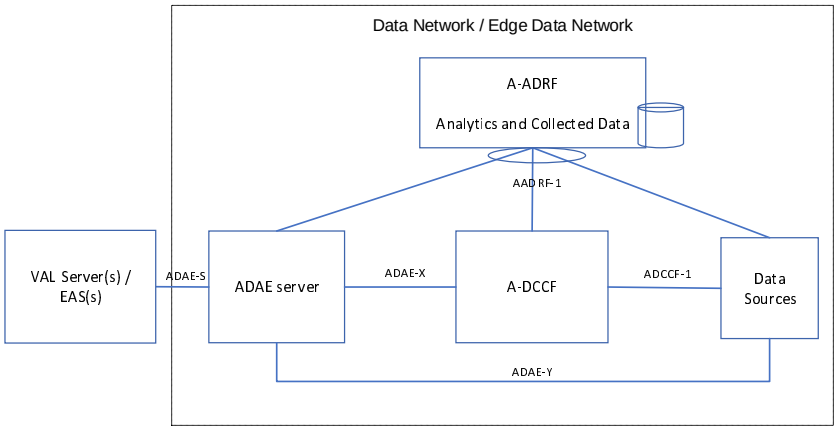

Figure 2 Generic functional model based on network data analytics model

New ADAE Analytics Capabilities

In TS 23.436 [3], a set of capabilities have been discussed including application and edge related performance analytics. The main capabilities include:

1) Application Server or Session performance analytics

Data analytics related to the application end-to-end QoS and statistics and predictions on the application server or application session performance and load can be useful for the application specific layer, so as to proactively identify potential adaptations of the application service and to trigger adaptations at the communication layer. Such analytics aim to provide insight on the operation and performance of an application service (VAL server or EAS, application session) and in particular statistics or prediction on parameters related to e.g. VAL server number of connections for a given time and area, VAL server rate of connection requests, connection probability failure rates, Round Trip Time (RTT) and deviations for a VAL server or VAL UE session, packet loss rates etc

2) Edge load analytics

Edge load analytics provide insight on the operation and performance of an EDN and in particular statistics or prediction on parameters related to:

- the EAS / EES load for one or more EAS/EES
- edge platform load parameters, which include the aggregated load per EDN or per DNAI due to the edge support services and e.g., load level of edge computational resources.

Such analytics can improve edge support services by allowing the pro-active edge service operation changes to deal with possible edge overload scenarios.

3) UE-to-UE session performance analytics

This capability introduces application layer analytics to predict the performance of an application session among two or more VAL UEs within a service or group. Such prediction relates to application QoS attributes prediction for a given time horizon and area. This can be requested by the VAL server during the session, or the VAL server can subscribe to receive predicted application QoS downgrade indication for an ongoing session. Such analytics will help improving the application service experience and allow the VAL layer to pro-actively adapt to predicted application QoS changes.

4) Slice-related app performance analytics

This capability introduces application layer analytics to provide insight on the performance of the VAL applications when using a given network slice (from a list of subscribed slices for the VAL customer). Such solution provides an analytics service to a consumer who can be either the VAL server (for helping to identify what slice it will use for its applications) or for other consumers such as SEAL NSCE to support on providing predictions of slice related performance.

5) Location accuracy analytics

This capability provides the translation of the per UE location report accuracy to an expected /predictive location accuracy derivation for the application requiring positioning services. Such location accuracy analytics and in particular the sustainability of vertical and horizontal accuracy per VAL application (e.g. group of field devices in industrial use cases) based on per UE reported location accuracies is beneficial to make sure that location server will meet the VAL customer location reporting requirements for a given time/area of location request validity.

6) Service API analytics

Service API analytics (such as the statistics on the successful/failed API invocation or predicted API availability for a given deployment) can be a tool to be used by the API provider (ASP, ECSP, MNO) to help optimizing the API usage by enabling them to trigger API related actions like API mashups, API rate limitations/throttling events, or pro-actively detecting API termination point changes which may affect service performance.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990115,970036,990020,990097,940017

[1] TR 23.700-36: "Study on Application Data Analytics Enablement Service".
[2] TS 23.434: "Service Enabler Architecture Layer for Verticals (SEAL) ".

[3] TS 23.436: “Functional architecture and information flows for Application Data Analytics Enablement Service”.
[4] TS 24.559: "Application Data Analytics Enablement Service (ADAES); Stage 3".
[5] TS 29.549: "Service Enabler Architecture Layer for Verticals (SEAL); Application Programming Interface (API) specification; Stage 3".

12 Multicast and Broadcast Services (MBS)

12.1 5G MBS Phase 2

989999	**5G multicast-broadcast services Phase 2**	**5MBS_Ph2**		SP-221131	**Meng Li, Huawei, Huawei**
940067	*Study on architectural enhancements for 5G multicast-broadcast services Phase 2*	FS_5MBS_Ph2	S2	SP-220072	**Meng Li, Huawei**
980013	**(Stage 2 of 5MBS_Ph2) Architectural enhancements for 5G multicast-broadcast services Phase 2**	5MBS_Ph2	S2	SP-230099	**Meng Li, Huawei, Huawei**
990001	CT1 aspects for 5MBS_Ph2	5MBS_Ph2	C1	CP-232031	**Meng Li, Huawei, Huawei**
990076	CT3 aspects for 5MBS_Ph2	5MBS_Ph2	C3	CP-232031	**Meng Li, Huawei, Huawei**
990077	CT4 aspects for 5MBS_Ph2	5MBS_Ph2	C4	CP-232031	**Meng Li, Huawei, Huawei**
1000005	Security Enhancements for 5G Multicast-Broadcast Services Phase 2	5MBS_Ph2	S3	SP-230559	**Longhua Guo, Huawei Technologies**
960041	*Study on security enhancements for 5G multicast-broadcast services Phase 2*	FS_5MBS_SEC_Ph2	S3	SP-220539	**Longhua Guo, Huawei Technologies**
1000010	*Charging Aspects for SMF and MB-SMF to Support 5G Multicast-broadcast Services*	5MBS_CH	S5	SP-231712	**Dong Jia, China Mobile**

Summary based on the input provided by China Mobile in SP-240336 for the charging aspects.

Charging Aspects for SMF and MB-SMF to Support 5G Multicast-broadcast Services

SA2 have specified architecture enhancements for 5G multicast-broadcast services in TS 23.247[1]. Charging enhancement of EPC eMBMS services is defined in TS 32.273[2]. To support charging for 5G multicast and broadcast services, SA5 work item mainly focus on charging aspect of 5G multicast-broadcast services, specifying the corresponding charging architecture, charging principles, charging scenarios, charging procedures, and the corresponding Open API and ASN.1 update.

Define the charging architecture for 5G multicast-broadcast services, and introduce N101 interface between MB-SMF and the CHF in TS 32.240[3]. Add MB-SMF as service consumer of Nchf_ConvergedCharging service in TS 32.290[4].

Define charging principles, charging triggers, message flows for SMF to support PDU session charging of 5G multicast services in TS 32.255[5].

A new charging specification TS 32.279[6] specifies charging enhancement for MB-SMF to support 5MBS charging, including the charging principles, charging triggers, message flows, and CHF CDR charging information for MBS session charging.

Stage 3 work on WI 5MBS_CH includes adding 5G MBS Specified Data Type and update Nchf_ConvergedCharging API in TS 32.291[7] and updating CHF record to supported 5G MBS charging in TS 32.298[8].

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=989999,940067,980013,990001,990076,990077,1000005,960041,1000010

[1] TS 23.247: "5G multicast-broadcast services"
[2] TS 32.273: "Multimedia Broadcast and Multicast Service (MBMS) charging"
[3] TS 32.240: "Charging architecture and principles"

[4] TS 32.290: "5G system; Services, operations and procedures of charging using Service Based Interface (SBI)"
[5] TS 32.255: "5G data connectivity domain charging"
[6] TS 32.279: "5G Multicast-broadcast Services charging"
[7] TS 32.291: "5G system, charging service"
[8] TS 32.298: "Charging Data Record (CDR) parameter description"

12.2 Enhancements of NR MBS

940099	**Enhancements of NR Multicast and Broadcast Services**	**NR_MBS_enh**		RP-232993	**CATT**
940199	Core part: Enhancements of NR Multicast and Broadcast Services	NR_MBS_enh-Core	R2	RP-232993	Rui Zhou, CATT

Summary based on the input provided by CATTin RP-232994.

This work item specifies further enhancements based on Rel-17 MBS, i.e. Multicast reception by UEs in RRC_INACTIVE, shared processing for MBS broadcast and unicast reception, and resource efficiency improvement for MBS broadcast reception in RAN sharing scenarios.

To support a large number of UEs in a cell for services like Mission Critical Services, it is important to support multicast for UEs in RRC_INACTIVE. In the case that UE simultaneously receives broadcast service and unicast service from the network(s) of same or another operator, UEs may share the hardware resources between broadcast and unicast, which motivates the enhancement to support the shared processing for MBS broadcast and unicast reception. In RAN sharing deployment scenario, a broadcast service may be provided by two (or more) operators separately. This service would be recognized as separate MBS sessions and duplicated PTM radio resources are allocated in the same cell for the transmission of the same content. This justifies the enhancement for the resource efficiency improvement of MBS broadcast in the RAN sharing scenarios.

Multicast reception by UEs in RRC_INACTIVE

Multicast reception by UEs in RRC_INACTIVE is supported, with the following characteristics:

PTM configuration

MBS multicast configuration information is provided in RRCRelease and on multicast MCCH.

Multicast MCCH carries the MBSMulticastConfiguration message which indicates the MBS multicast sessions that are provided in the cell as well as the corresponding scheduling related information for these sessions. Optionally, the MBSMulticastConfiguration message may also contain a list of neighbour cells providing the same MBS multicast service(s) for RRC_INACTIVE as provided in the current cell. This allows the UE, e.g., to resume RRC connection without reading SIB and multicast MCCH of the neighbour cell, if the interested service which is activated is not available to the UE in RRC_INACTIVE state. The configuration information required by the UE to receive multicast MCCH is provided in SIB When the network changes (some of) the multicast MCCH information, it notifies the UEs about the change via PDCCH.

For multicast reception by UEs in RRC_INACTIVE, the following R17 functions for multicast in RRC_CONNECTED are not supported,

- PTP transmission
- SPS
- HARQ feedback

Multicast DRX is configured per G-RNTI for multicast reception by UEs in RRC_INACTIVE.

The CFR for the multicast reception in RRC_INACTIVE state and the CFR for broadcast can be configured differently. If one CFR is not completely contained within the other CFR, then UE in RRC_INACTIVE state is not required to receive both broadcast and multicast simultaneously.

Notification

It is up to gNB to decide whether the UE receives data of MBS multicast session in RRC_CONNECTED state or RRC_INACTIVE state. The gNB moves the UE from RRC_CONNECTED state to RRC_INACTIVE state via RRCRelease message, and moves the UE from RRC_INACTIVE state to RRC_CONNECTED state via group notification or UE-specific paging.

For UEs receiving data of MBS multicast session in RRC_INACTIVE state, the gNB notifies the UE to stop monitoring PDCCH addressed by corresponding G-RNTI via RRCRelease message or multicast MCCH when there is temporarily no data to be sent or when the session is deactivated. If the UE receiving data of MBS multicast session in RRC_INACTIVE state in a cell is notified to stop monitoring PDCCH addressed by G-RNTI for all the joined multicast sessions, the UE does not monitor PDCCH addressed by multicast-MCCH-RNTI until the group notification is received.

Upon reception of the group notification that indicates to allow the multicast reception in RRC_INACTIVE, the UE stays in RRC_INACTIVE state and starts the multicast reception.

Service Continuity

Mobility procedures for multicast reception allow the UE in RRC_INACTIVE state to continue receiving MBS service(s) when changing cells without resuming RRC connection if the PTM configuration of the new cell can be acquired by the UE from the multicast MCCH after cell reselection. During an active MBS multicast session, the UE is required to resume RRC connection to get the PTM configuration if the PTM configuration is not provided on the multicast MCCH of the new cell. Even if the UE in RRC_INACTIVE state received indication to stop monitoring PDCCH addressed by G-RNTI for an MBS multicast session in the source cell, the UE acquires MCCH in the reselected cell after cell reselection.

The UE may be configured with dedicated frequency priorities in RRCRelease message which the UE applies during cell reselection while receiving data of MBS multicast session in RRC_INACTIVE state.

The UE receiving multicast session(s) in RRC_INACTIVE state triggers RRC connection resumption if the latest measured RSRP or RSRQ of the serving cell becomes lower than the threshold configured by the network. The threshold can be configured per MBS session via RRCRelease message or multicast MCCH.

The gNB may indicate to UE that the PDCP COUNT of a multicast session is synchronized in the RNA (i.e. the cells in the RNA follow a common QoS flow to MRB mapping rule and at the same time PDCP COUNT is set according to the MBS QoS Flow SN). Upon moving to a cell where the PDCP COUNT of a multicast MRB is synchronized within the RNA, the UE doesn't initialize the PDCP state variables.

Shared processing for MBS broadcast and unicast reception

If the UE in RRC_CONNECTED state is receiving or interested to receive an MBS broadcast service from a non-serving cell, the UE may use MBS Interest Indication message to inform the serving gNB about the parameters used for the non-serving cell broadcast reception. The gNB may enable the sending of the MBS Interest Indication by including an indication in SIB1. The UE may indicate to the serving cell the UE capability for receiving MBS broadcast service from a non-serving cell.

In case the UE only reports the frequency for broadcast service reception from the non-serving cell in MBS Interest Indication due to some parameters (e.g., SCS, bandwidth) not available, the UE may transmit updated MBS Interest Indication once the parameters are available to the UE.

Resource efficiency improvement in the RAN sharing scenarios

To improve resource efficiency for MBS broadcast reception in RAN sharing scenarios, 5GC provides the Associated Session ID allocated to the MBS Broadcast service to NG-RAN node to enable identification of MBS services providing the same Broadcast content. NG-RAN node could decide to establish one or multiple NG-U tunnels for the MBS broadcast services delivering the same MBS content. The gNB may trigger the NGAP Broadcast Session Transport procedure towards one 5GC participating in RAN sharing to set up NG-U resources to maintain NG-U connectivity.

For disaggregated gNB cases, improvement of resource efficiency is supported for both MOCN scenario and Multiple Cell-ID Broadcast scenario. gNB-DUs sharing the same physical cell resources receive via F1-C information enabling identifying broadcast MBS sessions providing identical content. The identification is based on Associated Session ID. For the identification of location dependent MBS services, the MBS Service Area is also taken into account.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940099,940199

12.3 UE pre-configuration for 5MBS

990078	**UE pre-configuration for 5MBS**	**UEConfig5MBS**		CP-230201	**Herrero-Veron, Christian (Huawei)**
990022	CT1 aspects of UEConfig5MBS	UEConfig5MBS	C1	CP-230201	**Herrero-Veron, Christian (Huawei)**
990079	CT6 aspects of UEConfig5MBS	UEConfig5MBS	C6	CP-230201	**Herrero-Veron, Christian (Huawei)**

Summary based on the input provided by Huawei in CP-233306.

Multicast-broadcast services in 5G (5MBS) is a feature of the Rel-17 version of 3GPP specifications which encompasses support for functions such as how to deliver multicast and broadcast communications including support within certain location areas, mobility, multicast/broadcast services (MBS) session management and QoS; and covers interworking with E-UTRAN and EPC based eMBMS for Public Safety (e.g. mission critical (MCX) services).

The MBS architecture is defined by TS 23.247 [1] and follows the 5G System (5GS) architectural principles, enabling distribution of the MBS data from the 5GS ingress to NG-RAN node(s) and then to the UE. TS 23.247 [1] on "Architectural enhancements for 5G multicast-broadcast services" specifies the possibility of having UE pre-configuration for broadcast services and other MBS information.

The UE pre-configuration for 5MBS (UEConfig5MBS) work is based on the work developed in Rel-17 on 5MBS and addresses the realization of UE pre-configuration for multicast/broadcast services (MBS) in order to receive the data of multicast communication services and broadcast communication services.

Multicast communication service: the same service and the same specific content data is provided to a dedicated set of UEs.

Broadcast communication service: the same service and the same specific content data are provided simultaneously to all UEs in a geographical area. For location dependent broadcast service, it is similar as the one for multicast.

Based on the MBS architectural requirements stated in TS 23.247 [1], broadcast MBS reception is supported and there is possibility for the UE to be pre-configured with necessary information (e.g., by 5GCN/operator, at factory) to receive broadcast data. So the UE does not need to interact with the network for fetching the information for broadcast data. This functionality is considered necessary by operators and vendors to provide MBS service and expected functionality to users/customers. Similarly, other MBS information can also be pre-configured in the UE for obtaining multicast services. UE pre-configuration for 5MBS is necessary for some operators, at least, where the UE may not be able to connect to a PLMN. For example, in a disaster scenario, there will not be any PLMN coverage but broadcast communication services could be available. Also, note that it is possible that a UE can simultaneously receive broadcast data and unicast data so a UE could be developed in such a way that it has a dual module to handle broadcast and unicast data simultaneously.

The UE may support pre-configuration of information for services using MBS or UE pre-configuration for 5MBS. If the UE is pre-configured with information related to services using MBS, the UE can discover and receive data for services by using the provisioned configuration.

The UE pre-configuration for 5MBS contains a list of PLMNs in which for each PLMN, the following information can be configured:

a) PLMN identity of the PLMN for which the configuration applies;
b) RAN information based on NR absolute radio frequency channel number (NR-ARFCN) on which the broadcast communication service is available;
c) list of temporary mobile group identity (TMGI), on which the broadcast communication service is available, each associated with user service description (USD) information (see TS 26.517 [5]) for the MBS broadcast service. If TMGI and USD information for the MBS user service is configured for the PLMN selected for broadcast communication service, the UE uses the information configured therein to acquire the broadcast communication service; and
d) default DNN and S-NSSAI pair for PDU sessions that can be used to join MBS multicast sessions (as specified in TS 24.501 [2]) for which no other information is available.

As documented in TS 24.501 [2], UE pre-configuration for 5MBS can be provided in one or more of the following ways:

a) in a UE implementation-specific way (e.g. factory configuration);
b) in the USIM (see EF5MBSUECONFIG file in TS 31.102 [3]); or
c) in the UE pre-configuration MO for MBS (see TS 24.575 [4]).

Pre-configuration on the USIM is based on enhancing the USIM by adding a new service (no. 147) in the USIM service table (see EFUST in TS 31.102 [3]) and adding a new dedicated file (DF) at the USIM ADF (Application DF) level called DF5MBSUECONFIG. That DF can contain the EF5MBSUECONFIG file and the file EF5MBSUSD. Multiple EF5MBSUSD files may exist in the DF, each one associated with a different entry in EF5MBSUECONFIG.

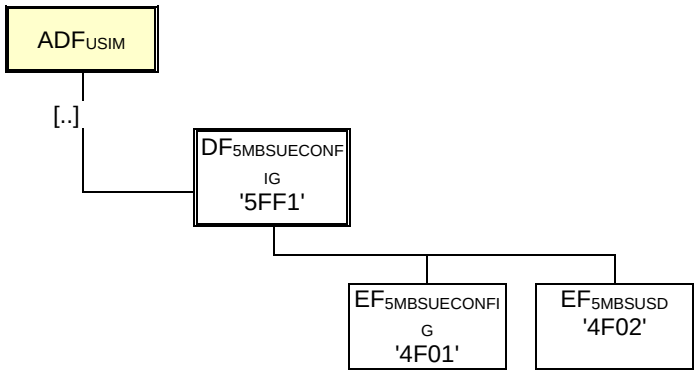

Figure 1: File identifiers and directory structures of the USIM for the DF5MBSUECONFIG.

Pre-configuration based on management object (MO) can be used to configure the UE with parameters related to reception of data of multicast communication services or broadcast communication services or both. The MO is compatible with the OMA device management (DM) protocol specifications, version 1.2 and upwards, and is defined using the OMA DM device description framework (DDF). The MO consists of nodes and leaves conveying UE pre-configuration parameters used for multicast communication service and broadcast communication service selection and data reception. The below figures 2 and figure 3 illustrates the MO for UE pre-configuration.

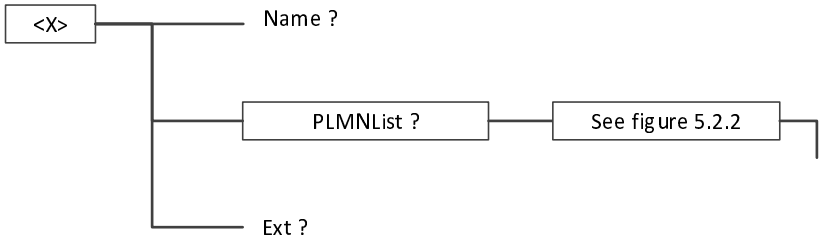

Figure 2: UE pre-configuration MO

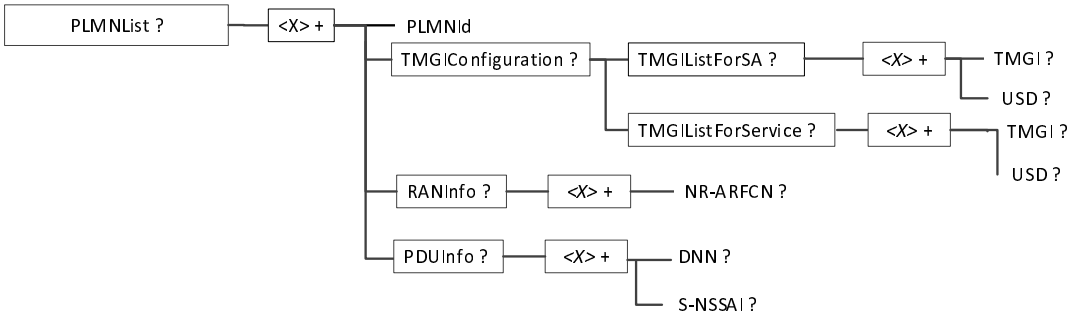

Figure 3: PLMNList node

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990078,990022,990079

[1] TS 23.247, "Architectural enhancements for 5G multicast-broadcast services".

[2] TS 24.501, "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".
[3] TS 31.102, "5G Multicast-Broadcast User Services; Protocols and Formats".
[4] TS 24.575, "5G System; Multicast/Broadcast UE pre-configuration Management Object (MO)".
[5] TS 26.517, "5G Multicast-Broadcast User Services; Protocols and Formats".

12.4 Other MBS aspects

940099	**Enhancements of NR Multicast and Broadcast Services**	**NR_MBS_enh**		RP-231829	**Erlin Zeng, CATT**
940199	Core part: Enhancements of NR Multicast and Broadcast Services	NR_MBS_enh-Core	R2	RP-231829	**Erlin Zeng, CATT**
920071	**New bands and bandwidth allocation for 5G terrestrial broadcast - part 2**	**LTE_terr_bcast_bands_part2**		RP-223378	**Gene Fong, Qualcomm**
920171	Core part: New bands and bandwidth allocation for 5G terrestrial broadcast - part 2	LTE_terr_bcast_bands_part2-Core	R4	RP-232590	**Gene Fong, Qualcomm**

No summary provided for spectrum related Core parts.

13 Network Slicing

13.1 Network Slicing Phase 3

980127	**Network Slicing Phase 3**	**eNS_Ph3**		SP-221135	**ZHU Jinguo, ZTE**
940063	*Study on Enhancement of Network Slicing Phase 3*	FS_eNS_Ph3	S2	SP-220073	**ZHU Jinguo, ZTE**
960029	*Study on enhanced security for network slicing Phase 3*	FS_eNS_Ph3	S3	SP-220527	**Zander Lei, Huawei**
980017	**Stage 2 of Network Slicing Phase 3**	eNS_Ph3	S2	SP-230104	**ZHU Jinguo, ZTE**
990015	CT1 aspects of Network Slicing Phase 3	eNS_Ph3	C1	CP-230194	**Hannah Wang, ZTE**
990081	CT3 aspects of Network Slicing Phase 3	eNS_Ph3	C3	CP-230194	**Hannah Wang, ZTE**
990082	CT4 aspects of Network Slicing Phase 3	eNS_Ph3	C4	CP-230194	**Hannah Wang, ZTE**
991037	**Network Slicing Phase 3: NR aspects**	**eNS_Ph3-NR**	**R3**	RP-230787	**Dapeng Li, ZTE**
991137	Core part: Network Slicing Phase 3: NR aspects	eNS_Ph3-NR-Core	R3	RP-231396	**Dapeng Li, ZTE**
1030024	**Network Slice Replacement charging**	eNS_Ph3_CH	S5	SP-240075	Maryse Gardella, MATRIXX Software

Summary based on the input provided by ZTE, LG Electronics in SP-231535 for General aspects, in RP-233947 for RAN aspects and by MATRIXX Software in SP-240576 for charging aspects.

General aspects

This work item specifies enhancements on network slicing to support the following features:

1) Network Slice usage control
2) Temporarily available network slices
3) Partial Network Slice support in a Registration Area
4) Network Slice Area of Service (NS-AoS) not matching deployed Tracking Areas (TA)
5) Network Slice Replacement and Network Slice Instance Replacement
6) Centralized Network Slice Admission Control (NSAC) architecture and Hierarchical NSAC architecture

The detailed description is shown below.

1) Support of Network Slice usage control, as described in clause 5.15.15 of TS 23.501 [1]

A network-controlled Slice Usage Policy is introduced to control the network slice usage in the UE side. The network-controlled Slice Usage Policy is provided to the UE in the Registration Accept or the UE Configuration Update Command, and includes following:

- An indication, whether this Network Slice is on demand S-NSSAI, i.e. whether the UE only registers with the Network Slice with the network when applications in the UE require data transmission in the Network Slice.

- For all on demand S-NSSAI(s) of the HPLMN in the Configured NSSAI, a slice deregistration inactivity timer that causes the UE to deregister the Network Slice after the last PDU Session associated with the S-NSSAI is released.

The SMF configures PDU Session inactivity timer to the UPF so that PDU Session can be released when there is no traffic over the PDU Session. The UE and AMF may start slice deregistration inactivity timer when the on-demand slice is not used by any PDU Session. If the timer is expired, the UE and AMF removes the on-demand S-NSSAI from the Allowed NSSAI.

2) Optimized handling of temporarily available network slices, as described in clause 5.15.16 of TS 23.501 [1]

A network slice may be available only for a limited time that is known at the network in advance e.g. by OAM or subscription. The AMF, based on OAM configuration or information received from the UDM or NSSF, may indicate to a UE the validity time for one or more S-NSSAIs in the Configured NSSAI in the Registration Accept message or via the UE Configuration Update procedure. If the validity time indicates the S-NSSAI is available, the UE may request the S-NSSAI in a Requested NSSAI. Otherwise, the UE does not include the S-NSSAI in the Requested NSSAI and remove the S-NSSAI from the Allowed NSSAI or Partially Allowed NSSAI (see Partial Network Slice support in a Registration Area). The UE also locally releases any PDU Sessions associated with the S-NSSAI.

3) Partial Network Slice support in a Registration Area, as described in clause 5.15.17 of TS 23.501 [1]

In Rel-17, the S-NSSAI of the Allowed NSSAI shall be supported in all the TAs of the Registration Area. This restriction may increase Mobility Registration Update signalling if an S-NSSAI is supported in a TA. In order to resolve such restriction, Partially Allowed NSSAI and S-NSSAI rejected partially in the RA are introduced. When the AMF provides Partially Allowed NSSAI or S-NSSAIs rejected partially in the RA, the AMF includes a list of TAs where the S-NSSAI is supported. When a UE received Partially Allowed NSSAI or S-NSSAI rejected partially in the RA,

- the UE is considered registered with an S-NSSAI of the Partially Allowed NSSAI in the whole Registration area and does not trigger registration when moving between the TAs of support and non-support for the S-NSSAI within the RA.

- the UE is allowed to initiate a Mobility Registration Update procedure to request registration with the S-NSSAI only when the UE is in a TA supporting this S-NSSAI.

The user plane resource is not allowed to be activated for a PDU Session of an S-NSSAI part of the Partially Allowed NSSAI and the UE moves to a TA which is not part of the list of TAs associated with the S-NSSAI.

4) Support for NS-AoS not matching deployed TAs, as described in clause 5.15.18 of TS 23.501 [1]

In order to support S-NSSAI deployed over an area not matching TAs, S-NSSAI location availability information is introduced. The S-NSSAI location availability information defines additional restrictions to the usage of an S-NSSAI in TAs where the Network Slice availability does not match the TA boundaries. The AMF is configured per S-NSSAI whether to send the S-NSSAI location availability information to the UE. The S-NSSAI location availability information includes, for each applicable S-NSSAI of the Configured NSSAI, Location information indicating the cells of TAs in the RA where the related S-NSSAI is available if the S-NSSAI is not available in all the cells of the TA. The UE can request the S-NSSAI only if the S-NSSAI location availability information indicates that the S-NSSAI is available at the cell where the UE is camping. If the UE is in a cell within the RA but outside the location availability information of the S-NSSAI, the user plane resource for any already established PDU Session with that S-NSSAI is released.

5) Support of Network Slice Replacement and Network Slice Instance Replacement, as described in clauses 5.15.19 and 5.15.20 of TS 23.501 [1]

a) The Network Slice Replacement

This feature is used to replace an S-NSSAI with an Alternative S-NSSAI when an S-NSSAI becomes unavailable or congested without impacting application layer. The Network Slice Replacement can be triggered by NSSF, PCF or OAM. Based on the notification above from NSSF or PCF or OAM, the AMF may determine that an S-NSSAI is to be replaced with Alternative S-NSSAI. The AMF provides the Alternative S-NSSAI for this S-NSSAI in the Allowed NSSAI and in the Configured NSSAI. The Network Slice Replacement is applicable for both new PDU Session and existing PDU Session. During the Network Slice Replacement, the AMF provides both the replaced S-NSSAI and the Alternative S-NSSAI to the SMF and the SMF to PCF. For existing PDU Session, the SMF sends the Alternative S-NSSAI to the supporting UE either in PDU Session Modification Command or in PDU Session Release, to replace the S-NSSAI of the PDU Session.

b) Network Slice Instance Replacement

The Network Slice Instance Replacement is used when a PDU Session for a given S-NSSAI is established using a selected Network Slice instance and the selected Network Slice instance is no longer available (e.g. due to overload). The AMF may subscribe with the NSSF for notifications when any of the Network Slice instances served by the AMF is congested or no longer available. When the NSSF notifies the AMF that a Network Slice instance is congested or no longer available, the AMF may delete old NSI ID corresponding to the Network Slice instance that is no longer available. Then the AMF notifies the SMF of the PDU Session(s) selected by using such old NSI ID to release the PDU Session(s). Subsequently, the SMF triggers the impacted UE(s) to establish new PDU Session(s) associated with the same S-NSSAI. The AMF selects a new Network Slice instance for the given S-NSSAI during PDU Session Establishment.

6) Support of Centralized NSAC architecture and Hierarchical NSAC architecture, as described in clause 5.15.11 of TS 23.501 [1]

In Rel-17, multiple NSAC service area is supported and for each NSAC service area, independent NSACF is deployed. Such deployment has limitation because each NSAC service area has its own maximum number of UEs per network slice and/or maximum number of PDU Sessions per network slice and there is no interaction between the NSACFs deployed in different NSAC service area. Therefore, network cannot use common maximum allowed number of UEs/PDU Sessions per network slice. In order to resolve such limitation, two additional architecture options are added:

a) Centralized NSAC architecture

In this architecture, a single centralized NSACF is deployed in the network to handle admissions in all NSAC service areas. The centralized NSACF is configured with the total number of UEs per network slice and the maximum number of PDU Sessions for the entire PLMN. In this architecture, NSAC Requests from AMF or SMF to the single centralized NSACF includes the NSAC service area of the NF consumer if multiple NSAC service areas are deployed in PLMN.

b) Hierarchical NSAC architecture

In this architecture, there are two roles of NSACF, i.e. Primary NSACF and NSACF. The Primary NSACF, controls and distributes of the maximum number of UEs and/or the maximum number of PDU Sessions for other NSACF(s) deployed in different NSAC service Area. The Primary NSACF handles overall NSAC for an S-NSSAI at the global level (i.e. it is ultimately responsible for the NSAC for an S-NSSAI). The NSACF is responsible for one or multiple NSAC service area. One NSAC service area is only associated with one NSACF instance or one NSACF Set.

RAN aspects

As for RAN aspects, “Network Slicing Phase 3 NR aspects” specifies the following key functionalities:

RAN to support Network Slice Service continuity scenario:

This feature enables the 3GPP system to support Network Slice Replacement feature. The feature is used to replace an S-NSSAI with an Alternative S-NSSAI when an S-NSSAI becomes unavailable or congested in the Core network. The current S-NSSAI is reused as Alternative S-NSSAI in the PDU Session Modification message in NGAP for Network Slice replacement.

RAN to support Partially Allowed NSSAI in RRC_Connected Mode

This feature enables the 3GPP system to deploy a Network Slice partially allowed in one or more TAs in a PLMN/SNPN as defined in specified in TS 23.501. The NG-RAN may be signalled with the Partially Allowed NSSAI from the AMF. The NG-RAN may decide to use the Partially Allowed NSSAI for mobility decision.

RAN to support Slice Area of Service not mapping to existing TA

This feature enables the 3GPP system to support for Network Slices with Network Slice Area of Service not matching deployed Tracking Areas is specified in TS 23.501. NG-RAN cells that are outside the Area of Service may be configured with zero resources for the concerned slice(s). The concerned slice(s) cannot use any dedicated, prioritized nor any shared resources of that cell. Awareness of zero resources configured for a slice in one or more cells may be exchanged with neighbour NG-RAN nodes for mobility reasons.

Charging aspects

The charging aspect of Network Slice Replacement feature are specified in TS 23.501 [1] clause 5.15.19, used to temporarily replace an S-NSSAI with an Alternative S-NSSAI.

UE PDU session charging (TS 32.255 [2]) is enhanced for the CHF to be aware of the use of Alternative S-NSSAI instead of S-NSSAI. A new "S-NSSAI replacement" trigger is introduced for reporting to CHF when the serving S-NSSAI is replaced by an Alternative S-NSSAI during an ongoing UE PDU session.

UE registration charging (TS 32.256 [3]) is enhanced with the list of mapping between the S-NSSAI to be replaced and the alternative S-NSSAI provided by the AMF.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=981039,981139,1030024

[1] TS 23.501: "System Architecture for the 5G System; Stage 2".
[2] TS 32.255: "Telecommunication management; Charging management; 5G Data connectivity domain charging; stage 2".
[3] TS 32.256: "Telecommunication management; Charging management; 5G connection and mobility domain charging; stage 2".
[4] TS 32.291: "Charging management; 5G system; Charging service, stage 3".
[5] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

13.2 Enhancement of NSAC for maximum number of UEs with at least one PDU session/PDN connection

980129	**Enhancement of NSAC for maximum number of UEs with at least one PDU session/PDN connection**	**eNSAC**		SP-220988	**ZHU Jinguo, ZTE**
970058	**Stage 2 of eNSAC**	**eNSAC**	**S2**	SP-230113	**ZHU Jinguo, ZTE**
980086	CT3 aspects of eNSAC	eNSAC	C3	CP-232025	**Li, Zhijun, ZTE**
980087	CT4 aspects of eNSAC	eNSAC	C4	CP-232025	**Li, Zhijun, ZTE**

Summary based on the input provided by ZTE in SP-231536.

This work item specifies the support of new NEST attribute "maximum number of UEs with at least one PDU session/PDN connection" as an added capability to what the system currently supports.

A network slice subject to both NSAC and EPS counting shall be configured with only one of the options:

- Maximum number of registered UEs and/or maximum number of PDU Session; or

- Maximum number of UEs with at least one PDU Session/PDN Connection and/or maximum number of PDU Session

When EPS counting is required for a network slice and NSACF is configured with maximum number of UEs with at least one PDU Session/PDN Connection, the NSACF keeps track of the current number of UEs with at least one PDU session/PDN connection established on a network slice to ensure it does not exceed the maximum configured number. Two options are introduced:

1. Option 1: Triggering an Nnsacf_NSAC_NumOfUEsUpdate_Request to NSACF for NSAC for maximum number of UEs when the UE establishes first PDU Session/PDN connection associated with the network slice in the SMF+PGW-C, or when the last PDU Session/PDN connection associated with the network slice is released

2. Option 2: Triggering an Nnsacf_NSAC_NumOfPDUsUpdate_Request as described in clause 5.15.11.5 to NSACF and the NSACF performs admission control for the number of UEs with at least one PDU Session/PDN connection

See more details in TS 23.501[1] clause 5.15.11.5a

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980129,970058,980086,980087

[1] TS 23.501: “System architecture for the 5G System (5GS)

13.3 Enhancement of Network Slicing UICC application for network slice-specific authentication and authorization

1000002	**Enhancement of Network Slicing UICC application for network slice-specific authentication and authorization**	eNS_UICC	C6	CP-231351	**COLLET, Hervé, Thales**

Summary based on the input provided by Thales in CP-233301.

This Rel-18 work item "Enhancement of Network Slicing UICC application for network slice-specific authentication and authorization" introduces support of network slice-specific authentication and authorization (NSSAA), as defined in TS 33.501 clause 16, as a UICC enhancement.

In the same way as TS 31.102 specifies the USIM, the new Rel-18 specification TS 31.105, as the outcome of the work item, specifies the "Characteristics of the Slice Subscriber Identity Module application" for the SSIM, a new application on-top of the UICC.

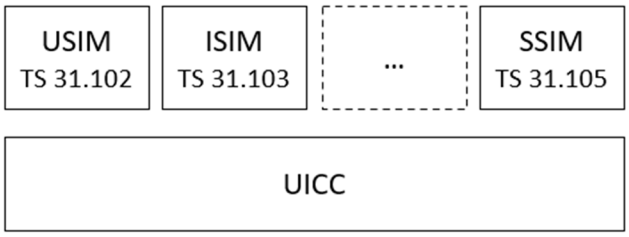

Figure 1: UICC architecture, SSIM with other applications

TS 31.105 specifies the interface between the ME and the UICC, covering:
- the definition of a new application embedded on the UICC, the SSIM;
- the identification, selection and initialisation procedures to be used by the ME;
- the AUTHENTICATE command supported by the SSIM to exchange relevant EAP packets between the ME and the SSIM.

An SSIM shall be defined in the EFDIR of the UICC to be able to be selected and used by the ME. A specific Application Identifier (AID) is defined, the '3GPP SSIM', to identify an SSIM entry in EFDIR.

The S-NSSAI list supported by an SSIM and the associated EAP ID to be used for the NSSAA procedure are defined at the SSIM level for the ME usage.

The ME, during an ongoing NSSA procedure, exchanges EAP messages with the AMF using dedicated NSSAA message in NAS messaging as defined in TS 24.501 and transfers relevant EAP packets to the related SSIM using the AUTHENTICATE command to perform the EAP authentication using credentials stored in the SSIM.

An SSIM can support more than one S-NSSAI and simultaneous NSSAA procedure at the same time.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000002

[1] TR 31.826, "Study on new UICC application for NSSAA"
[2] TS 31.105, "Characteristics of the Slice Subscriber Identity Module application"

13.4 Charging Aspects of Network Slicing Phase 2

900023	*Study on Charging Aspects for Network Slicing Phase 2*	FS_NETSLICE_CH_Ph2	S5	SP-201082	**Gerald Görmer, MATRIXX Software**
980025	**Charging Aspects of Network Slicing Phase 2**	NETSLICE_CH_Ph2	S5	SP-230176	**Gerald Görmer, MATRIXX Software**

Summary based on the input provided by MATRIXX Software in SP-240323.

This feature introduces a set Network Slice level new criteria for charging Network Slices usage, allowing Mobile Network Operators to monetize Network Slice(s) assigned to third-party providers based on these. The new criteria are number of registered UEs and number of PDU Sessions per network slice as well as the volume and actual duration per Network Slice.

NSACF (Network Slicing Admission Control Function) is specified in TS 23.501 [1] clause 5.15.11 for monitoring the number of registered UEs and/or the number of PDU Sessions per network slice. The charging solution for number of registered UEs and number of PDU Sessions per network slice is specified in TS 28.203 [4] and relies a new reference point from the NSACF using the NchfConvergedCharging service, specified in TS 32.290 [5] and TS 32.291 [6] extended for this purpose.

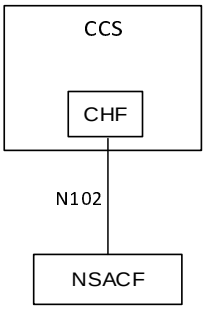

Figure 1: Non-Roaming Network Slice Admission Control converged charging architecture - reference point representation

The charging solution for volume and duration per Network slice is based on "5G Data Connectivity" charging between SMF and CHF for individual UEs PDU sessions specified in TS 32.255 [3], extended under a new charging framework to encompass the Network Slice serving the UEs. A new B-CHF (Business-CHF) connecting to individual UEs C-CHF (Consumer CHF) introduced in the generic charging architecture, applies for Network Slice charging in the specific context of "5G Data Connectivity" charging. In this solution, the B-CHF handles the Tenant the Network Slice (identified by the S-NSSAI) is assigned to,

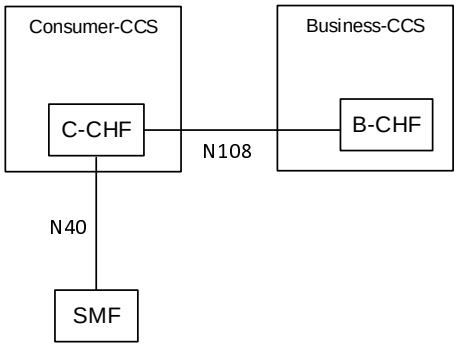

Figure 2: 5G data connectivity converged charging architecture Consumer CHF to Business CHF architecture in reference point representation

UEs PDU session charging over N40 extended between C-CHF and B-CHF, based on the S-NSSAI identifying the Network Slice, allow the B-CHF to perform volume and duration based charging per Network Slice.

In addition, the new charging framework includes the capability for individual UE PDU sessions charging of SMF performed by the C-CHF to be influenced by Network Slice charging criteria supplied by the B-CHF.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980025

[1] TS 23.501: "System Architecture for the 5G System; Stage 2".

[2] TS 32.240: "Charging management; Charging architecture and principles".
[3] TS 32.255: "Charging management; 5G Data connectivity domain charging; stage 2".
[4] TS 28.203: "Charging management; Network slice admission control charging in the 5G System (5GS)".
[5] TS 32.290: "Charging management; 5G system; Services, operations and procedures of charging using Service Based Interface (SBI)
[6] TS 32.291: "Charging management; 5G system; Charging service, stage 3".
[7] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

13.5 Charging Aspects for Network Slice-Specific Authentication and Authorization (NSSAA)

990032	**Charging Aspects for Network Slice-Specific Authentication and Authorization (NSSAA)**	NSSAA_CH	S5	SP-230182	**Gerald Görmer, MATRIXX Software**

Summary based on the input provided by MATRIXX Software in SP-240324.

This feature introduces a new capability for Mobile Network Operators to monetize Network Slice(s) assigned to third-party providers based on allowing such third-party to grant authorization or not to individual UEs for accessing a particular network slice using Network Slice-Specific Authentication and Authorization (NSSAA) procedures specified in TS 23.501 [1] clause 5.15.10.

The charging solution is specified in Network Slice-Specific Authentication and Authorization (NSSAA) charging TS 28.204 [4]. and relies on a new reference point from the NSSAAF (Network Slice-Specific Authentication and Authorization Function) and existing N42 from AMF, both using the NchfConvergedCharging service, specified in TS 32.290 [5] and TS 32.291 [6] extended for this purpose.

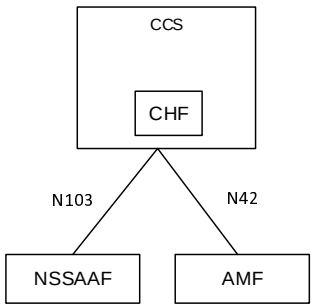

Figure 1: Non-Roaming Network Slice-Specific Authentication and Authorization converged charging architecture - reference point representation

The per UE NSSAA procedures via MNO AMF and NSSAAF towards the third-party provider AAA Server (AAA-S) specified in TS 23.502 [2] clause 4.2.9, for this UE to be granted access to a specific Network Slice, can be under MNO CHF quota control. Corresponding generated CDRs as specified in TS 32.298 [7], are specified for wholesale purpose between the MNO and the third-party the Network Slice is assigned to.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990032

[1] TS 23.501: "System Architecture for the 5G System; Stage 2".
[2] TS 23.502: "Procedures for the 5G System".
[3] TS 32.240: "Charging management; Charging architecture and principles".
[4] TS 28.204: "Charging management; Network slice-specific authentication and authorization charging in the 5G System (5GS)".
[5] TS 32.290: "Charging management; 5G system; Services, operations and procedures of charging using Service Based Interface (SBI)
[6] TS 32.291: "Charging management; 5G system; Charging service, stage 3".
[7] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

13.6 Charging enhancement for Network Slice based wholesale in roaming

1000011	**Charging enhancement for Network Slice based wholesale in roaming**	CHNSWO	S5	SP-230625	**Maryse Gardella, MATRIXX Software,**

Summary based on the input provided by MATRIXX Software in SP-240390.

This feature introduces a capability for network slice differentiation in 5G roaming to allow network slice based wholesale between Mobile Network Operators (MNO) roaming partners.

The charging solution is based on enhancing the Network Slice identifier(s) in charging information available in the Visited PLMN, with the Network Slice identifier(s) supplied by HPLMN they are mapped to.

This enhancement is specified for "5G Data connectivity" of SMF in TS 32.255 [2]: PDU Session Charging includes the HPLMN S-NSSAI the serving VPLMN S-NSSAI is mapped to.

This enhancement is specified for "5G connection and mobility" of AMF in TS 32.256 [3]: Registration charging and N2 connection charging include the mapping of VPLMN S-NSSAI(s) to HPLMN S-NSSAI(s).

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000011

[1] TS 32.240: "Charging management; Charging architecture and principles".
[2] TS 32.255: "Charging management; 5G Data connectivity domain charging; stage 2".
[3] TS 32.256: "Charging management; 5G connection and mobility domain charging; Stage 2
[4] TS 32.291: "Charging management; 5G system; Charging service, stage 3".
[5] TS 32.298: "Charging management; Charging Data Record (CDR) parameter description".

13.7 Network Slice Capability Exposure for Application Layer Enablement

910022	*Study on Network Slice Capability Exposure for Application Layer Enablement*	FS_NSCALE	S6	SP-211509	**Zheng, Shaowen, CMCC**
960013	**Network Slice Capability Exposure for Application Layer Enablement**	NSCALE	S6	SP-220470	**Zheng, Shaowen, CMCC**

Summary based on the input provided by CMCC in SP-240781.

Network slicing is the key technology for differentiated network requirements of vertical industries. SA1 defines the relevant requirements of the open network slicing capability API for trusted third parties in TS 22.261[1] section 6.10, including the need to support the creation, modification, and deletion of slices, support the definition and update of slice capabilities, and support slice-related UE and service information configuration.

This work item is based on the conclusions captured in TR23.700-99[2]. Network slice capability enablement (NSCE) service specified in this work item enables the network slice related capabilities towards 3rd party on the basis of R17 SEAL. The NSCE service provides additional functionality and exposes slice capabilities based on 5GS management system services (e.g MnS services) and 5GS network services (e.g. NEF APIs, NWDAF APIs, NSACF APIs).

The following functionilties are supported:

- Slice API configuration and translation, provides the exposure of APIs in a slice-tailored manner by configuring and translating the slice API to service APIs based on per slice requirements, as specified in clause 9.3 of TS 23.435[3].
- Discovery of management service exposure as specified in clause 9.6 of TS 23.435[3].
- Network slice performance and analytics monitoring as specified in clause 9.7 of TS 23.435[3].
- Network slice diagnostics as specified in clause 9.14 of TS 23.435[3]..
- Network slice fault management capability exposure as specified in clause 9.15 of TS 23.435[3].
- Slice requirements verification and alignment capability exposure as specified in clause 9.16 of TS 23.435[3].
- Network Slice Information delivery as specified in clause 9.17 of TS 23.435[3].
- Network Slice Allocation as specified in clause 9.18 of TS 23.435[3].
- Information collection from NSCE server(s), supports the network slice status exposure to other NSCE server(s) if some agreement has been made, as specified in clause 9.8 of TS 23.435[3].

- Application layer network slice lifecycle management as specified in clause 9.4 of TS 23.435[3].
- Network slice optimization based on VAL server policy as specified in clause 9.5 of TS 23.435[3].
- Multiple slices coordinated resource optimization, monitors the slice usage status of multiple slices (PNI-NPN slice(s) and its private slice in the PLMN) of the PNI-NPN owner in a combined manner, as specified in clause 9.10 of TS 23.435[3].
- Predictive slice modification in edge based NSCE deployments, avoids degradation of the application service performance by service continuity negotiation among NSCE servers in different EDNs, as specified in clause 9.9 of TS 23.435[3].
- Predictive slice modification in Inter-PLMN based slice service continuity, NSCE service provider provides slice service continuity when connected to two PLMNs and has SLAs with them, as specified in clause 9.13 of TS 23.435[3].
- Network slice adaptation for VAL application, adapts the network slice for the VAL application via providing a guidance to update the URSP rules at the 5GS, as specified in clause 9.11 of TS 23.435[3].
- Slice related communication service lifecycle management as specified in clause 9.12 of TS 23.435[3].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000011

[1] TS 22.261: "Service requirements for the 5G system; Stage 1".
[2] TR 24.700-99: “Study on Network Slice Capability Exposure for Application Layer Enablement (NSCALE)”
[3] TS 23.435: “Procedures for Network Slice Capability Exposure for Application Layer Enablement Service”

13.8 Other slice aspects

910038	**Enhanced Access to and Support of Network Slice**	**EASNS**		SP-210210	**Chun, SungDuck, LG Electronics**
880035	*Study on EASNS*	FS_EASNS	S1	SP-200571	**Chun, SungDuck, LG Electronics Inc**
910032	**Stage 1 for EASNS**	EASNS	S1	SP-210210	**Chun, SungDuck, LG Electronics**
1000023	CT1 aspects of Slice-based PLMN Selection	PLMNsel_NS	C1	CP-232165	**Shuang Liang, ZTE**
1000044	CT4 aspects of Slice-based PLMN Selection	PLMNsel_NS	C4	CP-232165	**Shuang Liang, ZTE**
1000045	CT6 aspects of Slice-based PLMN Selection	PLMNsel_NS	C6	CP-232165	**Shuang Liang, ZTE**
940045	**Network slicing provisioning rules**	NSRULE	S5	SP-211449	**Robert Petersen, Ericsson**
950039	*Study on intent-driven management for network slicing*	FS_NETSLICE_IDMS	S5	SP-220278	**Jan Groenendijk , Ericsson**
940013	**Enhanced security for Phase 2 network slicing**	eNS2_SEC	S3	SP-211361	**Lei, Zander, Huawei**
960005	*Study on new UICC application for network slice-specific authentication and authorization (NSSAA)*	FS_NS_Slice-USIM	C6	CP-221186	**COLLET, Hervé, Thales**

No summary was provided by the rapporteurs for these aspects.

14 eXtended, Augmented and Virtual Reality (XR, AR, VR), immersive

14.1 XR (eXtended Reality) enhancements for NR

981039	**XR (eXtended Reality) enhancements for NR**	**NR_XR_enh**		RP-232778	**Nokia**
981139	Core part: XR (eXtended Reality) enhancements for NR	NR_XR_enh-Core	R2	RP-232778	**Benoist Sébire, Nokia**
981139	Study on XR (eXtended Reality) enhancements for NR	FS_NR_XR_enh	R2	RP-220285	**Benoist Sébire, Nokia**

Summary based on the input provided by Nokia in RP-232988.

The RAN Study Item on XR Enhancements for NR had identified several enhancements for the support for XR services in NG-RAN. This work item specified those enhancements, which revolve around three main areas: awareness, power saving, and capacity. It complements the work done by SA2 on Architecture Enhancements for XR (Extended Reality) and media service, and the work done by SA4 on Traffic Models and Quality Evaluation Methods for Media and XR Services in 5G Systems, Immersive Real-time Communication for WebRTC (iRTCW), Media Capabilities for Augmented Reality (MeCAR), IMS-based AR Conversational Services (IBACS), Terminal Audio quality performance and Test methods for Immersive Audio Services, Split Rendering Media Service Enabler (SR_MSE), and Real-time Transport Protocol Configurations.

For XR Awareness, in addition to the assistance information provided by 5GC to the gNB (PDU Set Information and traffic assistance information), the following is introduced in order to enhance the scheduling of uplink resources by NG-RAN:

- One additional buffer size table to reduce the quantisation errors in BSR reporting (e.g. for high bit rates);

- A new MAC CE for the Delay Status Report (DSR) of buffered data;

- Reporting of uplink assistance information (jitter range, burst arrival time, UL data burst periodicity) per QoS flow by the UE via UE Assistance Information.

For power saving enhancements, the gNB may configure a DRX cycle expressed in rational numbers so that the DRX cycle matches the periodicities of video frame rates (15, 30, 45, 60, 72, 90 and 120 fps). In addition, configured grants may be configured without the need for the UE to monitor possible UL retransmissions, thus increasing the number of power saving opportunities for the UE.

For capacity enhancements, configured grant-based PUSCH transmission are enhanced with the following:

- Support of multiple CG PUSCH transmission occasions within a single period of a CG configuration;

- Indication of unused CG PUSCH occasion(s) of a CG configuration with Uplink Control Information multiplexed in CG PUSCH transmission of the CG configuration.

Also, in uplink, the UE may be configured with PDU Set based discard operation for a specific DRB. When configured, the UE discards all packets in a PDU set when one PDU belonging to this PDU set is discarded. This is used when the remaining PDUs of that PDU Set can be considered as no longer needed by the application, as indicated by the PDU Set Integrated Handling Information (PSIHI) obtained by 5GC for that QoS flow.

In addition, in case of congestion, the gNB may use the PDU Set Importance (PSI) of the GTP-U header for PDU set discarding. For uplink, dedicated downlink signalling is used to request the UE to apply a shorter discard timer to low importance SDUs in PDCP.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980127,980017,990015,990081,990082,991037,991137

14.2 Media Capabilities for Augmented Reality

950015	**Media Capabilities for Augmented Reality**	MeCAR	S4	SP-220242	**Emmanuel Thomas, Xiaomi**

Summary based on the input provided by Xiaomi in SP-240209.

MeCAR “Media Capabilities for Augmented Reality” specifies the media capabilities of a UE for the execution of AR services and applications. The work resulted in TS 26.119 [1] which defines audio, video, scene description and XR system capabilities for four device types representing different form factors of XR devices. Developed to support different services, TS 26.119 provides common data structures and semantics for some metadata and QoE metrics generated by the UE. An example of specifications leveraging TS 26.119 is the TS 26.565 “Split Rendering Media Service Enabler” [2].

The four device types defined in TS 26.119 are type 1 “Thin AR glasses”, type 2 “AR glasses”, type 3 “XR phone” and type 4 “XR head-mounted display”. Note that the targeted services and applications belong to the AR domain while the

device types 3 (XR phone) and 4 (XR head-mounted display) may be capable of running other types of XR applications but those other mode operations are out of scope of TS 26.119.

For each device type, TS 26.119 specifies the mandatory and optional media capabilities to be supported by the UE. Those media capabilities pertain to audio, video, scene processing and XR systems capabilities and are summarised in terms of supports of audio codecs (EVS, IVAS and AAC-ELDv2), video codecs (AVC and HEVC), scene description formats (glTF 2.0 [3] and its extension in MPEG-I Scene Description [4]).

Regarding metadata, the defined common metadata in TS 26.119 are the pose information, possibly predicted for a future point in time, the action object representing actions performed by a user of an AR application and the available visualization space object representing a 3D space within the user's real-word space that is suitable for rendering virtual objects.

Lastly, to assess the quality of experience of an AR application, TS 26.119 defines a set of QoE metrics which can be reported by the UE. Those metrics are time duration from pose to render to photon, time duration from render to photon, time duration for roundtrip interaction delay, time duration for user interaction delay, time of content age and time duration for scene update.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950015

[1] TS 26.119: "Device Media Capabilities for Augmented Reality Services".
[2] TS 26.565: "Split Rendering Media Service Enabler".
[3] ISO/IEC 12113:2022 Information technology Runtime 3D asset delivery format Khronos glTF™2.0.
[4] ISO/IEC 23090-14:2023 Information technology Coded representation of immersive media Part 14: Scene description.

14.3 Real-time Transport Protocol Configurations

960046	**Real-time Transport Protocol Configurations**	5G_RTP	S4	SP-230541	**Igor Curcio, Nokia Corporation**

Summary based on the input provided by Nokia in SP-240072.

The work item 5G_RTP ("5G Real-time Media Transport Protocol Configurations") specifies a horizontal protocol specification in TS 26.522 that can be used by different 3GPP 5G XR services and enablers.

The origin of this work was TR 26.998 (5G Glass-type AR/MR) which identified multiple aspects of normative work to support "5G/AR Real-time Communication" (clause 8.4). TR 26.998 identified normative work needed to support the delivery of immersive media via RTP for IMS-based and WebRTC-based conversational services.

Further improvements in performance and QoE over the 5G system has been achieved by specifying RTP configurations that are integrated and optimized for the 5G system, and leverage cross-layer optimizations used by other 3GPP specifications. In particular, this work item was performed in collaboration with SA2 and related to their FS_XRM study.

This is the primary feature list developed as part of TS 26.522:

- RTP header extension for PDU Set marking: this is an RTP packet extension that allows a sender to insert specific information that can be used by the network to perform an informed PDU set handling, in case of congestion or other necessary reason. The informed PDU set handling has the goal of limiting the negative impact on the end-to-end QoE. The high level semantic definition of PDU Sets and data bursts is the mechanism through which this functionality is realized. PDU Sets are delimited by an End PDU. And a data burst is delimited by a bit defined in the RTP header extension. The PDU Set Importance (PSI) field indicates the relative importance of a PDU Set compared to other PDU Sets in a video stream. Other useful information is also added as part of the RTP header extension in order to help the network with PDU set handling to minimize impact on the QoE. Guidelines for setting the PSI field for the H.264 and H.265 video codecs (and for setting other fields) are given.

- RTP header extension for XR pose: an RTP sender that uses RTP to deliver pre-rendered video streams to a UE should include an RTP HE for XR pose to indicate the XR pose used for rendering the media (rendered pose). The RTP HE for XR pose may be used for signaling either a 6DoF XR pose or a 3DoF XR pose.

• RTP header extension for in-band end-to-end delay measurement: an RTP HE that allows an RTP packet to carry timestamp(s) may help obtain measured delays that are representative of the end-to-end instantaneous delays experienced by the media in the user plane.

• RTCP feedback reporting for transmission of timing information data for QoE measurements: In the context of interactive immersive services, one important parameter to estimate the user quality of experience is the roundtrip interaction delay. The roundtrip interaction delay is defined as the sum of the age of content and the user interaction delay.

• SDP Signaling: Related SDP signaling of the above features is also defined.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960046

14.4 Immersive Audio for Split Rendering Scenarios (ISAR)

990025	**Immersive Audio for Split Rendering Scenarios**	ISAR	S4	SP-231291	**Stefan Bruhn, Dolby Laboratories Inc**

Summary based on the input provided by Dolby Sweden AB in SP-240700.

“Immersive Audio for Split Rendering Scenarios (ISAR)” develops solutions for immersive binaural audio on head-tracked devices that are compatible with split architectures envisaged in TSs 26.119 [1] and 26.998 [2]. The developed solutions have considered low-complex and lightweight devices and demonstrated operational benefits over solutions with full decoding and rendering in the end device.

The following aspects have been specified:

- Relevant requirements applicable for various split rendering scenarios (in TR 26.865 [3]).
- Provision of a format specification for intermediate split immersive audio rendering representation(s) in TS 26.249 [4], TS 26.253CR0003 [5], TS 26.258CR0002 [6].
- Provision of encoder, bitstream and decoder specification for intermediate representations including audio with and without post-rendering control metadata in TS 26.249 [4], TS 26.253CR0003 [5], TS 26.258CR0002 [6].
- Provision of a specification for decoded intermediate representations to provide binaural audio output with and without head-tracker input and post-rendering control metadata in TS 26.249 [4], TS 26.253CR0003 [5], TS 26.258CR0002 [6].
- Specification of interfaces suitable to connect the IVAS codec or other immersive audio codecs or renderers with the ISAR split rendering solutions in TS 26.249 [4].
- Characterization of the developed split rendering solutions in TR 26.996 [7].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990025

[1] TS 26.119, "Media Capabilities for Augmented Reality"
[2] TR 26.998, "Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices"
[3] TR 26.865, "Immersive Audio for Split Rendering Scenarios; Requirements"
[4] TS 26.249, "Immersive Audio for Split Rendering Scenarios"
[5] S4-241056, "Adding ISAR track-a split rendering feature”, TS 26.253 CR0003r1
[6] S4-241171, "Adding ISAR track-a split rendering feature to TS 26.258 and Corrections to the IVAS C-Code and corresponding specification text”, TS 26.258 CR0002r2
[7] TR 26.996, "Immersive Audio for Split Rendering Scenarios; Performance characterization", provided for SA approval

14.5 Immersive Real-time Communication for WebRTC

950014	**Immersive Real-time Communication for WebRTC**	iRTCW	S4	SP-230977	**Kyunghun Jung, Facebook**

Summary based on the input provided by Samsung Electronics in SP-240779.

This Work Item enables WebRTC protocol for immersive enabling media delivery over 5G System. Specifically, it provides the set of Stage-3 procedures, APIs, and protocols for the reference points defined in Real-Time Media Communication (RTC) architecture [2].

In parallel to iRTCW work item, there was another work on developing the generalized media delivery architecture, which consolidates both RTC and 5G Media Streaming (5GMS) architectures [3]. As a result, the common set of APIs were identified and specified in TS 26.510 under the work item 5GMS_Pro_Ph2 (5G Media Streaming Protocols Phase 2). Then, iRTCW results in TS 26.113 [1] with descriptions of RTC-specific APIs as well as references to TS 26.510 for common APIs.

iRTCW also provided the WebRTC signalling protocol for the exchanging of signalling information, RTC-specific RTC QoE metric reporting protocol, and packet loss handling mechanisms. It was also discussed to specify the media capabilities for an RTC Client, but concluded to provide minimum set of requirements for service interoperability to TS 26.114 [4].

This is the primary feature list developed as part of TS 26.113:

- RTC-specific APIs:.In the provisioning API, Real-time Media Communication Provisioning was introduced for provision an RTC configuration by the RTC Access Function in facilitating RTC session. The configuration is included in Service Access Information retrieved from the RTC AF by the RTC Media Session Handler. In addition, all the required reference points to support RTC configuration were identified from generalized media delivery architecture.

- WebRTC Signalling Protocol: The Simple WebRTC Application Protocol (SWAP) was developed in TS 26.113 to support the case when the operator is capable of providing the WebRTC Signalling Function inside the media AS. The message syntax and semantics were also specified to be exchanged between endpoints over the WebSocket connection

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950014

[1] TS 26.113: "Real-Time Media Communication; Protocols and APIs".
[2] TS 26.506: "5G Real-time Media Communication Architecture (Stage 2)".
[3] TS 26.510: "Media delivery; interactions and APIs for provisioning and media session handling".
[4] TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction".

14.6 IMS-based AR Conversational Services

960042	**IMS-based AR Conversational Services**	IBACS	S4	SP-230165	**Gunkel, Simon, KPN N.V.**

Summary based on the input provided by KPN N.V. in SP-240866.

The work item IBACS (“IMS-based AR Conversational Services”) specifies extensions to DCMTSI clients in terminal extending towards conversational services in AR. The newly defined AR-MTSI client in terminal enhances existing IMS communication features specified in TS 26.114 [1] to support AR media and experiences (e.g., AR conferencing).

The origin of this work was TR 26.928 (Extended Reality (XR) in 5G) [2] which identified multiple aspects of potential normative work with respect to conversational services (clause 7.6 & 7.8), and TR 26.998 (5G Glass-type AR/MR) [3] which identified multiple aspects of normative work to support “5G/AR Real-time Communication” (clause 8.4). Further, the work in IBACS was related and aligned with the developments in MeCAR, TS 26.119 (Media Capabilities for Augmented Reality) [4], and 5G_RTP, TS 26.522 (5G Real-time Media Transport Protocol Configurations) [5].

IBACS concluded with the resulting TS 26.264 [6] with a minimal set of features to support communication over IMS in 3D (AR) space. This will allow new communication services in RL18 and build a foundation for the development of more complex IMS immersive communication features in the coming releases.

This is the primary feature list developed as part of TS 26.264 [6]:

- Immersive AR media: there is no extension on media codecs as defined in TS 26.114. The main difference from an AR-MTSI client in terminal and an DCMTSI client in terminal is that AR media (i.e., Video, text and images) can be positioned spatially via AR metadata (specifically for video this might be as overlay as defined in TS 26.114). Further an AR-MTSI client in terminal may render AR Media as defined in TS 26.119 clause 9.2.

- AR metadata - Spatial descriptions: this extension adds the support to an AR-MTSI client in terminal to signal the available visualization space, user position and other trackable poses to an AR MF/MRF (as defined in TS 26.119).
- AR metadata - Scene descriptions: this extentention adds support to complient AR-MTSI clients to support capabilities requirements for scene description as described in clause 10 of TS 26.119.
- Network media rendering and configuration: this extension supports metadata formats as defined in clause 8.3 of TS 26.565 to support network media rendering. Further, the extension covers the negotiation between an AR-MTSI client in terminal and an AR AS to establish the split-rendering configuration (as specified in clause 8.4.2 of TS 26.565).
- AR Data Transport: this extension is based on the data transport specified in TS 26.114, clause 7, and adds the support of RTP Header Extension for PDU Set Marking (clause 4.2, TS 26.522), XR Pose (clause 4.3, TS 26.522) and the transmission of timing information data for QoE measurements (clause 5.2, TS 26.522).
- Quality of Experience: extension to the current Quality of Experience (QoE) requirements specified in TS 26.114 are for further studies for AR-MTSI clients in terminal.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950014

[1] TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction".
[2] TR 26.928: “Extended Reality (XR) in 5G”.
[3] TR 26.998: “5G Glass-type AR/MR”
[4] TS 26.119: “Media Capabilities for Augmented Reality".
[5] TS 26.522: “5G Real-time Media Transport Protocol Configurations".
[6] TS 26.264: “IMS-based AR Real-Time Communication”.

14.7 Split Rendering Media Service Enabler

960045	**Split Rendering Media Service Enabler**	SR_MSE	S4	SP-220685	**Bouazizi, Imed, Qualcomm**

Summary based on the input provided by Qualcomm in SP-240894.

The work item defines the split rendering Media Service Enabler (MSE) in TS 26.565 [1].

It defines a a split rendering Media Service Enabler (MSE), which allows developers to easily create applications that are able to automatically delegate rendering to the edge. It leverages several enablers to simplify the deployment of this enabler by abstracting details of edge discovery, format negotiation, connection establishment, QoS policy allocation, etc.

The specification also defines the media and metadata formats for split rendering. It provides guidelines to the split rendering server on how to encode the rendered media.

In its current version, TS 26.565 [1] defines several split rendering profiles that support different types of devices and different split strategies.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960045

[1] TS 26.565, Split Rendering Media Service Enabler

14.8 Extended Reality and Media service (XRM)

990110	**Architecture Enhancements for XR (Extended Reality) and media service**	**XRM**		SP-221326	**Dan WANG, China Mobile**
940068	*Study on architecture enhancement for XR and media services*	FS_XRM	S2	SP-220705	**Dan Wang, China Mobile**
980016	**(Stage 2 for XRM) Architecture Enhancements for XR (Extended Reality) and media service**	XRM	S2	SP-230092	**Dan WANG, China Mobile**

990006	CT3 aspects of XRM	XRM	C3	CP-232134	**Zhennning Huang, China Mobile**
990084	CT4 aspects of XRM	XRM	C4	CP-232134	**Zhennning Huang, China Mobile**
950012	*Study on immersive Real-time Communication for WebRTC Phase 2*	FS_eiRTCW	S4	SP-230166	**Yoshihiro INOUE, NTT**

Summary based on the input provided by China Mobile in SP-240897.

In 5G era, mobile media services, e.g. cloud AR/VR, cloud gaming, video-based tele-control for machines or drones, are expected to contribute more and more traffics to 5G network. All media traffics have some common characteristics. These characteristics can be very useful for better transmission control and efficiency. However, currently 5GS uses common QoS mechanisms to handle media services together with other data services without taking full advantage of these information.

Furthermore, considering the XR/media traffics have natural interval between periodic video/audio frames, it would be possible to enhance power saving mechanisms (e.g. CDRX) considering the XR/media traffic pattern.

Some advanced XR or media services may include more modalities besides video and audio stream, such as information from different sensors and tactile or emotion data for more immersing experience e.g. haptic data or sensor data. To support such tactile and multi-modality communication services (identified by SA WG1 TACMM), the 5G system may need to address service requirement of different types of traffic steams with coordinated QoS selection and packet processing, guaranteed latency and reliability, time synchronization of these parallel information, in order to ensure best service experience.

This work item specifies the following aspects:

1) Support of policy control enhancements to support multi-modality flows for single UE, based on AF provisioned information.
2) Support of policy control enhancements to support multi-modality flows for multiple UEs.
3) Support 5GS information exposure for XR/media enhancements;
    a. Support for ECN marking for the purpose of L4S by NG-RAN.
    b. Support for ECN marking for the purpose of L4S by PSA UPF.
    c. Support API based information exposure to AF including QNC for GBR QoS Flow, congestion information, data rate, delay difference, round trip delay of QoS flow and estimated bandwidth for 5QI.
4) Support PDU set based QoS handling including PDU set integrated handling and differentiated handling;
    a. Support PDU set based QoS Parameters with PCF determination and provisioning, based on AF provisioned information.
    b. Support PDU set information identification and marking by PSA UPF.
    c. Support potential enhancement for UL PDU set handling based on RAN WGs conclusion.
5) Support uplink-downlink transmission coordination to meet round-trip latency requirements;
    a. Support RT latency split for UL and DL PDB for different QoS flows considering AF QoS requirement.
    b. Use of QoS monitoring to adjust the UL and DL PDB to meet RT latency.
6) Support policy enhancements for jitter minimization;
    a. Support AF and 5GC interaction for jitter monitoring and exposure, jitter requirements provisioning and policy enhancements.
7) Support enhancements to UE power savings for XR services;
    a. 5GS enhancement to provide assistant information to NG-RAN via NGAP message and GTP-U header.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960045

[1] TS 23.501: " System architecture for the 5G System (5GS)"
[2] TS 23.502: " Procedures for the 5G System (5GS)"
[3] TS 23.503: " Policy and charging control framework for the 5G System (5GS); Stage 2"
[4] TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3"
[5] TS 29.508: " 5G System; Session Management Event Exposure Service; Stage 3"
[6] TS 29.512: " 5G System; Session Management Policy Control Service; Stage 3"
[7] TS 29.514: " 5G System; Policy Authorization Service; Stage 3"
[8] TS 29.522: " 5G System; Network Exposure Function Northbound APIs; Stage 3"
[9] TS 29.591: " 5G System; Network Exposure Function Southbound Services; Stage 3"

[10] TS 29.281: " General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)"
[11] TS 29.244: " Interface between the Control Plane and the User Plane nodes"
[12] TS 29.502: " 5G System; Session Management Services; Stage 3"

14.9 Other XR/AR/VR items

950013	*Study on Smartly Tethering AR Glasses*	FS_SmarTAR	S4	SP-220240	**Thomas Stockhammer, Qualcomm**
960044	**Generic architecture for RT and AR/MR**	GA4RTAR	S4	SP-220672	**Hakju Ryan Lee, Samsung**
960049	*Study on AR and MR QoE Metrics*	FS_ARMRQoE	S4	SP-220708	**Shuai Gao, chinaunicom**
960050	*Study on Audio Aspects for Glasses-type AR/MR Devices*	FS_Audio_5GSTAR	S4	SP-220617	**Stéphane Ragot, Orange**

15 Mission Critical and emergencies

15.1 Gateway UE function for Mission Critical Communication

930043	**Gateway UE function for Mission Critical Communication**	**MCGWUE**		SP-210959	**Oettl, Martin, Nokia**
880033	*Study of Gateway UE function for Mission Critical Communication*	FS_MCGWUE	S6	SP-200335	**Oettl, Martin, Nokia**
930017	**(Stage 2 of) Gateway UE function for Mission Critical Communication**	MCGWUE	S6	SP-210959	**Oettl, Martin, Nokia**
990011	**CT1 aspects of MCGWUE**	MCGWUE	C1	CP-232164	**Magnus Tränk, Ericsson**

Summary based on the input provided by Nokia in SP-241077.

An MC gateway UE has the functionality of providing service access with the MC service system for multiple MC service clients operating on devices that have no MC UE capabilities and no corresponding UICC capabilities.

Description and procedures related to MC gateway UE support are specified in TS 23.280 [2]. Descriptions are provided for:
- the functional model to support the MC gateway UE functionality.
- the mapping of MC user identities to non-3GPP devices which can host MC service clients.
- the mapping of MC user identities which are mapped to non-3GPP devices which cannot host MC service clients.
- how data and signalling is routed to MC service clients on non-3GPP devices via MC gateway UEs.

Stage 1 requirements to support MC gateway UEs are specified in TS 22.179 [1].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930043,930017,990011

[1] TS 22.179: "Mission Critical Push to Talk (MCPTT); Stage 1".
[2] TS 23.280: "Common functional architecture to support mission critical services; Stage 2".

15.2 Mission critical security enhancements phase 3

940015	**Mission critical security enhancements phase 3**	MCXSec3	S3	SP-211363	**Woodward, Tim, Motorola Solutions,**

Summary based on the input provided by Motorola Solutions in SP-241079.

This Work Item enhances the well-defined security architecture, procedures and information flows to protect the mission critical service (MCX). The security architecture, messages and procedures include mechanisms to protect the Common Functional Architecture for mission critical applications. This includes Push-To-Talk (MCPTT), Video (MCVideo) and Data (MCData). Additionally, security mechanisms relating to on-network use, off-network use, roaming, migration, interconnection, interworking, and multiple security domains are covered.

It complements the mission critical Common Functional Architecture defined in TS 23.280 [1], the functional architecture for MCPTT defined in TS 23.379 [2], the functional architecture for MCVideo defined in TS 23.281 [3], the functional architecture for MCData defined in TS 23.282 [4], the Interworking of 3GPP mission critical systems with Land Mobile Systems defined in TS 23.283 [5] and the mission critical services using 5GS defined in TS 23.289 [6].

The MC Service can be used for public safety applications and also for general commercial applications e.g. utility companies and railways. As the security model is based on the public safety environment, some MC security features may not be applicable for commercial purposes.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940015

[1] TS 23.280: "Common functional architecture to support mission critical services; Stage 2".
[2] TS 23.379: "Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT); Stage 2".
[3] TS 23.281: "Functional architecture and information flows for mission critical video; Stage 2".
[4] TS 23.282: "Functional model and information flows for Mission Critical Data".
[5] TS 23.283: " Mission Critical Communication Interworking with Land Mobile Radio Systems; Stage 2".
[6] TS 23.289: "Mission Critical services over 5G System; Stage 2".

15.3 Mission Critical ad hoc group Communications

1010020	**Mission Critical ad hoc group Communications**	**MC_AHGC**	**S6**	SP-221235	**Kiran Gurudev Kapale, Samsung**
930025	**Ad hoc Group Communication support in Mission Critical Services**	AHGC	S1	SP-211058	**Erik.Guttman, Samsung**
980051	**Stage 2 of Mission Critical ad hoc group Communications**	MC_AHGC	S6	SP-221235	**Kiran Gurudev Kapale, Samsung**
1010004	**CT1 aspects of Mission Critical ad hoc group Communications**	MC_AHGC	C1	CP-232162	**Kiran Gurudev Kapale, Samsung**

Summary based on the input provided by Samsung in SP-241337.

The Public Safety and Railway organizations require support for an ad hoc group communication feature which enables the authorized users to combine a set of MCX service users into a group and enable communication. The ad hoc group is used for a single communication session and it does not persist when the communication is terminated. This non-persistent characteristic of an ad hoc group makes it different from the existing user regroup functionality. Similarly, an ad hoc group emergency alert feature is also supported, in which the authorized users combine a set of MCX service users into a group and send an ad hoc group emergency alert followed by an ad hoc group communication if required. The ad hoc group is persisted until the outstanding ad hoc group emergency alert exists and the communication is ongoing on the ad hoc group.

Stage 1 (i.e. SA1) identified the requirements for ad hoc group communications and included them in TS 22.280 [2]. The SA6 studied these requirements as part of FS_MCAHGC and developed solutions in TR 23.700-76 [7]. Normative work has been completed in stage 2 (i.e. SA6 WG) and is specified in the TS 23.280 [3], TS 23.379 [4], TS 23.281 [5], and TS 23.282 [6] to support ad hoc group communications for all mission critical services (i.e. MCPTT, MCVideo, and MCData). The stage 3 (i.e. CT1 WG) aspects of ad hoc group communications are specified in the TS 24.379 [8] and TS 24.380 [9] for MCPTT, TS 24.281 [10] and TS 24.581 [11] for MCVideo, and TS 24.282 [12] and TS 24.582 [13] for MCData. The stage 3 (i.e. CT1 WG) aspects of common core services for ad hoc group communication are specified in TS 24.481 [14], TS 24.482 [15], TS 24.483 [16], and TS 24.484 [17].

In Rel-18, the following functionalities have been introduced as a part of ad hoc group communication for all the mission critical services (MCPTT, MCVideo and MCData):

1) Ad hoc group communications involving one MC system and multiple MC systems for MCPTT service:
   a) Call setup (based on participant list or criteria) procedures using on-demand session and pre-established session.
   b) Call release procedures using on-demand session and pre-established session.
   c) Call rejoin procedures using on-demand session and pre-established session.
   d) Call leave procedures using on-demand session and pre-established session.

e) Call participants modify (based on participant list) procedures using on-demand session by the MCPTT client.
f) Call participants modify (based on criteria) procedures initiated by the participating MCPTT function.
g) Ad hoc group call participants' determination based on the criteria for inviting to/ removing from ad hoc group sessions.
h) Configuration parameters required for ad hoc group communications.

2) Same for MCVideo service, except that this is defined for on-demand session only (no pre-established session).
3) Same for MCData subservices SDS and FD using media plane, also for on-demand session only.
4) Ad hoc group emergency alert support involving one MC system and multiple MC systems for MCPTT/MCData/MCVideo services:
a) Ad hoc group emergency alert (based on criteria) origination and cancellation.
b) Ad hoc group emergency alert notification.
c) Ad hoc group emergency alert participants modify (based on criteria) procedures initiated by the participating function.
d) Ad hoc group emergency alert participants' determination based on the criteria for inviting to/ removing from outstanding ad hoc group emergency alert.
e) Configuration parameters required for ad hoc group emergency alerts.
5) Ad hoc group communications support pre-configured group for end-to-end security involving one MC system and multiple MC systems for MCPTT/MCData/MCVideo.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1010020,930025,980051,1010004

[1] TS 22.282 Mission Critical Data services; Stage 1;
[2] TS 22.280 Mission Critical Services Common Requirements (MCCoRe); Stage 1;
[3] TS 23.280 Common functional architecture to support mission critical services; Stage 2;
[4] TS 23.379 Functional architecture and information flows to support Mission Critical Push-To-Talk (MCPTT); Stage 2;
[5] TS 23.281 Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2;
[6] TS 23.282 Functional architecture and information flows to support Mission Critical Data (MCData) Stage 2;
[7] TR 23.700-76 Study on ad hoc group communication support for mission critical services;
[8] TS 24.379 Mission Critical Push To Talk (MCPTT) call control; Protocol specification;
[9] TS 24.380 Mission Critical Push To Talk (MCPTT) media plane control; Protocol specification;
[10] TS 24.281 Mission Critical Video (MCVideo) signalling control; Protocol specification;
[11] TS 24.581 Mission Critical Video (MCVideo) media plane control; Protocol specification;
[12] TS 24.282 Mission Critical Data (MCData) signalling control; Protocol specification;
[13] TS 24.582 Mission Critical Data (MCData) media plane control; Protocol specification;
[14] TS 24.481 Mission Critical Services (MCS) Group Management; Protocol specification;
[15] TS 24.482 Mission Critical Services (MCS) Identity Management; Protocol specification;
[16] TS 24.483 Mission Critical Services (MCS) Management Object (MO);
[17] TS 24.484 Mission Critical Services (MCS) Configuration Management; Protocol specification;
[18] TS 33.180: Security of the mission critical service;

15.4 Mission Critical Services over 5GProSe

970055	**Mission Critical Services over 5GProSe**	**MCOver5GProSe**		SP-211517	**Yanmei YANG, Huawei**
940023	**Stage 2 of Mission Critical Services over 5GProSe**	MCOver5GProSe	S6	SP-211517	**Yanmei YANG, Huawei**
970034	**CT1 aspects of Mission Critical Services over 5GProSe**	MCOver5GProSe	C1	CP-222176	**Haitao Wei, Huawei**

Summary based on the input provided by Huawei in SP-241343.

This WID specifies the support of MC Services over 5GS to cover both Off-network communication and On-network communication of Mission Critical Services (encompassing UE-to-network relay support) with the following objectives:
1) Functional model: To address necessary updates (e.g. referencing and editorial alignments with TS 23.304) on MC common functional model and MC service functional models in correspondence to the 5G ProSe architectural

model for supporting Off-network communication and On-network communication of Mission Critical Services over UE-to-Network relay.
2) Identification: To address differences in the use of 5G ProSe identifiers.
3) Off-network communication and On-network communication of Mission Critical Services over UE-to-Network relay signalling procedure aspects.

The stage 2 is provided in TS 23.289 [1].

Function Model

Functional architectures are defined to support Off-network communication and On-network communication of Mission Critical Services via 5G prose UE-to-network relay.

Figure 1 shows the on-network architectural model for the MC system solution, where the MC system provides one or more MC services via a single PLMN, which including UE2 connect to MC system via a UE1 which can take the role ofUE-to-network relay.

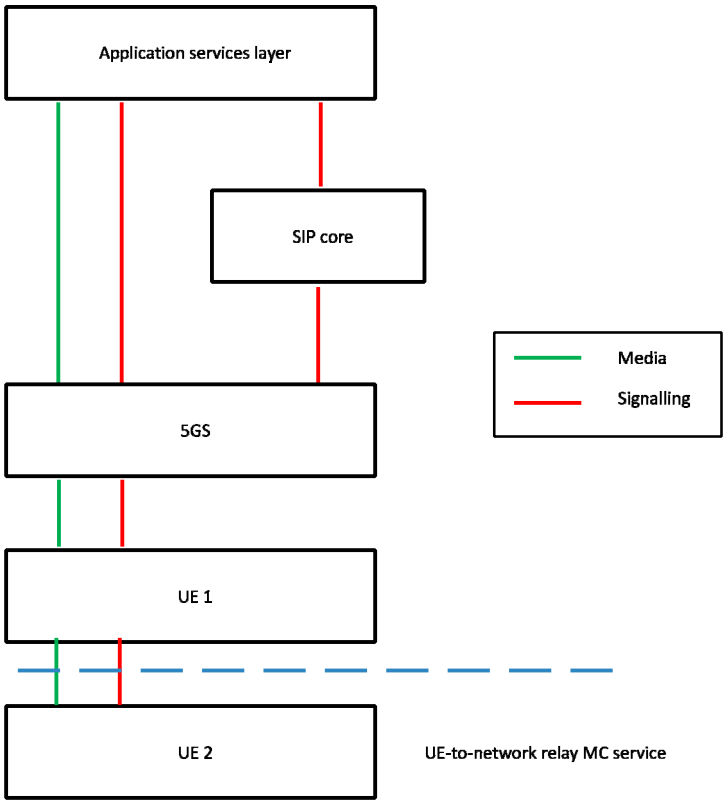

Figure 1: On-network architectural model with UE-to network relay support

Figure 2 shows the off-network architectural model for the MC system solution for 5G inter-UE communication, where no relay function is used.

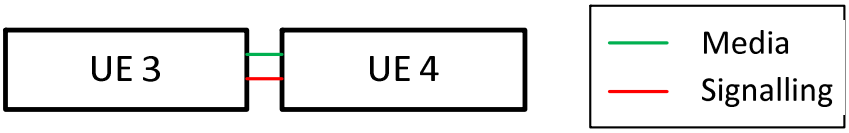

Figure2: Off-network architectural model for 5G inter-UE communication where no relay function is used

Figure 3 shows the off-network architectural model for the MC system solution for configuration management and group management. The description in clause 9.3.1 of TS 23.280 [3] applies.

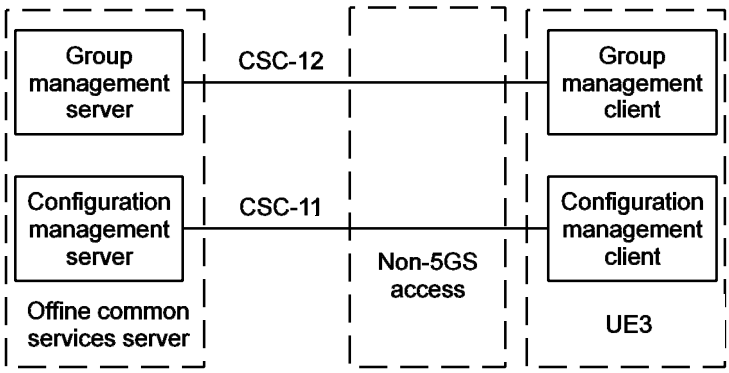

Figure3: Off-network architectural model for configuration management and group management

Identification

The MC service group ID as application layer group identifier is used as Application Layer Group ID, which is defined in TS 23.304 [2].

The association between MC service group ID and Prose layer ID used in group member discovery or group communication is required to be provisioned in the UE through UICC or through ProSe function as specified in TS 23.304 [2], or be delivered from group management server for online configuration and provisioned from configuration management server for offline configuration.

To support the requirement that a public safety ProSe UE-to-network relay shall be able to restrict the relayed group communication on a per group basis, the MC service has to able to provide a means for an MC service administrator to configure a ProSe UE-to-network relay with a list of allowed MC service groups. For each allowed MC service group, a unique associated relay service code is allocated and may be provided to the relay UE from MC service server or DPF.

Table1: Parameters mapping between MC service layer and 5G Prose layer

MC service group ID	M	MC service group ID of the group
Layer-2 Group ID	M	A layer-2 group identifier that may be used to address a set of users at the 3GPP lower layers. This ID is used as destination ID for one-to-many ProSe Direct Communication, or group member discovery as defined in TS 23.304.
Associated relay service code (as specified in TS 23.304 [2])	O	For each allowed MC service group, a unique associated relay service code should be allocated

Signalling procedure aspects

The application layer signalling procedures, defined in TS 23.280 [3], TS 23.379 [4], TS 23.281 [5] and TS 23.282 [6], can be used to support the following functions:
- Off-network MCPTT group call; group member discovery; private call
- On-network MCPTT group call via UE-to-Network relay; private call via UE-to-Network relay
- Off-network MCPTT group call;
- Off-network MCVideo group communication; group member discovery; communication
- On-network MCVideo group communication via UE-to-Network relay
- On-network one-to-one MCData communication via UE-to-Network relay
- Off-network MCData group communication; group member discovery
- Off-network one-to-one MCData communication
- On-network MCData group communication via UE-to-Network relay
- On-network one-to-one MCData communication via UE-to-Network relay

In addition to above, a new feature called “Path switch between MBS session and 5G ProSe UE-to-network relay” is defined to support Service continuity with the following principle:

- Path switch from MBS session to a 5G ProSe UE-to-network relay:
When a MC service UE is in the weak coverage area of MBS session while using MBS session to receive group communication, it shall be switched to unicast receiving mode firstly, then further change to a UE-to-network relay receiving mode if UE-to-network relay is discovered and connected.

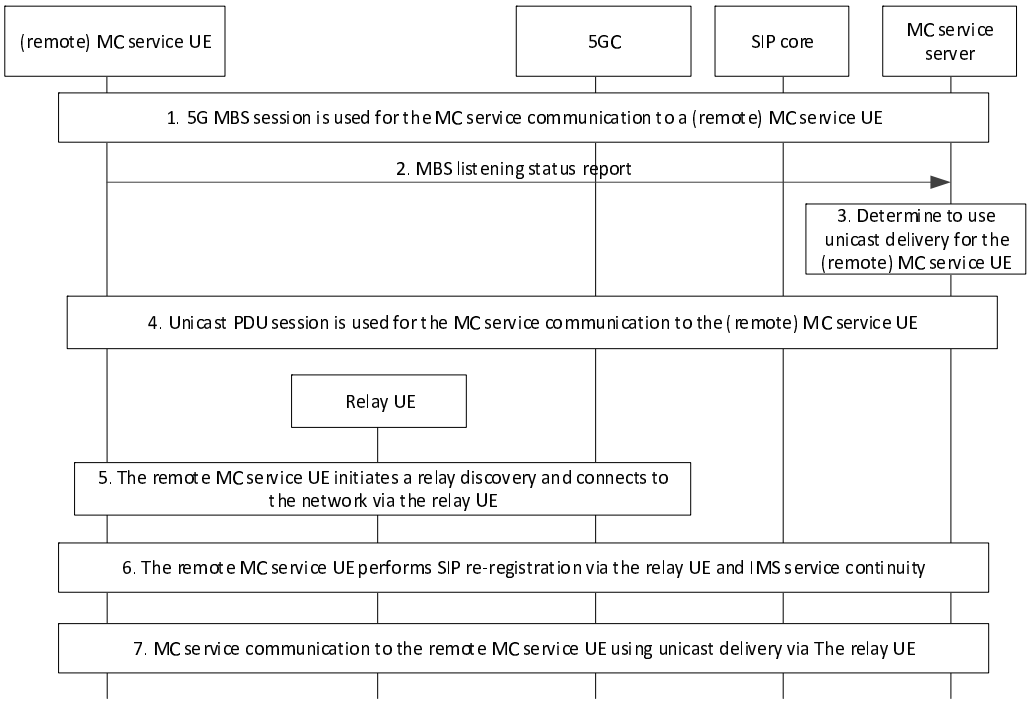

Figure 4 : Path switch from MBS session to a 5G ProSe UE-to-network relay.

- Path switch from a 5G ProSe UE-to-network relay to MBS session:
If a MC service UE in UE-to-Network relay receiving mode detects the MBS session quality is good, it can send a MBS statues listening report to MC service server. The MC service serve determines to stop sending the MC service communications (e.g., DL media, application layer control signalling) using the unicast delivery. Further, the MC server sends the MC service communications via the MBS session. The MC service client switches to receive the MC service communications from the MC service server via the MBS session.

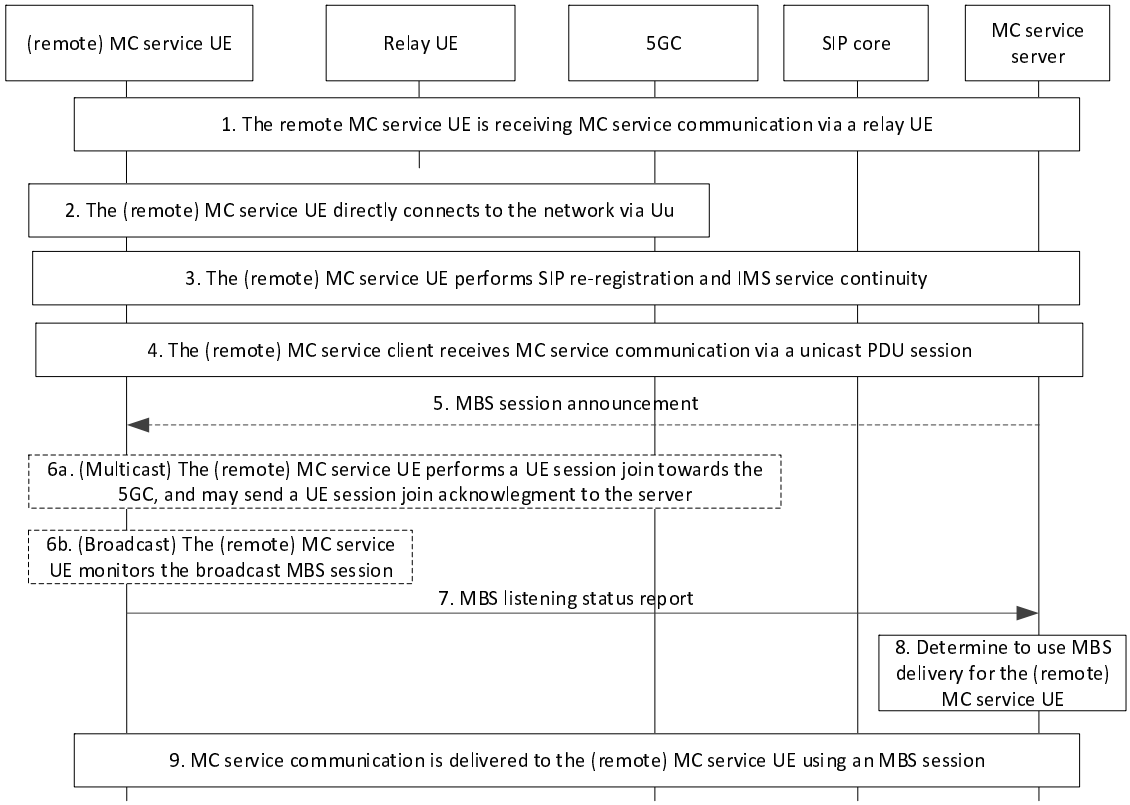

Figure 5: Path switch from a 5G ProSe UE-to-network relay to MBS session.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970055,940023,970034

[1] TS 23.289, Mission Critical services over 5G System
[2] TS 23.304, Proximity based Services (ProSe) in the 5G System
[3] TS 23.280, Common functional architecture to support mission critical services
[4] TS 23.379, Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT)
[5] TS 23.281, Functional architecture and information flows to support Mission Critical Video (MCVideo)
[6] TS 23.282, Functional architecture and information flows to support Mission Critical Data (MCData)

15.5 Other Mission Critical Services aspects

970054	**Mission Critical Services over 5MBS**	**MCOver5MBS**		SP-210958	**Wendler, Ingo, UIC**
930016	**Stage 2 of Mission Critical Services over 5MBS**	MCOver5MBS	S6	SP-210958	**Wendler, Ingo, UIC**
970033	**CT1 aspects of Mission Critical Services over 5MBS**	MCOver5MBS	C1	CP-222175	**Chen, Ying, TD Tech Ltd.**
970027	*Stopped - ProSe Secondary Authentication*	PROSESA	S3	SP-220874	**Samir Ferdi , Interdigital**
940022	*Study on Mission Critical ad hoc group communications*	FS_MCAHGC	S6	SP-211516	**Arunprasath Ramamoorthy, Samsung**
940020	*Study on sharing of administrative configuration between interconnected MC service systems*	FS_MCShAC	S6	SP-211514	**Azem, Dania, BDBOS**
850043	*Study on sharing administrative configuration between interconnected MCX Service systems*	FS_SACI_MCS	S1	SP-190837	**Toobe, Jens, BDBOS**
800023	*Study on Mission Critical services support over 5G System*	FS_MCOver5GS	S6	SP-200837	**Verweij, Kees, The Police of the Netherlands**
960014	**SMS over IMS to emergency centre**	SMS2EC	S1	SP-220438	**Philippe Lotin, Orange**
930026	**Sharing administrative configuration between interconnected MCX Service systems**	SACI_MCS	S1	SP-211059	**Toobe, Jens, BDBOS**
1000042	**Enhanced Mission Critical Push-to-talk architecture phase 4**	**enh4MCPTT**		SP-211519	**Lazara, Dom, Motorola Solutions**
940025	**Stage 2 of enh4MCPTT**	enh4MCPTT	S6	SP-211519	**Lazara, Dom, Motorola Solutions**
1000020	**CT aspects of enh4MCPTT**	enh4MCPTT	C1	CP-231355	**Kiran Kapale, Samsung,**

No summaries were provided for these WIDs.

16 Transportations (Railways, V2X, aerial)

16.1 MBS support for V2X services

1000043	**MBS support for V2X services**	**TEI18_MBS4V2X**		SP-220793	**LaeYoung Kim (LG Electronics),**
970003	**(Stage 2 of) MBS support for V2X services**	TEI18_MBS4V2X	S2	SP-220793	**LaeYoung Kim (LG Electronics),**
1000022	**CT1 aspects of MBS support for V2X services**	TEI18_MBS4V2X	C1	CP-231357	**Herrero Veron, Christian (Huawei)**
1010021	**CT6 aspects of MBS support for V2X services**	TEI18_MBS4V2X	C6	CP-231357	**Herrero Veron, Christian (Huawei)**

Summary based on the input provided by LG Electronics in SP-240328.

This work item specifies Multicast/Broadcast Service (MBS) support for Vehicle-to-Everything (V2X) services.

They are specified in TS 23.287 [1], which covers:

- For NR connected to 5GC, V2X communication over Uu reference point can be multicast/broadcast as defined in TS 23.247 [2].

- MBS for Uu based V2X architecture reference model
- Functionalities for UE, PCF and V2X Application Server related to V2X communication via MBS
- Policy/Parameters related to V2X communication via MBS
- V2X message transmission and reception via MBS: V2X messages are routed from the V2X Application Server towards UEs via broadcast MBS sessions or multicast MBS sessions
- V2X Application Server discovery using broadcast MBS session
- MBS Service Description for V2X use: MBS session announcement for V2X communication, MBS session announcement for V2X Application Server Discovery

Regarding QoS handling for MBS support for V2X services, QoS characteristics values for 5QI = 75 that could be used for V2X message delivery via MBS are specified in TS 23.501 [3].

V2X over MBS is also supported in Stand-alone Non-Public Network (SNPN).

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000043,970003,1000022,1010021

[1] TS 23.287: "Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".
[2] TS 23.247: "Architectural enhancements for 5G multicast-broadcast services; Stage 2".
[3] TS 23.501: "System architecture for the 5G System (5GS)".

16.2 Air-to-ground network for NR

950075	**Air-to-ground network for NR**	**NR_ATG**		RP-230279	**Guo Chunxia, CMCC**
950175	Core part: Air-to-ground network for NR	NR_ATG-Core	R4	RP-230279	**Guo Chunxia, CMCC**
950275	Perf. part: Air-to-ground network for NR	NR_ATG-Perf	R4	RP-230279	**Guo Chunxia, CMCC**

Summary based on the input provided by ZTE in RP-232884.

Air-to-ground (ATG) network refers to in-flight connectivity technique, using ground-based cell towers that send signals up to an aircraft's antenna(s) of onboard ATG terminal. As a plane travels into different sections of airspace, the ATG UE automatically connects to the cell with strongest received signal power, just as a mobile phone does on the ground. In this network, a direct radio link will be established between BS on the ground and ATG UE, i.e. the terminals or user equipments which are mounted in aircraft and support ATG feature.

Thhis WID has achieved the following:

- Study and evaluate adjacent channel co-existence between ATG and Terrestrial network.
- Study and specify RF requirements for ATG gNB and ATG UE such that ATG deployment are well supported.
- Study and specify RRM requirement supporting ATG network deployment and ATG UE mobility

Adjacent channel co-existence between ATG and Terrestrial network.

RAN4 has performed the adjacent channel co-existence simulation between ATG network and TN network under the synchronized operation and non-synchronized operation assumptions. 4GHz and 2GHz are chosen as example bands using antenna array and omni-directional antenna at ATG UE side respectively.

The synchronized operation assumption is used to derive adjacent channel co-existence RF requirements, i.e., ACLR and ACS. Two kinds of layout have been conducted to simulate different location relationship between ATG UE and TN network, one for ATG UE on top of TN network and the other for ATG UE away from TN UE in azimuth. For adjacent channel co-existence, RAN4 has concluded to reuse legacy FR1 TN BS and UE RF requirements (i.e., ACLR and ACS) for ATG BS and UE, respectively.

The non-synchronized operation assumption is used to analyze isolation distance between ATG BS and TN network based on derived ACLR and ACS from synchronization operation. Moreover, a total of 3 cases have been performed to describe different boresight relationship between ATG BS and nearest TN BS. ATG BS point directly at nearest TN BS in azimuth is the worst case. RAN4 concludes optimistic and pessimistic isolation distance for different propagation conditions.

RF requirements for ATG

RAN4 has specified following ATG UE requirement: *ATG UE power class and requirement type; Frequency error; MOP requirements; Configured transmitted power; Minimum output power; Transmit OFF power; Transmit ON/OFF time mask; Power control; Transmit signal quality; Occupied bandwidth; SEM requirements; ACLR requirements; Spurious emission; Transmit intermodulation; REFSENS requirements; Maximum input level; Adjacent channel selectivity; In-band blocking requirements; Out-of-Band blocking requirements/ Spurious response; Narrow band blocking requirements; Intermodulation characteristics; Receiver Spurious emissions*.
RAN4 has specified following ATG BS requirement: *ATG BS class and BS type; ATG Base station power; Transmitted signal quality; Unwanted emission requirements; Transmitter spurious emissions; Transmitter intermodulation; Reference sensitivity level; Dynamic range; ACS; In-band blocking; Receiver intermodulation; Out of band blocking*.

RRM requirements for ATG

RAN4 has specified RRM requirement for FR1 NR ATG scenarios:

- Enhanced inter-frequency cell re-selection requirement
- Location-based CHO
- HO delay requirement for ATG UEs with antenna arrays
- RRC Re-establishment delay requirement for ATG UEs with antenna arrays
- RRC connection release with redirection delay requirement for ATG UEs with antenna arrays
- Initial transmit timing requirements Te
- Gradual timing adjustment requirement
- Timing advance adjustment delay requirement
- RLM/BFD requirement for ATG UEs with antenna arrays
- L1/L3 measurement requirements for ATG UE with antenna arrays
- Applicability rule of ‘deriveSSB-IndexFromCell’ for NR TDD intra-frequency measurement
- Additional scheduling restriction for ATG UEs with antenna arrays

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950075,950175,950275

16.3 Interconnection and Migration Aspects for Railways

980122	**Interconnection and Migration Aspects for Railways**	**IRail**		SP-220098	**Oettl, Martin, Nokia**
950025	**Stage 2 of Irail**	**IRail**	**S6**	SP-220098	**Oettl, Martin, Nokia**
980070	CT1 aspects of eMCSMI_IRail	eMCSMI_IRail	C1	CP-223105	**Won, Sung Hwan, Nokia**
980071	CT4 aspects of eMCSMI_IRail	eMCSMI_IRail	C4	CP-223105	**Won, Sung Hwan, Nokia**
900026	*Study on FRMCS Phase 4*	FS_FRMCS_Ph4	S1	SP-220436	**Guillaume Gach; UIC**
930014	*Study on enhancements to application layer support for V2X services; Phase 2*	FS_eV2XAPP2	S6	SP-220466	**Niranth Amogh, Huawei Telecommunications India**
880034	*Study of Interconnection and Migration Aspects for Railways*	FS_IRail	S6	SP-200336	**Oettl, Martin, Nokia**
880036	*Study on Off-Network for Rail*	FS_OffNetRail	S1	SP-200572	**Guillaume Gach**

Summary based on the input provided by Nokia in SP-241076.

The Rel-18 enhancements for railways focus on interconnection and migration of railways systems.

Functional architecture enhancements to support location information for interconnected MC systems is added, including information flows and procedures for:

- migration of private calls using a functional alias towards a partner MC system.
- migration towards another MC system during an ongoing private communication.
- migration towards another MC system during an ongoing group communication.
- private call forwarding between MCPTT systems.
- private call transfer between MCPTT systems.

The following technical specifications on MCPTT (Mission Critical Push-To-Talk), MCVideo, MCData have been updated:

Stage 2: TS 23.379 [1], TS 23.281 [2], TS 23.282 [3], TS 23.280 [4]

Stage 3: TS 24.379 [5], TS 24.281 [6], TS 24.282 [7], TS 24.484 [8], TS 24.482 [9], TS 24.582 [10]

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980122,950025,980070,980071

[1] TS 23.379: "Common functional architecture to support mission critical services; Stage 2".
[2] TS 23.281: "Functional architecture and information flows to support Mission Critical Video (MCVideo); Stage 2".
[3] TS 23.282: "Functional architecture and information flows to support Mission Critical Data (MCData); Stage 2".
[4] TS 23.280: "Common functional architecture to support mission critical services; Stage 2".
[5] TS 24.379: "Mission Critical Push To Talk (MCPTT) call control; Protocol specification".
[6] TS 24.281: "Mission Critical Video (MCVideo) signalling control; Protocol specification".
[7] TS 24.282: "Mission Critical Data (MCData) signalling control; Protocol specification".
[8] TS 24.484: "Mission Critical Services (MCS) configuration management; Protocol specification".
[9] TS 24.482: "Mission Critical Services (MCS) identity management; Protocol specification".
[10] TS 24.582: "Mission Critical Data (MCData) media plane control; Protocol specification".

16.4 Enhanced NR support for high speed train scenario in frequency range 2 (FR2)

950079	**Enhanced NR support for high speed train scenario in frequency range 2 (FR2)**	**NR_HST_FR2_enh**		RP-233151	**WANG, He (Jackson), Samsung**
950179	Core part: Enhanced NR support for high speed train scenario in frequency range 2 (FR2)	NR_HST_FR2_enh-Core	R4	RP-233151	**WANG, He (Jackson), Samsung**
950279	Perf. part: Enhanced NR support for high speed train scenario in frequency range 2 (FR2)	NR_HST_FR2_enh-Perf	R4	RP-233151	**WANG, He (Jackson), Samsung**

Summary based on the input provided by Samsung in RP-231731.

This Rel-18 WI on enhanced NR support for high speed train (HST) scenario in Frequency Range 2 (FR2) introduces the enhancement to Rel-17 FR2 HST scenario. Same as Rel-17 work item by still focusing on train roof-mounted high-power devices for NR standalone FR2-1 HST scenario with speed up to 350km/h and applicable frequency up to 30GHz, this Rel-18 WI is tasked to introduce the enhanced NR support including intra-band Carrier Aggregation (CA), simultaneous multi-panel operation and enhanced UL timing adjustment solution, and to further study the FR2-1 HST operation in tunnel deployment scenario.

In this WI, to enable the FR2-1 intra-band contiguous and non-contiguous CA deployment, the RF and RRM requirements are introduced for FR2-1 power class 6 (PC6) UE (corresponding to the UE type of high speed train roof-mounted one), which has been introduced without the support of CA operation in Rel-17. More specifically, new PC6-specific intra-band CA RF requirements of Maximum Power Reduction (MPR), Additional Maximum Power Reduction (A-MPR), minimum output power, carrier leakage and in-band emission are introduced, while other existing CA RF requirements shall still be applied for PC6 UE. From RRM perspective, the new requirements of inter-frequency measurement, intra-frequency measurement on Secondary Component Carrier (SCC) and enhanced Secondary Cell (SCell) activation delay requirement for HST scenario are specified.

In FR2-1 bi-directional HST deployment, to enable the simultaneous multi-panel reception with two receive panels which are corresponding to two spherical coverage areas as specified for PC6 UE, new 2 Angle of Arrival (AoA) spherical coverage requirement is introduced in this WI. From RRM perspective accordingly, the enhancement on radio link monitoring, beam failure detection, Layer-1 measurement requirements and the Maximum Receive Timing Difference (MRTD) to be handled are provided for FR2-1 PC6 UE supporting the simultaneous multi-panel reception.

To enable the TCI state switch across non-collocated remote radio heads (RRHs), the uplink timing adjustment solution with the explicit network signalling assistance is introduced. Specifically, with the enhanced MAC CE indication for TCI state switch in FR2-1 HST scenario, UE is informed of the timing difference between downlink signals, based on which the TCI state switch delay and uplink transmission timing adjustment requirements are provided.

In this WI, the reference tunnel deployment is studied with the conclusion that pathloss model in tunnel might have similar characteristics compared to urban open space scenarios, and multi-path components (MPCs) extensively exist but the delay spread is small making MPCs indistinguishable from each other, thus making Line-of-Sight (LoS) propagation model be assumed for tunnel deployment scenario. Moreover the mobility performance in the tunnel scenario is also studied based upon the system-level evaluation.

The BS/UE performance requirements are being discussed for the above-mentioned enhanced features for FR2-1 HST scenario, which will further be completed in the performance phase of this work item.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950079,950179,950279

16.5 Application layer support for V2X services; Phase 3

980125	**Application layer support for V2X services; Phase 3**	**V2XAPP_Ph3**		SP-220916	**Niranth Amogh, Huawei Telecommunications India**
970039	**Stage 2 of V2XAPP_Ph3**	**V2XAPP_Ph3**	**S6**	SP-221229	**Niranth Amogh, Huawei Telecommunications India**
980072	CT1 aspects of V2XAPP_Ph3	V2XAPP_Ph3	C1	CP-231285	**Herrero Veron, Christian (Huawei)**
980073	CT3 aspects of V2XAPP_Ph3	V2XAPP_Ph3	C3	CP-231285	**Herrero Veron, Christian (Huawei)**

No summary was provided for these WIDs.

17 User Plane traffic and services

17.1 Enhanced Multiparty RTT

980007	**Enhanced Multiparty RTT**	MP_RTT	S4	SP-221346	**Huan-yu Su, Huawei**

Summary based on the input provided by Huawei in SP-240218.

S4-220978 summarized the market needs of multiparty real-time text featuresand triggered the creation of this WID, which resulted in the following:

- Both Multiparty RTT over RTP Solution and over IMS Data Channel Solution were developed;
- Normative changes to TS 26.114 to support Multiparty RTT;
- “Implementation guidelines for Multiparty RTT” (TR 26.982), which contains only informative recommendations;

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980007

17.2 5G-Advanced media profiles for messaging services

1000015	5G-Advanced media profiles for messaging services	PROMISE	S4	SP-230542	**Frédéric Gabin (Dolby Laboratories)**

Summary based on the input provided by Dolby France SAS in SP-240428.

There are many messaging applications that leverage the capabilities of 4G/5G IP connectivity to offer instant exchange between individuals or groups of users of text messages but also multimedia content such as images, audio, and video clips. At the same time, GSMA RCS (Rich Communications Services) support is increasing, while SMS/MMS is still a very popular service with universal support, interoperability and roaming. SMS/MMS is used as fallback to GSMA RCS.

In a liaison letter [5], GSMA confirmed that 3GPP SA4 should be specifying SMS/MMS/RCS/Messaging formats and codecs that GSMA can then reference/profile: e.g. add at least AMR-WB and EVS for RCS messaging and consider more advanced formats including XR. GSMA confirmed that a new generic 3GPP specification for messaging apps in general and RCS in particular seems beneficial from both a system and interoperability perspective.

In addition, new media types are evolving in context of XR applications. Sharing 3D assets and scenes for XR experiences has been identified as an important use cases in TR 26.928 [6], TR 26.918 [7] and TR 26.998 [8]. Extending messaging services to support sharing of simple 3D scenes and assets for XR experiences is important.

Because of this, it was considered important to maintain and upgrade the relevant 3GPP specifications in support for messaging applications and services for 5G-Advanced in Rel-18.

The purpose of this Work Item was to specify SMS/MMS/RCS/Messaging formats and codecs that GSMA and other organizations or application vendors can then reference and/or profile to improve messaging service quality and interoperability.

In particular the following objectives were addressed:

1) Adding and upgrading codecs and formats in TS 26.140, TS 26.141 & Removing codecs and formats in TS 26.140, TS 26.141 (Consider each profile and formats in light of deployed services and remove unused ones) [3][4]. For MMS and IMS messaging:

a. Clarify MMS Message Body Formats;
b. Specified applicable Media Types and corresponding requirements;
c. Introduced EVS codec and support for Super-Wideband and Full band for speech message;
d. Introduced IVAS codec for speech and audio messaging;
e. Introduced xHE-AAC support for audio messaging;
f. Removed requirement to support AMR-WB+;
g. Made synthetic audio and vector graphics support optional;
h. Introduced HEIF image format;
i. Upgraded Video requirements with Full HD and HDR in alignment with TS 26.511 5G Media streaming;
j. Clarified file format requirements;
k. Added 3D Scene presentation formats;
l. Removed the requirements for SMIL and xHTML;
m. Added 3D scenes and Assets media types;

2) Create a new Messaging Media profiles specification for potential reference by MMS, GSMA RCS and third-party messaging application potentially used over the 5G System:

a. TS 26.143 [2] was created: this document specifies the media types, formats, codecs capabilities and profiles for the messaging applications used over the 5G System. The scope of the present document extends to codecs for speech, audio, video, still images, bitmap graphics, 3D scenes and assets, and other media in general, as well as scene description.
b. This specification provides the definition of an multimedia messaging body part (MMBP) using the ISO Base Media File format to provide features for mixing multiple sub-parts into a single body part. The MMBP Player and Data models are specified.
c. Media Capabilities are defined for the relevant media types: Container formats; Text; Speech; Audio; Image; Video; Subtitles and text; 3D scenes and assets; Presentation format
d. Profiles are defined: Baseline MMBP Player Profile; Baseline MMBP Generator Profile

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000043,970003,1000022,1010021

[1] Tdoc SP-230542, New WID on 5G-Advanced media profiles for messaging services (PROMISE), TSG-SA#100, June 2023.
[2] TS 26.143 “Messaging Media Profiles”, Rel-18 ((Tdoc SP-240047))
[3] CR 26.140-0021r7 Updates to codecs and formats (Rel-18) (Tdoc SP-240047)
[4] CR 26.141-0011r2 Updates to codecs and formats (Rel-18) (Tdoc SP-240047)
[5] LS from GSMA on 5G-Advanced formats and codecs for messaging services (Tdoc S4-230795)
[6] TR 26.928 “Extended Reality (XR) in 5G”
[7] TR 26.918 “Virtual Reality (VR) media services over 3GPP”
[8] TR 26.998 “Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices”

17.3 Next Generation Real Time Communication services and IMS Data Channel (DC)

920036	**Evolution of IMS Multimedia Telephony Service**	**eMMTEL**		SP-210519	**Hu Yue, China Mobile**
850042	*Study on evolution of IMS multimedia telephony service*	FS_MMTELin5G	S1	SP-190836	**Yan Di, China Mobile**
920029	**Stage 1 of Evolution of IMS Multimedia Telephony Service**	eMMTEL	S1	SP-210519	**Hu Yue, China Mobile**
940066	*Study on system architecture for next generation real time communication services*	FS_NG_RTC	S2	SP-220288	**Yi Jiang, China Mobile**
970014	**System architecture for Next Generation Real time Communication services**	NG_RTC	S2	SP-230098	**Yi Jiang, China Mobile**
990023	CT1 aspects of NG_RTC	NG_RTC	C1	CP-232169	**Chen Xu, China Mobile**
990086	CT3 aspects of NG_RTC	NG_RTC	C3	CP-232169	**Chen Xu, China Mobile**
990087	CT4 aspects of NG_RTC	NG_RTC	C4	CP-232169	**Chen Xu, China Mobile**
1030027	CT6 aspects of NG_RTC	NG_RTC	C6	CP-240271	**Chen Xu, China Mobile**
990038	Security support for Next Generation Real Time Communication services	NG_RTC_SEC	S3	SP-230151	**Fei, Li, Huawei**
960032	*Study on security support for Next Generation Real Time Communication services*	FS_NG_RTC_SEC	S3	SP-220530	**Fei, Li, Huawei**

General aspects

SA2 covered further enhancements to the IMS to fulfil the stage 1 service requirements for IMS in TS 22.261 [1].

In Study Item FS_NG_RTC (ID 940066), SA2 studied the system architecture enhancements to support next generation real time communication services, with the following key issues:
- KI#1: Enhancement to support Data Channel usage in IMS network
- KI#2: IMS-based AR telephony communication
- KI#3: Third party specific user identities
- KI#4: Study of Applicability of Service based principles to IMS media control interfaces

SA2 has concluded the above key issues which was captured in TR 23.700-87 [2]. It is concluded that KI#3 will not progress in R18.

Based on the conclusion of FS_NG_RTC, the Work Item System architecture for Next Generation Real time Communication services (ID 970014) introduces the concept of IMS Data Channel and enhances the IMS architecture and procedures to support management of Data Channel in IMS network. Furthermore, the WI also specifies the procedures to provide AR communication based on IMS Data Channel.

The stage 3 WIs (ID 990023, 990086 and 990087) specifies the corresponding protocols of supporting IMS Data Channel and AR communications. The Stage 3 is covered in TS 29.175 [3], TS 29.176 [4] and TS 29.330 [5].

More precisely, the following aspects are specified in Rel-18:

1. Enhanced IMS architecture to support IMS Data Channel

The enhanced IMS architecture introduces signalling function,i.e. Data Channel Signalling Function (DCSF), and media function, i.e. Media Function (MF), supporting data channel services. DCSF provides data channel policy control and data channel media control. The MF provides media capabilities in support of IMS DC and Augmented Reality.

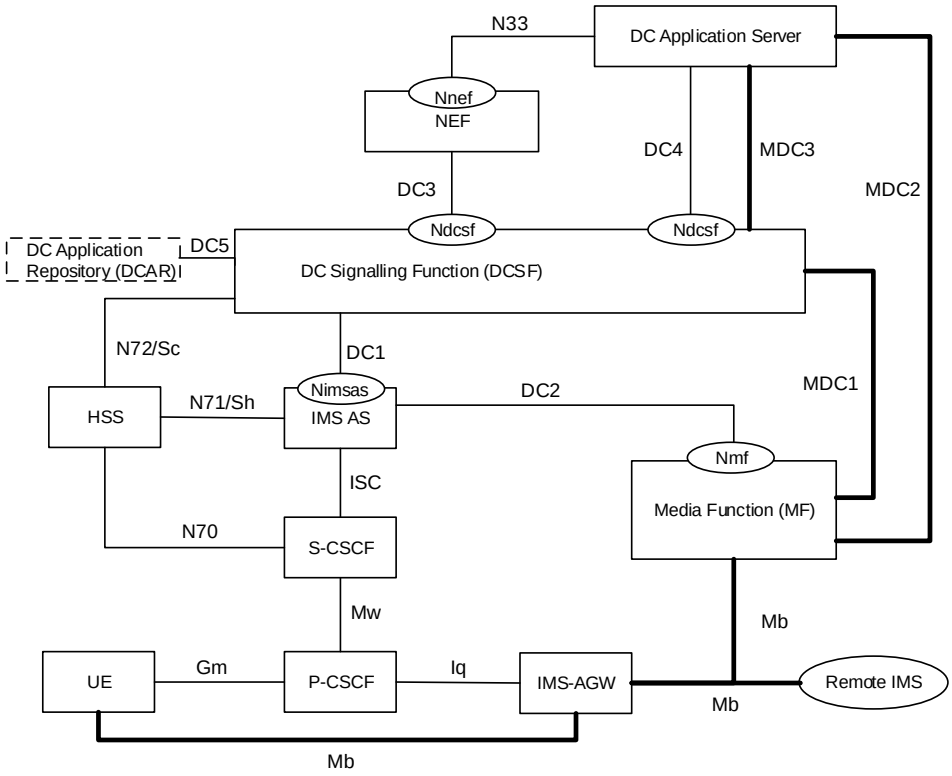

Figure 1: Enhanced IMS architecture to support IMS Data Channel

2. DC capability negotiation

The UE supporting IMS data channel includes the media feature tag in the initial REGISTER request and any subsequent REGISTER request to allow the home IMS network to discover its IMS data channel capability. If the IMS network supports IMS data channel, the S-CSCF includes a Feature-Caps header field indicating its data channel capability in the 200 OK response to the initial and any subsequent REGISTER request.

3. Procedures of IMS DC management

The IMS network supports the end-to-end procedures supporting establishment, modification and termination for bootstrap DC and application DC management in both P2P and A2P/P2A/P2A2P scenarios.

4. NF Services supporting IMS DC

The NRF services for service registration, discovery and selection used on IMS media control architecture and interfaces are enhanced to support capabilities of DCSF and MF. Services of IMS AS and MF is defined to support interactions between DCSF, IMS AS and MF for IMS DC management.

5. AR telephony communication

The IMS network supports procedure enhancements to support AR telephony communication under both UE rendering mode and network rendering mode, on top of DC architecture.

6. Interactions with existing supplementary services

The interactions between IMS Data Channel and the media related supplementary services of the MMTel(e.g. CDIV, HOLD, CONF) are identified, and additional requirements for the IMS network and the UE supporting IMS data channel are specified to support the DC management during services procedures.

Security aspects

Summary based on the input provided by Huawei in SP-240886.

SA2 has studied the system architecture for next generation real time communication services documented in TR 23.700-87 [2]. Based on SA2's study, SA3 has investigated a few potential security impacts.

Specifically, SA3 has been deeply involved in how to support 3rd party (e.g. enterprise) to securely demonstrate to the called party that the caller (e.g. employee) is authorized to use or referring to the specific business information when placing a call touches upon the 3rd parties' identity authentication and authorization in the IMS network.

The other relevant SA2 key issues are how to support data channel and service-based architecture in IMS network. SA3 has also revisited whether SBA mechanisms can fit in service-based architecture in IMS network and analysed security aspects to support Data Channel usage.

The following security aspects are covered:
- service-based architecture in IMS media control interfaces;
- Data Channel usage in IMS network.

The above security features have been specified in TS 33.328 [6].

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=SP-210519,SP-190836,SP-210519,SP-220288,SP-230098,CP-232169,CP-232169,CP-232169,CP-240271,SP-230151,SP-220530

[1] TS 22.261: "Service requirements for the 5G system; Stage 1"
[2] TR 23.700-87: "Study on system architecture enhancement for next generation real time communication; Phase 2"
[3] TS 29.175: "IP Multimedia Subsystem (IMS) Application Server (AS) Services; Stage 3".
[4] TS 29.176: "IP Multimedia Subsystems (IMS); Media Function (MF) Services; Stage 3".
[5] TS 29.330: " IP Multimedia Subsystem (IMS); Sc Interface based on the Diameter protocol".
[6] TS 33.328: "IP Multimedia Subsystem (IMS) media plane security"

17.4 Charging Aspects of IMS Data Channel

1000008	Charging Aspects of IMS Data Channel	IDC_CH	S5	SP-230621	**Chen, Ai, China Mobile,**

Summary based on the input provided by China Mobile in SP-240333.

The architecture, interfaces and procedures of next generation real time communication services have been specified in TS 23.228 [1]. The WID IDC_CH specifies the charging aspects of IMS data channel, including specifying charging principles and information.

The duration-based charging and volume-based charging for IMS data channel are introduced in the WID IDC_CH.

Duration-based charging for IMS data channel: As documented in TS 32.260 [2], the charging principle of this scenario is same as duration-based charging for IMS audio/video session. The information of each DC stream is available in SDP which can be used for IMS data channel charging.

Volume-based charging for IMS data channel: As documented in TS 32.255 [3], SMF may collect the charging information and report to CHF: relevant charging information of IMS data channel services, e.g. QoS support, identifier of caller and callee, supported via N7 interface.

The corresponding Open API and ASN.1 for IMS data channel charging are specified in the TS 32.291 [4] and TS 32.298 [5].

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000043,970003,1000022,1010021

[1] TS 23.228:"IP Multimedia Subsystem (IMS); Stage 2".
[2] TS 32.260: "Telecommunication management; Charging management; IP Multimedia Subsystem (IMS) charging".
[3] TS 32.255: "Telecommunication management; Charging management; 5G Data connectivity domain charging; stage 2".
[4] TS 32.291: "Telecommunication management; Charging management; 5G system; Charging service, stage 3".
[5] TS 32.298: "Telecommunication management; Charging management; Charging Data Record (CDR) parameter description".

17.5 Access Traffic Steering, Switch and Splitting support in the 5G system architecture; Phase 3

990111	**Access Traffic Steering, Switch and Splitting support in the 5G system architecture; Phase 3**	**ATSSS_Ph3**		SP-221334	**Apostolis Salkintzis, Lenovo**
940070	*Study on Access Traffic Steering, Switching and Splitting support in the 5G system architecture; Phase 3*	FS_ATSSS_Ph3	S2	SP-211612	**Salkintzis, Apostolis, Lenovo,**
970023	**Stage 2 of ATSSS_Ph3**	ATSSS_Ph3	S2	SP-221334	**Apostolis Salkintzis, Lenovo**
990021	CT1 aspects of ATSSS_Ph3	ATSSS_Ph3	C1	CP-230334	**Atarius, Roozbeh, Lenovo**
990089	CT3 aspects of ATSSS_Ph3	ATSSS_Ph3	C3	CP-230334	**Atarius, Roozbeh, Lenovo**
990090	CT4 aspects of ATSSS_Ph3	ATSSS_Ph3	C4	CP-230334	**Atarius, Roozbeh, Lenovo**

Summary based on the input provided by Lenovo in SP-241683

The ATSSS_Ph3 work item enhances the 5G system's Access Traffic Steering, Switching, and Splitting (ATSSS) functionality by addressing unresolved issues from Release 17 and introducing new capabilities.

During the study phase [1], the key objectives included:
- Advancing the QUIC-based steering functionality studied in Release 17 by addressing unresolved aspects and supporting per-packet splitting.
- Exploring a new steering functionality based on the DCCP protocol and its multipath extensions to enable per-packet splitting.
- Investigating redundant traffic steering for both GBR and non-GBR traffic to improve reliability and performance.
- Enabling traffic switching within an MA PDU Session between two non-3GPP access paths in the same PLMN, such as switching between paths involving N3IWF and TNGF.
- Examining support for MA PDU Sessions with one 3GPP access path via 5GC and one non-3GPP access path via ePDG/EPC.

In the normative phase, the work specified (i) a new steering functionality for UDP traffic (called Multipath QUIC; MPQUIC) based on the "Proxying UDP in HTTP" mechanism defined in RFC9298), (ii) support for redundant traffic steering for improved reliability, (iii) traffic switching within an MA PDU Session between two non-3GPP access paths in the same PLMN, and (iv) support for MA PDU Sessions with one 3GPP access path via 5GC and one non-3GPP access path via ePDG/EPC, complementing existing capabilities. Relevant CRs to TS 23.501[2], TS 23.502 [3] and TS 23.503 [4] were agreed.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990111,940070,970023,990021,990089,990090

[1] TR 23.742: "Study on Enhancements to the Service-Based Architecture"
[2] TS 23.501: "System architecture for the 5G System (5GS)"
[3] TS 23.502: "Procedures for the 5G System (5GS)"
[4] TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2".

17.6 UPF enhancement for Exposure and SBA

990112	**UPF enhancement for Exposure and SBA**	**UPEAS**		SP-220809	**Yan Han, China Mobile**
940076	*Study on UPF enhancement for Exposure And SBA*	FS_UPEAS	S2	SP-220417	**Yan Han, China Mobile**
970019	**Stage 2 of UPEAS**	UPEAS	S2	SP-230103	**Yan Han, China Mobile**
990002	CT4 aspects of UPF enhancement for exposure and SBA	UPEAS	C4	CP-232027	**Rong Wang, China Mobile**
990092	CT3 aspects of UPF enhancement for exposure and SBA	UPEAS	C3	CP-232027	**Rong Wang, China Mobile**

Summary based on the input provided by China Mobile in SP-240896

Study of extending SBA to user plane has been included in TR 23.742 [1], but without standardization. This work item specifies system enhancements to support UPF enhancement for event exposure and SBA in TS 23.501 [2], TS 23.502 [3], TS 23.503 [4], TS 23.288 [5], TS 29.502 [6], and TS 29.244 [7].

This work item specifies system enhancements to support UPF enhancement for event exposure and SBA, which are specified in TS 23.501 [2], TS 23.502 [3], TS 23.503 [4], TS 23.288 [5], TS 29.502 [6], and TS 29.244 [7]. It includes the following aspects:

- Enhancement in 5GC system to support UPF event exposure service registration and discovery in NRF.
- Enhancement in 5GC system to support UPF expose information to other NFs i.e. NWDAF, AF/NEF and TSN AF.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990112,970019,990002,990092

[1] TR 23.742: " Study on Enhancements to the Service-Based Architecture"
[2] TS 23.501: " System architecture for the 5G System (5GS)"
[3] TS 23.502: " Procedures for the 5G System (5GS)"
[4] TS 23.503: " Policy and charging control framework for the 5G System (5GS); Stage 2"
[5] TS 23.288: " Architecture enhancements for 5G System (5GS) to support network data analytics services"
[6] TS 29.502: " 5G System; Session Management Services; Stage 3"
[7] TS 29.244: " Interface between the Control Plane and the User Plane nodes"

17.7 Tactile and multi-modality communication services

930027	**Tactile and multi-modality communication services**	**TACMM**		SP-211053	**Xiaonan Shi, CMCC**
900027	*Study on TACMM*	FS_TACMM	S1	SP-210209	**Shi, Xiaonan, China Mobile**
930020	**Stage 1 of TACMM**	TACMM	S1	SP-211053	**Xiaonan Shi, CMCC**

Summary based on the input provided by China Mobile in SP-240783.

TACMM identifies new use cases and potential service requirements for 5GS support of tactile and multi-modality communication services.

Use cases involve immersive VR, remote control robot, support of skillset sharing for cooperative perception and maneuvering of robots, haptic feedback for a personal exclusion zone in dangerous remote environments, live event selective immersion, support for IEEE P1918.1 architecture and virtual factory.

Requirements involves service exposure requirements to enable 5G system support of tactile and multi-modality applications.

Stage 2 work of TACMM is within the scope of XRM study and normative work.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930027,930020

[1] TR 22.847:“Study on supporting tactile and multi-modality communication services”
[2] TS 22.261: “Service requirements for the 5G system”

17.8 UE Testing Phase 2

960043	**UE Testing Phase 2**	eUET	S4	SP-220610	**Stéphane Ragot, Orange**

Summary based on the input provided by HEAD acoustics GmbH, Orange in SP-240860.

This work item extends audio test specifications in TS 26.131 [2] and TS 26.132 [3], including the definition of SWB frequency masks and updates to jitter buffer management (JBM) behaviour tests. In addition, this work item resulted in a new specification (TS 26.130) to verify the conformance of the RTP payload implementation in terminals [4]. Furthermore, results from a round robin activity conducted under the Rel-17 work item HaNTE have also been

documented in TR 26.801 [5]. Note that this Work Item is sometimes referred to as "Enhancements to UE Testing" (eUET) within SA4.

The key functionalities of the eUET work item are summarized below:

- Enhancements of terminal tests defined in TS 26.131 (requirements) [2] and 26.132 (test methods) [3]:
  - Frequency masks in SWB mode have been missing since the introduction of SWB functionality in TS 26.131 in Rel-12. Specifically, tolerance masks were missing for headset UE (receive only), desktop hands-free UE, and handheld hands-free UE. Limits for frequency masks have been defined for these SWB test cases – see change request to TS 26.131 in S4-240331.
  - Jitter buffer management (JBM) tests in TS 26.131 and TS 26.132 have been limited to basic reporting of performance statistics with some preliminary profiles since Rel-12. These tests have been replaced with requirements using a new delay/loss profile (described in Annex F of TS 26.132) simulating realistic VoLTE conditions. The test method to assess JBM performance is based on existing UE delay test method in receiving. See change request to TS 26.131 and TS 26.132 in S4-240331 and S4-240342, respectively.
  - Besides, the description of vehicle-mounted hands-free UE, requirements and test methods for this UE type have removed from TS 26.131 and TS 26.132. It was noticed that this UE type was rather outdated and performance requirements only sparsely available – see CR to TS 26.131 in S4-221522 and CR to TS 26.132 in S4-221523
- Definition of a new specification on the RTP payload conformance in TS 26.130 [4]. Requirements and test methods are defined to verify correct implementations of the RTP payload format for 3GPP codecs (AMR, AMR-WB, EVS) used in conversational services in LTE, NR and WLAN terminals. The test setup is similar to TS 26.131 and TS 26.132; by default, electrical interfaces should be used for testing. For each codec, a list of test cases is defined (corresponding to different call instances), and tests at RTP packet level or on the received audio are specified.

In addition, HaNTE round robin test results have been available under Rel-17 - without proper documentation – and included into TR 26.801 (S4-232042).

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960043

[1] Void
[2] TS 26.131, "Terminal acoustic characteristics for telephony; Requirements"
[3] TS 26.132, "Speech and video telephony terminal acoustic test specification"
[4] TS 26.130, "Speech/Audio Codec RTP Payload Format Conformance for UE Testing"
[5] TS 26.801, "User Equipment (UE) supporting handset mode with non-traditional earpieces"

17.9 5G Media Streaming Protocols Phase 2

940010	*Study on 5G Media Service Enablers*	FS_5G_MSE	S4	SP-211338	**Thomas Stockhammer, Qualcomm**
1000018	5G Media Streaming Protocols Phase 2	5GMS_Pro_Ph2	S4	SP-230976	**Thomas Stockhammer, Qualcomm,**

Summary based on the input provided by Qualcomm, Tencent, BBC in SP-240895.

TS 26.501 defines the 5GMS architecture, call flows, and procedures. TS 26.512 defines the 5G Media Streaming protocols. In the 5GMS_Ph2 work item, extensions to 5G Media Streaming architecture are provided. Furthermore, course of the work item producing to TS 26.506 (5G Real-time Media Communication Architecture), many commonalities between streaming and real-time delivery were identified. Many of the features developed primarily for "5G Media Streaming"-based Session Handling are applicable to different service scenarios. Hence, a harmonized Media Session Handling taking into account stage-2 from 5G Media Streaming (TS 26.501) and 5G Real-time Media Communication Architecture (TS 26.506) was developed. Based on the updates in TS 26.501, the new specification TS 26.506 and the result of an extensive study in Rel-17, with outcome documented in TR 26.804, this work item addressed in total 12 topics that are added to 3GPP specifications to address stage-3 support for 5GMS protocol extensions and general Media Delivery interactions and APIs for provisioning and media session handling:

1) Support for uplink streaming as defined in TS 26.501
2) Support for end-to-end low latency live streaming as defined in TS 26.501.
3) Support for 5GMS over MBS and 5GMS hybrid services as defined in TS 26.501

4) Support for multiple media service entry points as defined in TS 26.501
5) Extensions to 5GMS protocols to support traffic identification
6) Addition of necessary parameter extensions to the M1, M5, and M6 reference points to provide access to Background Data Transfer
7) Specification of the usage of Oauth 2.0 (according to the SA3 guidelines) for 5GMS protocols
8) Specifications for the 3GPP Service Handler and URL including the necessary functions on UE and device to support automatic launch of 5G System services
9) Minor enhancements based on feedback from 5G-MAG Reference tool developments.
10) Specification of a RESTful API at reference point M3 for the configuration of 5GMS AS instances by 5GMS AF.
11) Specification of data types for data reporting of ANBR-based Network Assistance invocations and (in liaison with CT3) specification of data types for exposure of events relating to invocation of AF-based and ANBR-based Network Assistance.
12) Harmonization of the 5G media streaming and session handling across 5G Media Streaming and Real-time communication.

To address bullet 12, a new specification for Generalized media delivery was developed in TS 26.510 to document interactions and APIs for provisioning and media session handling consolidating the stage-3 specification for reference points M1/RTC-1, M5/RTC-5 and M6/RTC-6 and port general functionalities from TS 26.512 to this new specification. The work item also updates TS 26.512, TS 26.532 and the Emmy-award winning DASH specification TS 26.247.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000018

[1] TS 26.501, 5G Media Streaming (5GMS); General description and architecture
[2] TS 26.512, 5G Media Streaming (5GMS); Protocols
[3] TS 26.506, 5G Real-time Media Communication Architecture
[4] TR 26.804, Study on 5G media streaming extension
[5] TS 26.510, Media delivery; interactions and APIs for provisioning and media session handling
[6] TS 26.247, Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)
[7] TS 26.532, Data Collection and Reporting; Protocols and Formats

17.10 EVS Codec Extension for Immersive Voice and Audio Services

770024	**EVS Codec Extension for Immersive Voice and Audio Services**	IVAS_Codec	S4	SP-220608	**Bin Wang, Huawei Technologies Co Ltd**

Summary based on the input provided by Huawei in SP-240898.

This work item results from the agreement to establish an IVAS_Codec_Ph2 [1] to handle the IVAS fixed-point C-code development. It:

- Defines a series of Permanent Documents that governs the development and selection of the codec:
  - IVAS-1 “IVAS codec development overview” [2].
  - IVAS-2 “IVAS Project Plan” [3].
  - IVAS-3 “Performance Requirements” [4].
  - IVAS-4 “Design Constraints” [5].
  - IVAS-5 “Selection Rules” [6].
  - IVAS-6 “Selection_Deliverables” [7].
  - IVAS-7a “Processing plan for selection phase” [8].
  - IVAS-8a “Test Plan for Selection Phase” [9].
  - IVAS-9 “IVAS Usage Scenarios” [10].
- Conducted the selection of the codec according to the agreed plan
  - Conducted the selection tests based on a floating-point C-code candidate delivery by the sole proponant organization, i.e. IVAS Public Collaboration group formed by Dolby Sweden AB, Ericsson LM, Fraunhofer IIS, Huawei Technologies Co Ltd., Nokia Corporation, NTT, Orange, Panasonic Holdings Corporation, Philips International B.V., Qualcomm Incorporated, VoiceAge Corporation [11].

  - Reviewed the overall selection deliverables and test results that showed evidences of meeting or exceeding performance requirements established for the WI [12, 13].
  - Selected the proposed codec to be the IVAS standard.
- Based on the selected codec, the following IVAS related specifications are developed:
  - TS 26.250 “Codec for Immersive Voice and Audio Services (IVAS); General overview”
  - TS 26.252 “Codec for Immersive Voice and Audio Services (IVAS); Test sequences”
  - TS 26.253 “Codec for Immersive Voice and Audio Services (IVAS); Detailed Algorithmic Description incl. RTP payload format and SDP parameter definitions”
  - TS 26.254 “Codec for Immersive Voice and Audio Services (IVAS); Rendering”
  - TS 26.255 “Codec for Immersive Voice and Audio Services (IVAS); Error concealment of lost packets”
  - TS 26.256 “Codec for Immersive Voice and Audio Services (IVAS); Jitter Buffer Management”
  - TS 26.258 “Codec for Immersive Voice and Audio Services (IVAS); C code (floating-point)”
  - TR 26.997 “Codec for Immersive Voice and Audio Services (IVAS); Performance characterization”

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=770024

[1] IVAS_Codec_Ph2 WID in SP-240676
[2] S4-231032 IVAS codec development overview (IVAS-1) v0.5.0.
[3] S4-240369 IVAS-2 v0.8.0 IVAS Project Plan.
[4] S4-231049 IVAS-3 Performance Requirements 1.1.0.
[5] S4-231031 IVAS Design Constraints (IVAS-4) 1.2.0.
[6] S4-231086 - IVAS-5 Selection Rules - v.1.0.0.
[7] S4-231087_IVAS-6_Selection_Deliverables 1.0.0.
[8] S4-231306 IVAS-7a Processing plan for selection phase, v.1.1.0.
[9] S4-231115 IVAS Permanent Document IVAS-8a: Test Plan for Selection Phase v.1.1.0
[10] S4-231523 IVAS Usage Scenarios (IVAS-9), Version: 0.4.0
[11] S4-231233 High-Level Description of the IVAS Codec Candidate of the “IVAS Codec Public Collaboration”.
[12] S4-231228 Fulfilment of WID Objectives by the IVAS Codec Candidate.
[13] S4-231573 GAL_Report_IVAS_Selection_Phase.

17.11 5G Media Streaming Audio codec phase 2 for 5G-Advanced

980009	**5G Media Streaming Audio codec phase 2 for 5G-Advanced**	5GMS_Audio_Ph2	S4	SP-221033	**Frédéric Gabin (Dolby Laboratories)**

Summary based on the input provided by Dolby Laboratories in SP-250351.

The 5G Media Streaming stage 3 specification work done in Rel-16 limited the audio formats to a selection among legacy PSS specification TS 26.234. In Rel-18 it was felt important for the industry be able to rely on an efficient and high-performance set of specified audio codecs and formats for streaming services over 5G-Advanced networks and devices.

The purpose of the various 5G Media Streaming profiles is to specify interoperability points for various classes of 5G capable devices and services. While these are not mandated for any type of 5G devices, it is important that vendors and content providers can claim compliance to certain profiles and their normative requirements to ensure interoperability and performance of streaming services. Furthermore, for these profiles to be relevant for 5G streaming over 5G-Advanced networks, it is also important that they rely on state-of the art efficient and high-performance audio codecs and formats with wide industry support.

The xHE-AAC® codec features and performances over HE-AAC v2 (aka “eAAC+ stereo”) and AMR-WB+ are well documented:

- Audio Engineering Society Convention Paper 8654 at 132nd Convention, MPEG Unifed Speech and Audio Coding - The ISO/MPEG Standard for High-Efficiency Audio Coding of all Content Types, Max Neuendorf et al.

- Technical Paper, Extended HE-AAC – Bridging the gap between speech and audio coding, Fraunhofer Institute for Integrated Circuits IIS

Technical resources are also available at AAC Audio Tests Site:

- AAC Audio Playback Tests, Fraunhofer IIS. Website url: https://www2.iis.fraunhofer.de/AAC/index.html

xHE-AAC is supported by iOS and AOS devices and by many service providers like e.g. Netflix:

- Fraunhofer IIS Annual Report 2020, Apple, Amazon, and Android products with xHE-AAC. Website Url: https://www.iis.fraunhofer.de/en/profil/jb/2019/apple-amazon-android-with-xhe-aac.html

- Netflix Technology Blog, Optimizing the Aural Experience on Android Devices with xHE-AAC. Website url: https://netflixtechblog.com/optimizing-the-aural-experience-on-android-devices-with-xhe-aac-c27714292a33

As a result of this work, a new Audio Operation Point was specified in TS 26.117 [1] with support for the xHE-AAC codec to improve efficiency and performance for Audio content of 5G Media streaming services over 5G-Advanced networks and devices. TS 26.511 [2] was updated to guarantee interoperability with conditional mandatory support for eAAC+ for streaming default and Television (TV) profiles and the newly defined xHE-AAC stereo Audio operation point is specified as recommended for streaming default and Television (TV) profiles.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980009

[1] 3GPP TS 26.117, 5G Media Streaming (5GMS); Speech and audio profiles
[2] 3GPP TS 26.511, 5G Media Streaming (5GMS); Profiles, codecs and formats

17.12 5G Media Streaming Architecture Phase 2

960047	**5G Media Streaming Architecture Phase 2**	5GMS_Ph2	S4	SP-230164	**Iraj Sodagar, Tencent**

Summary based on the input provided by Qualcomm Incorporated, Dolby Laboratories, Tencent, BBC at SA#107.

TS 26.501 [1] defines the 5GMS architecture, call flows, and procedures, originally specified in Rel-16. Based on two feasibility studies "Study on 5G media streaming extensions (FS_5GMS_EXT)" and " Feasibility Study on Multicast Architecture Enhancements for 5G Media Streaming (FS_5GMS_Multicast)", several potential improvement areas were identified to initiate normative work in the context of 5GMS. The work item addressed the stage-2 aspects 5G Media Streaming Architecture Phase 2 based on the conclusions in TR 26.802 (for MBS) and in TR 26.804 (for 5GMS):

- Uplink streaming: While introduced in principle in Rel-16, uplink streaming was severely underdefined and lacked the essential features needed for mainstream deployments. Features initially only available to downlink streaming are generalized to also be usable for uplink stream and additional features are added to support different collaboration scenarios. Details of uplink streaming are defined in clause 5 of TS 26.501.

- 5GMS content delivery via 5G System and MBS: The MBS delivery feature is applicable to downlink media streaming only. It enables the 5GMS System to provision the delivery of downlink media streaming content via MBS User Services sessions. In addition, the clause defined details to support for the case that a 5GMS service is available on MBS and at the same time on unicast. The service on unicast may be richer and extended and may provide additional user experiences. This feature is defined in clause 4.9 and high-level procedures are defined in clause 5.12 of TS 26.501.

- Hybrid DASH/HLS operation: This feature considers the case that a 5GMSd Application Provider publishes the same service in different media formats, all to be ingested by the same logical 5GMSd AS. The different media formats of the service are described by different presentation manifests (e.g. Dynamic Adaptive Streaming over HTTP and HTTP Live Streaming) but are described by a common Content Hosting Configuration under a single Provisioning Session. The different media formats may or may not share the media resources described by their respective presentation manifests.

- Extensions to Dynamic Policies to support service operation points: A conceptual Service Operation Point is an abstract set of requirements that support a media streaming service (e.g., SD, HD, UHD, low latency). It is identified by an External reference that is used to tag Policy Template resources provisioned in the 5GMS System and Service Descriptions included in Media Entry Point documents. If there is a Policy Template available for the current media streaming session with the indicated External reference, the 5GMS Client instantiates this Policy Template by interacting with a network-side component of the 5GMS System in order to realise the Service Operation Point

described by the Policy Template and the Service Description. The effect of this is that the corresponding network Quality of Service is applied to the media streaming session.

- 5GMS AS configuration: Procedures on interface M3 are specified. This allows the 5GMSd AF to configure the related 5GMSd AS instance(s) via reference point M3d to prepare for media ingest for that particular Content Hosting Configuration. As well as configuring any necessary Server Certificates and/or Content Preparation Templates, this also involves instructing the 5GMSd AS instance(s) to set appropriate caching rules, to perform URL signature validation and to limit access through geofencing.

- Improvements to Data collection: The data collection, reporting and exposure feature is applicable to both downlink media streaming and uplink media streaming. It enables the 5GMS System to log data relating to media streaming sessions and to expose this to subscribers in the form of Events. In TS 26.501, this feature is defined in clause 4.7 and high-level procedures are defined in clause 5.11 (for downlink media streaming) and clause 6.8 (for uplink media streaming).

- 3GPP Service URL: Service URL handling is applicable to downlink and uplink media streaming. This feature is defined in clause 4.10 and high-level procedures are defined in clause 9 of TS 26.501. The intent of 3GPP Service URL handling is to launch UE functions based on the execution of a URL. This enables 5G Media Streaming services to be announced within a third-party application, a general web page, a messaging service or shared via social messages using a 3GPP Service URL for 5GMS. When a service is launched using a 3GPP Service URL for 5GMS, a 5GMS Client function for media session handling is expected to be launched implicitly alongside, for example, a primary media stream handling function

- Background Data Traffic: A new feature is added such that the Policy Template may include a reference to an existing Background Data Transfer policy. Parameters are specified that include desired time windows when Background Data Transfer may be advertised to 5GMS Clients, a quota representing the maximum number of 5GMS Clients that are permitted to take advantage of Background Data Transfers in each such time window and a quota representing a ceiling for the aggregate volume of data that all 5GMS Clients are permitted to transfer in each Background Data Transfer window. The procedures for downlink background data transfer using dynamic policy invocation are specified.

The work item and the respective CRs address the updates recommended above.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960047

[1] 3GPP TS 26.501, 5G Media Streaming (5GMS); General description and architecture

17.13 Other User Plane traffic and services items

830005	**Terminal Audio quality performance and Test methods for Immersive Audio Services**	ATIAS	S4	SP-190040	**Stéphane Ragot, Orange**

1000016	*Study on Film Grain Synthesis*	FS_FGS	S4	SP-230539	**Brian Lee (Dolby Laboratories)**
1000017	*Study on new HEVC profiles and operating points*	FS_HEVC_Profiles	S4	SP-230540	**Waqar Zia**
1000019	*Study of Avatars in Real-Time Communication Services*	FS_AVATAR	S4	SP-230544	**Bouazizi, Imed, Qualcomm**
870013	Traffic Models and Quality Evaluation Methods for Media and XR Services in 5G Systems	FS_XRTraffic	S4	SP-210043	**Thomas Stockhammer**

Summary not expected.

18 Edge computing

18.1 Edge Computing Phase 2

980123	**Edge Computing Phase 2**	FS_EDGE_Ph2			**Patrice Hédé, Huawei Technologies**

950049	*Study on Edge Computing phase 2*	FS_EDGE_Ph2	S2	SP-220070	**Patrice Hédé, Huawei Technologies**
940059	*Study on Stage 2 of Edge Computing phase 2*	FS_EDGE_Ph2	S2	SP-220352	**Patrice Hédé, Huawei Technologies**
950023	*Study on Security of Edge Computing phase 2*	FS_EDGE_Ph2	S3	SP-220201	**Bo Zhang, Huawei**
970026	**(stage 2 of) Edge Computing Phase 2**	EDGE_Ph2	S2	SP-230112	**Patrice Hédé, Huawei Technologies**
980076	CT3 aspects of EDGE_Ph2	EDGE_Ph2	C3	CP-220325	**Qi Caixia, Huawei**
980077	CT4 aspects of EDGE_Ph2	EDGE_Ph2	C4	CP-220325	**Qi Caixia, Huawei**
990039	Security Aspects of Support for Edge Computing in 5GC phase 2	EDGE_Ph2	S3	SP-230366	**Bo Zhang, Huawei Technologies**
900016	Stage 2 of eEDGE_5GC	eEDGE_5GC	S2	SP-201107	**Hui Ni, Huawei**
830008	Study on Application Architecture for enabling Edge Applications	FS_EDGEAPP	S6	SP-190065	**Basavaraj (Basu) Pattan, Samsung**

Summary based on the input provided by Huawei, HiSilicon in SP-240887.

eEDGE_5GC is the feature studied and specified by TS 23.548[1] and TS 23.558[2], used to provide efficient service experience with an EDGE server which is deployed near the UE. The security specification of EDGE is based on their work and defines the security protection for interfaces in the roaming scenario, and the corresponding authentication and authorization work related with EEC/ECS/EES.

This work item studies the security enhancements on the support for Edge Computing in the 5G Core network defined in TS 23.548 [1], and application architecture for enabling Edge Applications defined in TS 23.558 [2], and specified the security aspects of enabling Edge Computing in 5GC concluded in TR 33.739 [3], with the following aspects:

- Security enhancement for edge computing based on the architectural enhancements, such as
  - Authorization of PDU session to support local traffic routing to access an EHE in the VPLMN Authorization between EESes
  - Security of EAS discovery procedure via V-EASDF in VPLMN
- Security enhancement of enabling edge computing applications, such as
  - Authentication and authorization of the EEC/UE by the ECS/EES
  - Authentication mechanism selection between EEC and ECS/EES
  - Authentication and Authorization between V-ECS and H-ECS
  - Transport security for the EDGE10 interface
  - Authorization between EESes

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960043

[1] TS 23.548: "5G System Enhancements for Edge Computing; Stage 2".
[2] TS 23.558: "Architecture for enabling Edge Applications".
[3] TS 33.739: "Study on security enhancement of support for edge computing phase 2".

18.2 Architecture for enabling Edge Applications Phase 2

980132	**Architecture for enabling Edge Applications Phase 2**	**EDGEAPP_Ph2**		SP-221231	**Sapan Shah, Samsung**
970040	**(Stage 2 of EDGEAPP_Ph2) Architecture for enabling Edge Applications Phase 2**	**EDGEAPP_Ph2**	**S6**	SP-221231	**Sapan Shah, Samsung**
980074	CT1 aspects of EDGEAPP_Ph2	EDGEAPP_Ph2	C1	CP-231197	**Narendranath Durga Tangudu**
980075	CT3 aspects of EDGEAPP_Ph2	EDGEAPP_Ph2	C3	CP-231197	**Narendranath Durga Tangudu**
920017	*Study on enhanced architecture for enabling Edge Applications*	FS_eEDGEAPP	S6	SP-211510	**Gupta, Nishant, Samsung**

Summary based on the input provided by Samsung in SP-240863.

Edge computing is a well-known industry concept, and is supported within 3GPP networks with the introduction of Edge computing capabilities in 5G System Architecture. In Rel-17, 3GPP SA6 working group specified an architecture for enabling the edge applications in TS 23.558 [1] with basic capabilities. In Rel-18, enhancements are made to support

emerging industry requirements (e.g. GSMA OPG) and to add more capabilities to the functionalities that were specified in Rel-17.

In Rel-18 enhancements are done to specify following new features:

1) In Rel-18 enhancements are done to specify following new features: Support for roaming and federation: Architecture for local breakout and home routed PDU session were specified. Procedures and information flows defined for ECS discovery and Service provisioning info retrieval.

2) Edge node sharing: This feature is a special use case within federation. Home ECSP and partner ECSP have federation agreement, and partner ECSP shares its edge resources to the home ECSP – where home ECSP deploys the application server for its subscribers. Procedures and information flows defined to enable discovery of EAS deployed in partner ECSP.

3) Discovery of common EAS: The feature enables the participants of the same application specific group to discover same common EAS where all participants within an EDN can connect to. Architecture and procedures are enhanced to support common EAS discovery. New procedures are also defined to announce common EAS to other EESs and to exchange common EAS information to central repository.

4) Enhancements to dynamic EAS instantiation: During EAS discovery or ACR, the EES may fail to discover and select the EAS. The EES may trigger the ECSP management system to instantiate the EAS. Procedures are enhanced to provide EAS instantiation status to EEC.

5) Notification Management Service: In order to send notification from ECS or EES to EEC, Notification management service as defined in SEAL is reused in EDGEAPP where EEC acts as a VAL client, EES and ECS acts as a VAL server.

6) ACR between EAS and Cloud: Architecture and procedures are enhanced to support service continuity to cloud.

7) Bundle EASs: To provide services to the end user a typical AC communicates with multiple endpoints i.e. multiple EASs – called direct bundled EASs. In some case, to provide services to the end use, EAS partners with other EASs – called linked bundled EASs. Enhancements are made to discover bundled EASs and also to support service continuity for bundled EASs

Further, SA6 also enhanced architecture and procedure to enable edge applications to provide support for Exposure of EAS Service APIs using CAPIF, EAS Information provisioning, enhancements to service continuity planning, EDGE-5 APIs, Application traffic filter exposure, EEL service differentiation, Support for EAS synchronization, Application traffic influence from EAS, Support of constrained devices, Support of NAT deployed within EDN, ACR scenario combination, Simultaneously EAS connectivity in ACR, Usage of Edge Analytics.

Management aspects of application layer support of the Edge Applications is specified in TS 28.538 [2].

Security aspects of application layer support of the Edge Applications is specified in TS 33.558 [3].

Enhancements to stage 3 normative work for application layer support of the Edge Applications are specified as open APIs in TS 24.558 [4] and TS 29.558 [5].

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980132,970040,980074,980075

[1] TS 23.558: "Architecture for enabling Edge Applications".
[2] TS 28.538: "Management and orchestration; Edge Computing Management".
[3] TS 33.558: "Security aspects of enhancement of support for enabling edge applications".
[4] TS 24.558: "Enabling Edge Applications; Protocol specification".
[5] TS 29.558: "Enabling Edge Applications; Application Programming Interface (API) specification; Stage 3".

18.3 Edge Application Standards in 3GPP and alignment with External Organizations

960011	**Edge Application Standards in 3GPP and alignment with External Organizations**	EDGEAPP_EXT	S6	SP-231156	**Meghashree Dattatri Kedalagudde, Intel**

Summary provided by Intel.

The EDGEAPP_EXT work item captures the alignment and deployment aspects of EDGEAPP specified in TS 23.558 [1] with ETSI MEC and GSMA OP architectures. The recommendations and conclusion of the work is reported in TR 23.958[2].

The following highlights the summary of the work as part of the EDGEAPP_EXT work item:

- TR 23.958 provides recommendations for industry stakeholders regarding the alignment of the EDGEAPP architecture with the ETSI MEC reference architecture and the GSMA Operator Platform (OP).

- Alignment of EDGEAPP with ETSI MEC: TR 23.958 describes the relationship between EDGEAPP and ETSI MEC architectures, it maps EAS Profile and AppInfo to facilitate application registration across platforms. It describes EDGE-9 and Mp3 reference points.

- Alignment of EDGEAPP with GSMA OP: TR 23.958 illustrates the mapping relationship between the EDGEAPP architecture and the GSMA OPG reference architecture, including ECS, EES, and the Edge management system.

- CAPIF Framework: The CAPIF framework is aligned between 3GPP EDGEAPP and ETSI MEC architectures, allowing an Edge application acting as a CAPIF API invoker to discover and invoke Edge platform services from both 3GPP EDGEAPP and ETSI MEC.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960011

[1] TS 23.558: "Architecture for enabling Edge Applications".
[1] TR 23.958: " Edge Application Standards in 3GPP and Alignment with External Organizations "

19 Non-Public Networks

See also Further enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR and EN-DC

19.1 Non-Public Networks Phase 2

980128	**Non-Public Networks Phase 2**	**eNPN_Ph2**		SP-220805	**Hedman, Peter, Ericsson**
940075	*Study on enhanced support of Non-Public Networks phase 2*	FS_eNPN_Ph2	S2	SP-220418	**Hedman, Peter, Ericsson**
970015	**Stage 2 of Non-Public Networks Phase 2**	eNPN_Ph2	S2	SP-230096	**Hedman, Peter, Ericsson**
960033	*Study on security aspects of enhanced support of Non-Public Networks phase 2*	FS_eNPN_Ph2_SEC	S3	SP-220531	**Jost, Christine, Ericsson,**
990043	Security aspects of support of Non-Public Networks phase 2	eNPN_Ph2	S3	SP-230156	**Jost, Christine, Ericsson**
980078	CT1 aspects of eNPN_Ph2	eNPN_Ph2	C1	CP-231286	**Sedlacek, Ivo, Ericsson**
980079	CT3 aspects of eNPN_Ph2	eNPN_Ph2	C3	CP-231286	**Sedlacek, Ivo, Ericsson**
980080	CT4 aspects of eNPN_Ph2	eNPN_Ph2	C4	CP-231286	**Sedlacek, Ivo, Ericsson**
940043	*Study on Charging Aspects for Enhanced Support of Non-Public Networks*	FS_eNPN_CH	S5	SP-211447	**Chen, Ai, China Mobile**
990028	Charging Aspects for Enhanced Support of Non-Public Networks	eNPN_CH	S5	SP-230177	**Chen, Ai, China Mobile**
990034	Management of non-public networks phase 2	OAM_NPN_Ph2	S5	SP-230184	**ZHANG, Kai, Huawei**
940035	Study on enhancement of management of non-public networks	FS_OAM_eNPN	S5	SP-230185	Kai ZHANG, Huawei
991138	Core part: Non-Public Networks Phase 2: NG-RAN aspects	eNPN_Ph2-NGRAN-Core	R3	RP-231185	**Shengnan Liu, China Telecom**

Summary based on the input provided by by Ericsson in SP-240381 for the General aspects, by China Telecom in RP-233568 for the RAN aspects, by China Telecom in SP-240334 for the Charging aspects and by Huawei in SP-240143 for the management aspects (UID 990034 and 940035).

General aspects

The Rel-17 work item Enhanced support of Non-Public Networks further enhanced the support of non-public networks introduced in Rel-16. The Non-Public Networks provides 5GS coverage within a specific geographic area for non-public use and is a key demand of emerging 5G applications and verticals.

The Rel-18 work item on Non-Public Networks Phase 2 builds on the work in Rel-16 and Rel-17. It enables SNPN support for idle and connected mode mobility between equivalent SNPNs without new network selection, support for non-3GPP access for SNPN, and support for providing access to Localized Services.

Support for enhanced mobility by enabling support for idle and connected mode mobility between SNPNs without new network selection, including:

a. UE and AMF support of equivalent SNPN list in NAS;
b. NG-RAN and AMF support of equivalent SNPNs in NGAP; and
c. UE/NG-RAN/AMF take equivalent SNPN list into consideration, for supporting relevant functions, e.g., idle/connected mode mobility.

Support for non-3GPP access for SNPN: The Access Network from which the UE can access an SNPN can be a non-3GPP access i.e., Untrusted non-3GPP access network, or Trusted non-3GPP access network. This includes functionality to enable access via wireline access network to 5GCN of an SNPN, Non-Seamless WLAN offload (NSWO) procedure, and Non-5G-Capable over WLAN (N5CW) access to SNPNs. Support for non-3GPP access for SNPN required additional security specifications, since SNPN allows the use of additional EAP methods for mutual authentication between UE and network, e.g., certificate-based authentication, and the usage of anonymous SUCI for identifier privacy.

Support for providing access to Localized Services: Enabling UEs to perform SNPN selection for accessing SNPNs providing access to Localized Services. This was achieved by new lists for automatic SNPN selection i.e., Credentials Holder controlled prioritized list of preferred SNPNs for accessing Localized Services, and Credentials Holder controlled prioritized list of GINs for accessing Localized Services, and by enhancing manual SNPN selection as well.

Informative description how existing 5GS functionality can be used to enable access to Localized Services in SNPN or PNI-NPNs e.g., information that can be included in agreements with the Localized Service Providers, configuration of network, re-use of Session Management functionality, how to enable and restrict the UE's access to Localized Services and support for leaving network that provides access to Localized Services.

RAN aspects

The Rel-18 work item “Non-Public Networks Phase 2: NG-RAN aspects” objectives are to support the enhanced mobility by enabling support for idle and connected mode mobility between SNPNs without new network selection [RAN3, RAN2] and to support for non-3GPP access for SNPN [RAN3].

It specified the following key functionalities:

Support of equivalent SNPNs

For this feature, the following specification impacts are identified.

Cell (re)selection: to support idle mode mobility between SNPNs without new network selection, the UE NAS shall be able to maintain an equivalent SNPN list and provide it to UE AS for cell (re)selection. Based on the equivalent SNPN list, the UE AS will also consider a cell that is part of SNPN of the Equivalent SNPN list of the UE as a suitable cell when the cell (re)selection criteria is fulfilled. The support of equivalent SNPNs for cell (re)selection is introduced as an optional UE feature without signaling. It is optional for UE in SNPN access mode to support cell (re)selection for equivalent SNPNs.

Handover: to support equivalent SNPNs in mobility scenario, the selected SNPN ID should be indicated to the target NG-RAN node for Xn based and NG based handover. Specifically,

- For Xn based handover, if the change of serving SNPN happens, the source gNB should replace the serving SNPN ID with the identity of the target SNPN and move the serving SNPN to the equivalent SNPN list, before propagation the Mobility Restriction List.

- For NG based handover, the source NG-RAN node indicates the selected SNPN ID to the AMF together with the TAI in Handover Required message. Source AMF uses the selected SNPN ID together with the TAI information supplied by the source NG-RAN to select the target AMF. The source AMF should forward the selected SNPN ID to the target AMF. The target AMF indicates the selected SNPN ID to the target NG-RAN so that the target NG-RAN can select target cells for future handover appropriately.

NR-NR Dual Connectivity: The NR-NR dual connectivity across equivalent SNPNs is supported in this release, the MN may provide the selected NID to the SN during SN Addition and Modification procedures.

Support of non-3GPP access for SNPN

In Rel-18, it was agreed to support non-3GPP access for SNPN. In current NGAP specification, the INITIAL UE MESSAGE contains the “Selected PLMN Identity” for non-3GPP access. To align with the equivalent PLMN, the selected NID is introduced in the INITIAL UE MESSGAE.

Charging aspects

In SA5, TR 28.828 [1] studied "Charging Aspects for Enhanced Support of Non-Public Networks" and, following eNPN_CH, led to update TS 32.255 [2], TS 32.256 [3], TS 32.291 [4] and TS 32.298 [5].

The system architecture for the 5G System supporting Non-Public Network as specified in TS 23.501 [6]. The WID eNPN_CH specifies the charging principles, charging requirements and charging information for Non-Public Networks charging.

As documented in TS 32.255 [2], the following characteristics for converged charging for Non-Public Networks in SMF are specified:

- For SNPN data connectivity charging, SMF collects and reports the charging information which contains: SNPN ID (PLMN ID and NID identifying an SNPN), type of access network, and N3IWF IP address.

- For PNI-NPN data connectivity charging, SMF collects and reports the charging information which contains: S-NSSAI, or dedicated DNNs, or dedicated DNN and S-NSSAI combination, which identifies PNI-NPN.

As documented in TS 32.256 [3], the following characteristics for converged charging for Non-Public Networks in AMF are specified:

- For SNPN network access usage charging, AMF collects and reports the charging information including SNPN ID (PLMN ID and NID identifying an SNPN).

- For PNI-NPN network access usage charging, AMF collects and reports the charging information which contains: CAG Identifier(s), S-NSSAI, or dedicated DNNs, or dedicated DNN and S-NSSAI combination, which identifies PNI-NPN.

The corresponding Open API and ASN.1 for Non-Public Networks charging are specified in the TS 32.291 [4] and TS 32.298 [5].

Management aspects

This is the continuation of Rel-17’s “Management of non-public networks”. It covers the “enhanced management of SNPN and PNI-NPN”, the “requirements and solutions for management of the related information for NPN service customer context information”, the “requirements and solutions for fault management capabilities scoping NPN and 5G industry terminals” and the “requirements and solutions for SLA monitoring and evaluation in NPN scenarios”.

It specifies the requirements and solutions for:
- shared and dedicated resources demand for NPN service customers.
- management of the related information for NPN service customer context information (e.g., identifier of tenant, role, permitted MnSs), which can be applied by NPN service provider to restrict the management capabilities and corresponding managed network resources exposed to NPN service customer.
- fault management capabilities scoping NPN and UEs representing 5G industry terminals, taking 5G ACIA requirements (such as requirements on network monitoring and network configuration and maintenance for 5G NPN) into account.
- SLA monitoring and evaluation in NPN scenarios.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980128,940075,970015,960033,990043,980078,980079,980080,940043,990028,990034,991138

[g1] TS 23.501: “System architecture for the 5G System (5GS)”
[g2] TS 23.502, Procedures for 5G System; Stage 2.

[g3] TS 23.503, Policy and Charging Control Framework for the 5G System; Stage 2 Service Enabler Architecture Layer for Verticals
[g4] TS 23.402: "Architecture enhancements for non-3GPP accesses".
[g5] TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".
[g6] TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station in idle mode".
[g7] TS 33.501: "Security architecture and procedures for 5G system".
[1] TR 28.828: "Study on charging aspects for enhanced support of non-public networks".
[2] TS 32.255: "Telecommunication management; Charging management; 5G Data connectivity domain charging; stage 2".
[3] TS 32.256: "Telecommunication management; Charging management; 5G connection and mobility domain charging; stage 2".
[4] TS 32.291: "Telecommunication management; Charging management; 5G system; Charging service, stage 3".
[5] TS 32.298: "Telecommunication management; Charging management; Charging Data Record (CDR) parameter description".
[6] TS 23.501:"System Architecture for the 5G System".
[m1] TS 28.557: "Management of Non-Public Networks (NPN); Stage 1 and stage 2"
[m2] TR 28.907: "Study on enhancement of management of non-public networks"

19.2 5G Networks Providing Access to Localized Services

920038	**5G Networks Providing Access to Localized Services**	**PALS**		SP-210522	**Lola Awoniyi-Oteri, qualcomm**
890023	*Study on PALS*	FS_PALS	S1	SP-200799	**Jack Nasielski**
920031	**Stage 1 of PALS**	PALS	S1	SP-210588	**Lola Awoniyi-Oteri, qualcomm**

Summary based on the input provided by Qualcomm in SP-240888.

Providing Access to Local Services (PALS) refers to the capability to provide access to a hosting network and a set of services offered by the hosting network provider and/or 3rd party service providers (including other network operators and 3rd party application providers). The services can be localized (i.e. provided in specific/limited area) and can be bounded in time. The user can become aware of the available access to local services, and the process to gain and terminate access to the hosting network and local services. This process should be efficient, and convenient from a user experience standpoint.

This section covers the SA1 work on PALS. Subsequent stage-2/3 work was conducted under the SA2/CT/RAN work on eNPN (see sec. 19.1 in this TR).

Based on use cases identified in the study item, Stage 1 normative specs [1] introduce service requirements related to Providing access to local services (PALS), covering scenarios where the home and hosting networks are NPN. The requirements address the following areas:

- Configuration of Localized Services in Hosting Network
- User Manual Selection of Localized Services via Hosting Network
- UE Configuration, Provisioning, Authentication and Authorization
- UE Discovery, Selection and Access
- Hosting Network Localized Services and Home Operator Services
- Returning to Home Network
- Charging, Regulatory, Multicast and Broadcast services

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=920038,920031

[1] TS 22.261 5G service requirements; Stage-1

20 AM and UE Policy

20.1 5G AM Policy

990113	**5G AM Policy**	**AMP**		SP-221335	**Chen, Zhuoyi, China Telecom**
940064	*Study on 5G AM Policy*	FS_AMP	S2	SP-220647	**Chen, Zhuoyi, China Telecom**
970017	**Stage 2 of 5G AM Policy**	AMP	S2	SP-221335	**Chen, Zhuoyi, China Telecom**
990007	CT3 aspects of 5G AM Policy	AMP	C3	CP-232130	**SUN, Yue, China Telecom**
990095	CT4 aspects of 5G AM Policy	AMP	C4	CP-232130	**SUN, Yue, China Telecom**
840020	*Study on enhancement of 5G UE Policy*	FS_eUEPO	S2	SP-211649	

Summary based on the input provided by China Telecom in SP-231615.

This WID is to solve the ping-pong issue because of RFSP Index consistency when UE moves from 5GC to EPC, i.e., the 5GC keeps sending the UE to EPC based on authorized RFSP Index from PCF, while the MME only has the subscribed RFSP Index and kick the UE in the above scenarios back to 5G immediately.

The solution applies to N26-based interworking scenario by introducing a new attribute *RFSP Index in Use Validity Time*. The impacted nodes include MME, AMF and PCF.

In the case of mobility from 5GS to EPS, if the mobility is a result of the PCF modifying the RFSP Index value for the UE to indicate that EPC/E-UTRAN access is prioritized over the 5GS access, the AMF may be sent with a *RFSP Index in Use Validity Time* by the PCF. If the AMF receives *RFSP Index in Use Validity Time* and selects the RFSP Index in use identical to the authorized RFSP Index, then the AMF provides the MME with the RFSP Index in use and the *RFSP Index in Use Validity Time*, which indicates the time by which the RFSP Index in use will be used in the MME. The MME shall not re-evaluate the RFSP Index in Use before *RFSP Index in Use Validity Time* expires.

The *RFSP Index in Use Validity Time* will be transferred between MMEs in case of S1-handover before it expires.

In the case of mobility from EPS to 5GS, the *RFSP Index in Use Validity Time* if received from MME is ignored by the AMF.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990113,940064,970017,990007,990095

[1] TR 23.700-89: “Study on 5G AM Policy”
[2] TS 23.501: “System architecture for the 5G System (5GS)”
[3] TS 23.502: “Procedures for the 5G System (5GS)”
[4] TS 23.503: “Policy and charging control framework for the 5G System (5GS)”
[5] TS 29.274: “Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C)”
[6] TS 29.507: “Access and Mobility Policy Control Service”
[7] TS 29.513: “Policy and Charging Control signalling flows and QoS parameter mapping”

20.2 Enhancement of 5G UE Policy

840020	*Study on enhancement of 5G UE Policy*	FS_eUEPO	S2	SP-211649	
980114	**Enhancement of 5G UE Policy**	**eUEPO**		SP-220980	
970025	**(Stage 2 of) Enhancement of 5G UE Policy**	**eUEPO**	**S2**	SP-230094	
980081	CT1 aspects of eUEPO	eUEPO	C1	CP-232132	
980082	CT3 aspects of eUEPO	eUEPO	C3	CP-232132	
990093	CT4 aspects of eUEPO	eUEPO	C4	CP-232132	

Summary based on the input provided by Intel in SP-240468.

The User Equipment (UE) Policy was introduced into 5GS in Rel-15. The UE Policy information can be preconfigured in the UE and/or provisioned to the UE for access selection (i.e. ANDSP), PDU Session selection (i.e. URSP), V2X communications (i.e. V2XP), ProSe operations (i.e. ProSeP) and/or A2X communications (i.e. A2XP). Some gaps were identified in Rel-18 as described in the justification part of 3GPP SA approved WID [7].

The eUEPO work item specifies 5GS enhancements to the URSP related to the following mechanisms:

- enabling VPLMN specific URSP influence, generation and provisioning

- 5GC awareness of URSP enforcement in UE

- provisioning UE with consistent URSP across 5GS and EPS, and

- define standardized and operator-specific traffic categories in the Connection Capability of Traffic Descriptor of URSP rule.

The conclusions of the study phase are documented in TR 23.700-85 [1]. The Feature enhancement to the URSP in normative phase is specified in TS 23.501 [2], TS 23.502 [3] and TS 23.503 [4].

The following features were specified as part of the eUEPO work item:

- Enhancement of URSP generation influence in HPLMN by V-AF or V-PCF in VPLMN and URSP evaluation trigger upon PLMN change. A new definition of VPLMN specific URSP Rules is given. VPLMN ID is provided to UE along with the URSP using the UE policy management procedure as specified in TS 24.501 [9] annex D. A new URSP re-evaluation trigger at UE side is defined upon PLMN change.

- Support 5GC awareness of URSP enforcement in UE and new Analytics ID by NWDAF to monitor the traffic in one or multiple PDU Sessions. A UE supporting URSP rule enforcement reporting indicates UE support for reporting of URSP rule enforcement to the AMF during the registration procedure and reports URSP rule enforcement to the SMF if a URSP rule includes an indication for reporting URSP rule enforcement and if Connection Capabilities is in the TD (traffic descriptor of the URSP rule). The UE provides the URSP rule enforcement report with the Connection Capabilities contained in the TD to the PCF via SMF using the PDU session establishment or PDU session modification procedures as specified in TS 24.501 [9] and TS 24.526 [5]. The PCF receives reporting from URSP rule enforcement for a given UE via Policy Control Request Triggers. When the PCF serving the PDU session is not the same as the PCF serving the UE, the PCF serving the UE subscribes to the PCF serving the PDU session to receive the reporting of URSP rule enforcement for a given UE via PCF event reporting. The PCF for the UE may check whether the value of URSP rule enforcement and its PDU Session parameters (e.g. DNN/S-NSSAI) are compliant to the URSP rule of the UE. If the PCF for the UE recognizes inconsistency, the PCF for the UE may perform appropriate actions.

- Enhancement for provisioning UE with consistent URSP across 5GC and EPC based on URSP provisioning via ePCO in EPS. When the UE attaches in EPS, the UE includes the Indication of URSP Provisioning Support in EPS in the PDN Connectivity Request message as specified in TS 24.301 [8]. If the SMF+PGW-C supports URSP provisioning in EPS, it provides the Indication of URSP Provisioning Support in EPS in ePCO in the Create Session Response message. When the UE receives the Indication of URSP Provisioning Support in EPS included in ePCO in the PDN Connectivity Accept message, then the UE initiates the UE requested bearer resource modification without QoS update procedure and includes the UE STATE INDICATION message in the UE Policy Container ePCO in the Request Bearer Resource Modification message, the UE Policy Container in ePCO will be further forwarded by MME to SMF+PGW-C. When the UE Policy Container ePCO is received by SMF+PGW-C, it forwards transparently the UE Policy Container to PCF for the PDU Session, then the PCF for the PDU Session establishes the UE Policy Association with PCF for the UE. The PCF for the UE generates the corresponding URSP rules in a similar way as it is done in 5GS and sends the URSP rules to UE in the UE Policy Container as described in clause 4.11.0a.5 of TS 23.502 [3] and TS 24.501 [9] annex D. When the UE initially registers in 5GS, the UE provides the Indication of URSP Provisioning Support in EPS to the PCF during Registration using the UE-initiated UE state indication procedure as specified in TS 24.501 [9]. On receiving this indication and when the UE moves to EPS, if the UE has an active PDN connection transferred from 5GS, then the PCF for the PDU Session establishes a UE Policy Association with the PCF for the UE for URSP delivery in EPS.

- Support standardized and operator-specific traffic categories in the Connection Capability of Traffic Descriptor of URSP rule. The format and values of Connection Capabilities Traffic Descriptor to match against standardized traffic categories are defined in TS 24.526 [5] according to the requirements in GSMA PRD NG.135 [6]. The reserved values of Connection Capabilities to match operator-specific traffic categories are specified in TS 24.526 [5]. Traffic categories requested by the UE application are independent from the UE's Operating System. Operator-specific traffic categories values are out of scope of 3GPP specifications. Details on how UE applications indicate traffic categories to the UE's Operating System are out of scope of 3GPP specifications.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980114,970025,980081,980082,990093

[1] TR 23.700-85: "Study on enhancement of 5G User Equipment (UE) policy"
[2] TS 23.501: "System architecture for the 5G System (5GS)".
[3] TS 23.502: "Procedures for the 5G System; Stage 2".
[4] TS 23.503: "Policy and charging control framework for the5G System (5GS)".
[5] TS 24.526: "UE Equipment (UE) policies for 5G System (5GS); Stage 3".
[6] GSMA PRD NG.135, Version 3.0: "E2E Network Slicing Requirements".
[7] 3GPP SP-221127, "Revised WID: Enhancement of 5G UE Policy (eUEPO)".
[8] TS 24.301 "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".
[9] TS 24.501 "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

20.3 Dynamically Changing AM Policies in the 5GC Phase 2

990114	**Dynamically Changing AM Policies in the 5GC Phase 2**	**TEI18_DCAMP_Ph2**		SP-220799	**Yubing Liu**
970009	**Stage 2 of TEI18_DCAMP_Ph2**	TEI18_DCAMP_Ph2	S2	SP-230102	**Yubing Liu**
990005	**CT3 aspects on Dynamically Changing AM Policies in the 5GC Phase 2**	TEI18_DCAMP_Ph2	C3	CP-232129	**SUN, Yue, China Telecom**

Summary based on the input provided by China Telecom in SP-231614.

In release 17, TEI17_DCAMP defined the functionality of dynamically changing AM policies. It supported that the PCF serving a UE may receive notification from AF or from PCF(s) serving a PDU session that specific application traffic starts/stops, and then trigger AM policy check and update. Since the solution in R17 is only applicable to non-roaming scenario, this R18 WI was proposed to support providing dynamic AM policy for any roaming UEs in LBO roaming scenario.

To support changing AM policy dynamically for inbound roamers in LBO scenario, a new target of any inbound roaming UEs identified by their home PLMN ID(s) combined with DNN/S-NSSAI or External Application Identifier(s) is added to the related procedures, e.g. the procedure of AF influenced AM policies, management of AM policies depending on the application in use.

When UEs roam to VPLMN in LBO scenario, the AF can send a request to influence AM policy including the target information of any inbound roaming UEs identified by their PLMN ID(s). The target "any inbound roaming UEs identified by their PLMN ID(s)" is applicable if an External Application Identifier or list of (DNN, S-NSSAI) is also provided. And then, NEF would store, update, or remove the application data received from AF in the UDR. UDR would notify the PCF the change of the subscription once the PCF has subscribed to application data related to AM influence. After that, PCF can provide dynamic AM policies according to the received information.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990114,970009,990005

[1] TS 23.501: “System architecture for the 5G System (5GS)”
[2] TS 23.502: “Technical Specification Group Services and System Aspects; Procedures for the 5G System (5GS)”
[3] TS 23.503: “Policy and charging control framework for the 5G System (5GS)”
[4] TS 29.504: “5G System; Unified Data Repository Services”
[5] TS 29.513: “5G System; Policy and Charging Control signalling flows and QoS parameter mapping”
[6] TS 29.519: “5G System; Usage of the Unified Data Repository service for Policy Data and Structured Data for exposure”
[7] TS 29.522: “5G System; Network Exposure Function Northbound APIs”

20.4 Spending Limits for AM and UE Policies in the 5GC

1000041	**Spending Limits for AM and UE Policies in the 5GC**	**TEI18_SLAMUP**		SP-220794	**Baniel, Uriuri dot baniel at oracle dot com**
970004	**Stage 2 of TEI18_SLAMUP**	TEI18_SLAMUP	S2	SP-220794	**Baniel, Uriuri dot baniel at oracle dot com**

1000040	**CT aspects on TEI18_SLAMUP**	TEI18_SLAMUP	C3	CP-233125	**SUN, Yue, China Telecom**
1000040	CT3 aspects on TEI18_SLAMUP	TEI18_SLAMUP	C3	CP-233125	Yue Sun, China Telecom
1020048	CT4 aspects on TEI18_SLAMUP	TEI18_SLAMUP	C4	CP-233125	Yue Sun, China Telecom

Summary based on the input provided by Oracle, China Telecom in SP-241309.

Policy decisions based on spending limits allows PCF to take actions related to the status of policy counters that are maintained in the CHF. In Rel-17, this is limited to Session management related policy control (23.503[1] v17.4 clause 6.1.3).

TEI18_SLAMUP enhances the above capability to AM and UE policy.

NOTE: in the context of TEI18_SLAMUP, the term 'UE policies' refers to URSP (UE Route Selection Policy) only.

In addition to the PCF for the PDU Session, the PCF for a UE can use the Nchf_SpendingLimitControl service to obtain the Status of policy counters in the CHF.

Detection of change of a Status of policy counters in the CHF may trigger the PCF for a UE to dynamically push down updated AM policy decisions to the AMF or/and UE policy decisions to the UE via the AMF.

The scope of this Work Item in the context of both AM and UE policies applies to non-roaming.

An aspect of this feature is to have the PCF for a UE pass back the address of the CHF to the AMF. This is to allow a consistent use of the same CHF.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000041,970004,1000040, 1020048

[1] TS 23.501: "System architecture for the 5G System (5GS)"
[2] TS 23.502: "Technical Specification Group Services and System Aspects; Procedures for the 5G System (5GS)"
[3] TS 23.503: "Policy and charging control framework for the 5G System (5GS)"
[4] TS 29.507: "5G System; Access and Mobility Policy Control Service; Stage 3"
[5] TS 29.513: "5G System; Policy and Charging Control signalling flows and QoS parameter mapping"
[6] TS 29.519: "5G System; Usage of the Unified Data Repository service for Policy Data and Structured Data for exposure"
[7] TS 29.525: "5G System; UE Policy Control Service; Stage 3"
[8] TS 29.594: "5G System; Spending Limit Control Service; Stage 3"
[9] TS 29.504: "5G System; Unified Data Repository Services; Stage 3"

20.5 Rel-18 Enhancements of UE Policy

970001	**Rel-18 Enhancements of UE Policy**	**UEP18**		CP-233115	**Fuencisla García, Ericsson**
970045	CT3 aspects of UEP18	UEP18	C3	CP-233115	**Fuencisla García, Ericsson**
970046	CT4 aspects of UEP18	UEP18	C4	CP-233115	**Fuencisla García, Ericsson**

Summary based on the input provided by Ericsson in CP-241265.

The UE Policy Control service is used as part of the provisioning of UE policies to the UE and as part of the provisioning of N2 PC5 policy (for the applicable UE policies) to the NG-RAN.

During development and deployment of this service, it has been identified that there is a need to apply technical improvements and enhancements (e.g., improve specification clarity, improve the signaling and processing efficiency, increase the flexibility, etc.), specifically in the following areas:

- Feature (re)negotiation during AMF relocation.
- Use of Namf_Communication service.
- Error handling in roaming scenarios.

UEP18 introduces feature (re)negotiation for UE and AM Policy Control between the AMF and the PCF during AMF relocation, improves specification clarity for the use of the Namf_Communication service and completes error handling,

focusing on the error propagation in roaming scenarios. This work item also completes the specification of UE Policy Control service with the corrections and changes missed in previous 3GPP releases not covered in the scope of other dedicated Rel-18 work items.

Feature negotiation takes place between the NF service consumer (AMF) and NF service producer (PCF) during the creation of the AM/UE Policy Association, leaving feature re-negotiation during AMF relocation when the target AMF re-uses the PCF indicated by the source AMF unspecified in Release 15. After Release 15, new releases have been specifying new functionality, and consequently, bringing the possibility of network deployments that contain NFs with different feature level support. To enable that both, the target AMF and the PCF are aware of their respective feature level support, it has been specified feature re-negotiation during UE/AM policy association update service procedure.

Also related to AMF relocation procedures and the Namf_Communication service, how the PCF handles the subscription to notification of N1N2 messages with the new AMF was not specified in previous Releases. To optimize the signalling and processing resources, the solution developed in this Work Item specifies the use of the subscription Id obtained during initial subscription for any further interaction. In addition, to improve specification clarity, it has been specified that the PCF uses the AMF instance serving the UE received from the AMF to retrieve from the NRF the NF profile for the Namf_Communication service.

For error handling, the Work Item completes the definition of the application errors applicable to Namf_Communication and Npcf_UEPolicyControl services. For Namf_Communication service, the RetryAfter description is completed for UE Policy Delivery. For Npcf_UEPolicyControl, error situations related to UE non-reachable are completed and clarified, and additionally, it is specified the mapping of application errors between the VPLMN and the HPLMN.

References

List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970001,970045,970046

[1] TS 29.525: "UE Policy Control Service".
[2] TS 29.507: "Access and Mobility Policy Control Service".
[3] TS 29.513: "Policy and Charging Control signalling flows and QoS parameter mapping".
[4] TS 29.518: "Access and Mobility Management Services".

21 Service-based items

21.1 Enhancements on Service-based support for SMS in 5GC

990003	**Enhancements on Service-based support for SMS in 5GC**	eSMS_SBI	C4	CP-230025	**Liu, Liu, China Telecom**

Summary based on the input provided by China Telecom in CP-240084.

This WID is to solve legacy problems of WID SMS_SBI (Rel-17), i.e. incompatibility problems and protocol selection problems, and make SBI-based SMS NFs and legacy SMS NFs work in harmony. This translates to the following:

- Improvement of protocol selection mechanism of SMS, especially for MT SM Routing Info Retrieval, it is proposed to consider different cases and promote compatibility between SBI-based NFs and non-SBI-based NFs.

- Alignment of stage 2 and stage 3 SMS TSs.

In the Rel-17, WID SMS_SBI have defined service-based SMS framework, procedure and interfaces. Service-based SMS framework and procedures are depicted in TS 23.540 [1], and new NF services and interfaces are depicted in TS 29.577 [2] / TS 29.578 [3] / TS 29.579 [4]. At the end of Rel-17 research, there were still some legacy technical problems, and they have been solved in Rel-18 WID eSMS_SBI.

Rel-18 WID eSMS_SBI have solved incompatibility issues between SBI-based SMS and legacy SMS. In Rel-17, during SM MT delivery, when SMS-GMSC makes use of MAP or Diameter to retrieve RoutingInfoForSM from legacy UDM/HSS (i.e. UDM/HSS do not support SBI-based SMS), the response message is lack of SBI-support information of SMSF/IP-SM-GW/SMS Router, which may cause incompatibility problems. In Rel-18, SBI-support-indications for SMSF/IP-SM-GW/SMS Router are added in the RoutingInfoForSM Retrieval Response message in TS 29.338 [5], SBI-support-indications are also added in 3GPP specific AVP codes in TS 29.230 [6].

Rel-18 WID eSMS_SBI have added protocol selection mechanism for SMS-GMSC towards UDM/HSS during MT SM delivery. In Rel-17, SBI-based method is adopted by default, and no protocol selection is considered for SMS-GMSC RoutingInfoForSM towards UDM/HSS. It may cause problems when SMS-GMSC use SBI to get RoutingInfoForSM from legacy UDM/HSS. Rel-18 WID eSMS_SBI have added the protocol selection mechanism and adjusted the error judge mechanism for UDM discovery procedures in TS 23.540 [1].

Rel-18 WID eSMS_SBI have made some alignment of stage 2 and stage 3 of SMS TSs. e.g. Table 5.3.2-1 of TS 23.540 [1] defines Application errors for MO SM delivery response, HTTP status code of it only includes 403 and 504, but TS 29.579 [4] includes 307/308/400/403/504. Errors like this have been fixed in Rel-18 WID eSMS_SBI.

In summary, Rel-18 WID eSMS_SBI solves the legacy problems of Rel-17 WID SMS_SBI, and helps to improve serviced-based SMS.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990003

[1] TS 23.540: "Technical realization of Service Based Short Message Service".
[2] TS 29.577: "5G System; IP Short Message Gateway and SMS Router For Short Message Services; Stage 3".
[3] TS 29.578: "5G System; Mobile Number Portability Services; Stage 3".
[4] TS 29.579: "5G System; Interworking MSC For Short Message Services; Stage 3".
[5] TS 29.338: "Diameter based protocols to support Short Message Service (SMS) capable Mobile Management Entities (MMEs)".
[6] TS 29.230: "Diameter applications; 3GPP specific codes and identifiers".

21.2 Service based management architecture

990026	Service based management architecture	eSBMA	S5	SP-231443	Kai ZHANG, Huawei Robert Petersen, Ericsson Olaf Pollakowski, Nokia
910031	*Study on Enhancement of service-based management architecture*	FS_eSBMA	S5	SP-210136	Lan Zou, Huawei Robert Petersen, Ericsson
950027	*Study on Basic SBMA enabler enhancements*	FS_eSBMAe	S5	SP-230774	Olaf Pollakowski, Nokia

Summary based on the input provided by Huawei in SP-240142.

This work item focused on following main topics:

- elaborate the usage of SBMA, including add description on management of management functions, coordination enhancement on architecture to reflect the collaboration with other industry groups.

- implement the recommendations of TR 28.831 "Study on basic Service-Based Management Architecture (SBMA) enabler enhancements" into normative specifications.

It used input from the Rel-18 Study on Enhancement of service-based management architecture (FS_eSBMA) (UID: 910031) and Rel-18 Study on basic Service-Based Management Architecture (SBMA) enabler enhancements (FS_eSBMAe) (UID: 950027).

1. Improvement on the existing TS 28.533 description of SBMA including improving the overview of SBMA series specifications based on Rel-18 work progress.
2. Address the architecture enhancement based on the collaboration with other industry groups (e.g GSMA OPG etc.).
3. Restructure the specifications for Fault supervision.
4. Update 32.300 "Name convention for Managed Objects" to include SBMA.
   - Move information from Annex E IOC/MOC name in 32.300 to 32.156.
5. Update 32.404 " Performance Management (PM); Performance measurements; Definitions and template " to be valid for SBMA
6. Update stage 2 definitions of the Prov MnS based on the update proposals documented in clause 4.3, clause 4.4 and clause 4.6 of TR 28.831.
7. Add capability for advertising NRM properties.
8. Add common node selection mechanism
9. Add node selection mechanism (inspired by XPath) called JSON expression (Jex), HTTP/JSON SS only
10. Add support for advertising HTTP communication options, HTTP/JSON SS only

11. Add HTTP error response format, HTTP/JSON SS only
12. Add support for partial success to HTTP UPDATE operations, HTTP/JSON SS only
13. Add OAS definition versioning concept independent from the TS versioning, HTTP/JSON SS only

The objectives also include other small SBMA enhancements not explicitly listed above.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990026

[1] TS 28.111: "Fault Management"
[2] TS 32.161: "Management and orchestration; JSON expressions (Jex)"
[3] TS 28.532: "Management and orchestration; Generic management services"
[4] TS 28.533: "Management and orchestration; Architecture framework"
[5] TS 28.622: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)"
[6] TS 28.623: "Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions"
[7] TS 32.156: "Fixed Mobile Convergence (FMC) model repertoire"
[8] TS 32.158: "Design rules for REpresentational State Transfer (REST) Solution Sets (SS)"
[9] TS 32.300: "Configuration Management (CM); Name convention for Managed Objects"
[10] TS 32.404: "Performance Management (PM); Performance measurements; Definitions and template"
[11] TR 28.925: "Study on enhancement of service based management architecture"
[12] TR 28.831 "Study on basic Service-Based Management Architecture (SBMA) enabler enhancements"

21.3 Automated certificate management in SBA

990037	**Automated certificate management in SBA**	ACM_SBA	S3	SP-230768	**Peinado, German, Nokia**

Summary based on the input provided by Nokia, Nokia Shanghai Bell in SP-231635.

Digital certificates in 5G Core are used for different purposes, such as TLS authentication or validation of signatures. Similar to RAN certificate management framework, the “Automated Certificate Management in SBA” feature provides a standardized model and set of procedures for the automated certificate management in SBA for 5G Core Network Functions. The feature fixes the potential issues coming from manual management of certificates and inconsistencies in the associated procedures by profiling CMP (Certificate Management Protocol), and by adding requirements and recommendations that support the automation and security in the certificate management tasks.

The feature covers the following procedures:

- Set up of initial trust between NF (Network Function) and operator RA (Registration Authority)/CA (Certification Authority) for the certificate enrolment, facilitated by the OAM system.

- Certificate enrolment and renewal based on CMP:

    - Profiling of CMP protocol for 5G Core Network Functions.

    - Validation of the Network Function instances identifiers.

- Validation of the usage of certificates in SBA.

- Certification revocation schemas (CRL (Certificate Revocation List), OCSP (Online Certificate Status Protocol), OCSP Stapling).

- Considerations of the Network Functions lifecycle management in the certificate lifecycle management framework.

Additionally, a new informative annex (Guidance for 5GC certificates management procedures left to implementation) has been included with a set of guidelines for NF certificate updates in special circumstances, certificate management in Slicing, and security aspects in the key management.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990037

[1] TS 33.310: “Network Domain Security (NDS); Authentication Framework (AF)”

21.4 Security Aspects of the 5G Service Based Architecture Phase 2

980022	**Security Aspects of the 5G Service Based Architecture Phase 2**	5G_eSBA_Ph2	S3	SP-221145	**Anja Jerichow, Nokia**

Summary based on the input provided by Nokia in SP-240415.

The "Service-Based Architecture" (SBA) framework is the foundation of the 5GC architecture, which allows "Network Functions" (NFs) to consume services of other NFs via the interfaces of the common framework.

Security has been instrumental for SBA with the OAuth 2.0 authorization framework providing the baseline for consuming services when no static authorization applies.

For any given NF offering its services to other NFs, permissions to make use of these provided services is needed. The NRF (Network Repository Function) acts as the OAuth 2.0 authorization server granting access by providing access tokens to authorized NFs and/or to any "consumers" that are permitted. In direct communication models, the NF consumer instance is communicating directly with the NRF and the NF producer instance; in indirect communication authorization requests can be delegated to the SCP (Service Communication Proxy).

Phase 2 of SBA security enhancements studied in TR 33.875 a variety of potential threats possible under various trust model assumptions.

The normative work on SBA security enhancements focused on updating the security framework by improving against selective threat scenarios in indirect communication.

Rel-18 enhancements related to SBA security include the following updates to TS 33.501 [1].

- A clarification on the trust model assuming in indirect communication scenarios that the SCP is trusted to only ask access tokens for NF consumers that have requested a service. This trust is important since the NF service consumer is not able to prove the authenticity of the access token provider (NRF) or the NF service producer when the SCP is the entity requesting an authorization token and handling the service request on behalf of the NF service consumer.

- Details are added on handling token-based authorizations for subscribe/unsubscribe to be equal to request/response. Further, it was clarified for notifications that token-based authorization is not used in this release.

- Validation of parameters in access token requests in hierarchical NRF deployments has been added and the security implications are explained.

- Authorization for slices in inter-slice scenarios was clarified to prevent any malicious entity (for instance a NF Service Consumer) from accessing a slice that it is not authorized to access, or from requesting a service from a slice which it is not authorized to access. Verification of S-NSSAIs is required.

- Validation of NF details against the provided certificate information when requesting access tokens from NRF has been detailed.

Further, some generic SBA security related aspects were added to TS. 33.501such as the SEPP behaviour with respect to the 3GPP-Sbi-Originating-Network-Id header, the clarifications on adding and verifying the source PLMN-ID for SEPP and SCP, and clarifications on the separate handling of N32-c and N32-f including a description on N32-f connection establishment with TLS.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990037

[1] TS 33.501: "Security architecture and procedures for 5G System".

21.5 Service Based Interface Protocol Improvements Release 18

960052	**Service Based Interface Protocol Improvements Release 18**	**SBIProtoc18**		CP-221083	**Wang Rong, China Mobile**

960001	CT4 aspects of SBIProtoc18	SBIProtoc18	C4	CP-221083	**Wang Rong, China Mobile**
960060	CT3 aspects of SBIProtoc18	SBIProtoc18	C3	CP-221083	**Wang Rong, China Mobile**

Summary not expected.

22 Security-centric aspects

22.1 IETF DTLS protocol profile for AKMA and GBA

980021	**IETF DTLS protocol profile for AKMA and GBA**	AKMA_GBA_DTLS	S3	SP-221143	**Liu, yuze, ZTE**

Summary based on the input provided by ZTE in SP-240189.

IETF DTLS is currently specified as one choice for providing security for the Lightweight M2M standard. The work on IETF DTLS protocol profile for AKMA and GBA provides the details on how to provide secure DTLS connection between the UE and an Application Function (AF) in the network.

The AKMA WID [1] introduced a method of generating keys (AKMA key) to be used between a UE and an Application Function (AF) in the network. The AKMA DTLS protocol profiles provides the details on how to use the newly introduced AKMA key to provide secure DTLS connection between the UE and an Application Function (AF) in the network. The specification of the profiles is based on the AKMA TLS protocol profiles specified in TS 33.535[1].

The GBA WID [2] introduced a method of generating keys (GBA key) to be used between a UE and a Network Application Function (NAF) in the network. The GBA DTLS protocol profiles provides the details on how to use the newly introduced GBA key to provide secure DTLS connection between the UE and a Network Application Function (NAF) in the network. The specification of the profiles is based on the GBA TLS protocol profiles specified in TS 33.220[2].

Since the AKMA feature is deemed as a successor of these systems, the work is launched by SA3 without the involvement of stage 1.The stage 2 of the AKMA DTLS protocol profiles work is specified in TS 33.535 [1] while GBA DTLS protocol profiles work is specified in TS 33.220 [2]. There is no new work in the stage 3 compare to the AKMA TLS and GBA TLS related work.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980021

[1] TS 33.535: "Authentication and Key Management for Applications (AKMA) based on 3GPP credentials in the 5G System (5GS)"
[2] TS 33.220: "Generic Authentication Architecture (GAA);Generic Bootstrapping Architecture (GBA)"

22.2 IETF OSCORE protocol profiles for GBA and AKMA

980023	**IETF OSCORE protocol profiles for GBA and AKMA**	AKMA_GBA_OSCORE	S3	SP-221146	**Tsiatsis, Vlasios, Ericsson**

Summary based on the input provided by Ericsson in SP-231655.

The Generic Bootstrap Architecture (GBA) and the Authentication and Key Management for Applications (AKMA) features enable a User Equipment (UE) and an (Network) Application Function or (N)AF to authenticate each other and share a common secret key after an application session establishment procedure. Both GBA and AKMA are application frameworks which require a specific application protocol (called Ua in GBA and Ua* in AKMA) which uses this shared key for authentication or security establishment. This work item specified the Internet Engineering Task Force (IETF) Object Security for Constrained RESTful Environments (OSCORE) as an application protocol for GBA and AKMA.

Both GBA and AKMA include a generic application session procedure between a UE and a (N)AF. The UE provides some parameters to the (N)AF only known to the UE and the network functions, the Bootstrapping Server Function (BSF) in GBA and the AKMA Anchor Function (AAnF) in AKMA. After the application session request by the UE, the (N)AF requests a shared key from the network (the BSF in GBA or the AAnF in AKMA) using the parameters of the

application session request provided by the UE. The network (BSF or AAnF) responds with a shared key and potentially other parameters to the (N)AF. Then the UE and (N)AF use the shared key for authentication of each other and for other purposes such as encrypted channel establishment. The interactions between the UE and (N)AF are specified in GBA and AKMA in a generic way assuming a carrier application protocol (Ua for GBA and Ua* for AKMA) for the parameters of the application session request from the UE to the (N)AF and potentially for any response parameters for the application session response from the (N)AF to the UE.

The integration of OSCORE as an application protocol included the specification of the application session request/response between the UE and the (N)AF for both GBA and AKMA procedures, in other words this work item specified OSCORE as a Ua protocol for GBA and a Ua* protocol for AKMA. The key shared between the UE and (N)AF along with a set of OSCORE parameters is used for bootstrapping the OSCORE Master Secret Key for the protection of the communication between the UE and (N)AF.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980023

[1] TS 23.501: "System architecture for the 5G System (5GS)".
[2] TS 33.501: "Security architecture and procedures for 5G System".
[3] TS 33.220: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA)".
[4] TS 33.535: "Authentication and Key Management for Applications (AKMA) based on 3GPP credentials in the 5G System (5GS)".
[5] IETF RFC 8613: "Object Security for Constrained RESTful Environments (OSCORE)".

22.3 Home network triggered primary authentication

1010019	**Home network triggered primary authentication**	**HN_Auth**	**S3**	SP-221147	**He Li, Huawei**
950020	*Study of Security aspect of home network triggered primary authentication*	FS_HN_Auth	S3	SP-220198	**He Li, Huawei**
980024	Security aspects of home network triggered primary authentication	HN_Auth	S3	SP-221147	**He Li, Huawei**
1010001	CT aspects of home network triggered primary authentication	HN_Auth	C4	CP-232028	**Jing, Hao, Huawei**
950018	*Study on AKMA Phase 2*	FS_AKMA_Ph2	S3	SP-220991	**Xiaoting Huang, China Mobile**

Summary based on the input provided by Huawei in SP-240885.

The requirements for the support of a Home Network triggered primary authentication are captured in TS 33.501[1] and TS 29.503[2] based on the outcome of the study documented in TR 33.741 [3]. This new feature enables home network to trigger the primary authentication. In the past, it has been always the case that this procedure is only triggered by the visited network.

In this feature, the UDM is the central point that can trigger the primary authentication procedure. The UDM takes the decision based on local policy or a request from another NF (AAnF or OAM). The procedure is initiated by the UDM notifying the AMF. The AMF then based on its local policy and/or the status of the UE determines whether or not to trigger the primary authentication procedure. The procedure has been specified in TS 33.501 [1].

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1010019,980024,1010001

[1] TS 33.501: "Security architecture and procedures for 5G system".
[2] TS 29.503: "5G System; Unified Data Management Services; Stage 3".
[3] TR 33.741: "Study of Security aspect of home network triggered primary authentication"

22.4 AKMA phase 2

990040	**AKMA phase 2**	AKMA_Ph2	S3	SP-230153	**Huang Xiaoting, China Mobile**

Summary based on the input provided by China Mobile in SP-240902.

AKMA_Ph2 specifies the roaming aspects of Authentication and Key Management for Applications based on 3GPP credential in 5G (AKMA) as specified in TS 33.535. Besides, a new funtionality about Authentication Proxy (AP) is defined, in order to help the ASs behind the AP to execute AKMA procedures to save the consumption of signalling resources and AAnF computing resources.

The AKMA architecture and procedures has been specified by SA3 in TS 33.535 [1], with the related study showing how its general principles are derived documented in TR 33.835 [2]. This work item is to add roaming aspects and new funtionality of AP into AKMA, which follows the conclusion from the related study in TR 33.737[3]. detailed services and API definitions are specified by CT3 in TS 29.535[4].

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990040

[1] TS 33.535: “Authentication and Key Management for Applications (AKMA) based on 3GPP credentials in the 5G System (5GS)”
[2] TR 33.835: “Study on authentication and key management for applications based on 3GPP credential in 5G”
[3] TR 33.737: “Study on Authentication and Key Management for Applications (AKMA) phase 2”
[4] TS 29.535: “5G System; AKMA Anchor Services; Stage 3”

22.5 5G Security Assurance Specification (SCAS) for the Policy Control Function (PCF)

990044	**5G Security Assurance Specification (SCAS) for the Policy Control Function (PCF)**	SCAS_5G_PCF	S3	SP-230157	**Andreas, Joerg, BSI Germany**

Summary based on the input provided by BSI Germany in SP-240782.

The 5G Security Assurance Specification (SCAS) for the Policy Control Function (PCF) develops security requirements, specific assets and threats of the PCF [2].

Further on, test case content were put in place to build up the TS 33.528 SCAS_5G_PCF test spec.. The current assembly of test cases is referencing to the Catalogue of General Security Assurance Requirements [1] only, but is not limited to that in the future.

The SCAS TS 33.528 for the Policy Control Function (PCF) fills a gap in the availability of Security Assurance Specifications (SCAS) regarding 3GPP specified 5G core network functions. The TS 33.528 will be in use to evaluate the security requirements of the PCF network function via NESAS certification scheme.

The Policy Control Function (PCF) is a critical component of 5G networks, responsible for enforcing the session management and access policies set by operators. To ensure the security of this function, it is necessary to extend the Security Assurance Specifications (SCAS) to include the PCF.

The TS 33.528 SCAS_5G_PCF is a test specification for the PCF core network function. As a SCAS the TS has no impact on system behaviour or other network function. The PCF SCAS completes a list of test specifications for the 3GPP 5G core network functions. The PCF as a SBI 5G system core network function is defined in [3].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990044

[1] TS 33.117: "Catalogue of general security assurance requirements"
[2] TS 33.926: "Security Assurance Specification (SCAS) threats and critical assets in 3GPP network product classes"
[3] TS 23.501 "System architecture for the 5G System (5GS)"

22.6 Security aspects on User Consent for 3GPP services Phase 2

960039	*Study of Security aspects on User Consent for 3GPP Services Phase 2*	FS_UC3S_Ph2	S3	SP-220537	**Rong Wu, Huawei,**

1000004	Security aspects on User Consent for 3GPP services Phase 2	UC3S_SEC_Ph2	S3	SP-230557	**Rong Wu, Huawei Technologies,**

Summary based on the input provided by Huawei in SP-240883.

The work on User Consent for 3GPP services Phase 2 considers the roaming aspect. Since there is a possibility that the enforcement entity and UDM belong to different legal domains, i.e., subject to different regulations, this study concentrates on these cases. The user consent work inherits the framework defined in Annex V of TS 33.501 [1], and the all user consent work performed in Rel-18 pertains to CN and CN related features. Concept of user consent and some of background information are depicted in clause 4 in TR 33.867 [2]. There is no CR required for this study eventually as the general user consent framework and requirements in Annex V of TS 33.501 [1] are reused for roaming scenarios.

In total 4 key issues are documented and addressed. Key issue #1: user consent for roaming case in eNA; key issue #2: user consent for NTN; key issue #3: unified framework for user consent related data retrieval, notification, and revocation; and key issue #4: guidance for enforcing user consent. There are 2 solutions proposed to address key issue #1 and 2 solutions address key issue #1. There is one solution trying to address key issue #3. However, there is no normative work for key issue #2 and key issue #3. For key issue #1, there is conclusion about enforcement point definition stated in clause 7.3 of TR 33.896 [3].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000004

[1] TR 33.501: " Security architecture and procedures for 5G System"
[2] TR 33.867: "Study on User Consent for 3GPP services"
[3] TR 33.896: "Study of security aspects on user consent for 3GPP services phase 2"

22.7 SCAS for split-gNB product classes

950022	**SCAS for split-gNB product classes**	SCAS_5G_split_gNB	S3	SP-220200	**Escott, Adrian, Qualcomm**

Summary based on the input provided by Qualcomm in SP-240892.

This work item provides Security Assurance Specification (SCAS) specification for the various split gNB network entities, i.e. gNB-CU, gNB-CU-CP, gNB-CU-UP and gNB-DU, to enable each of these entities to be tested separately and not as part of a complete gNB.

The specification of SCAS for the gNB is covered in TR 33.926 [1], which include the threats and critical assets for a gNB, and TS 33.511 [2], which contains the gNB specific tests. The work on SCAS for split gNB builds heavily on this work with test cases for such split gNBs product classes based upon and borrowing heavily from the specification for the gNB product class (see TS 33.511 [6]). The main differences are the inclusion of cases for the F1 signalling and user plane connection and the E1 signalling connection on the top of the gNB cases as well as some revised cases to account for the split functionality.

The threats and critical assets for the split gNB cases are given in TR 33.926 [1], while the split gNB specific test cases are provide in TS 33.523 [3].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950022

[1] TR 33.926 : Security Assurance Specification (SCAS) threats and critical assets in 3GPP network product classes
[2] TS 33.511: Security Assurance Specification (SCAS) for the next generation Node B (gNodeB) network product class
[3] TS 33.523: 5G Security Assurance Specification (SCAS); split gNB product classes

22.8 Security Assurance Specification for AKMA Anchor Function Function (AAnF)

950019	**Security Assurance Specification for AKMA Anchor Function Function (AAnF)**	SCAS_5G_AAnF	S3	SP-220197	**Xiaoting Huang, China Mobile**

Summary based on the input provided by Qualcomm in SP-240892.

This work item delivers a new security assurance specification in TS 33.537[1] and a new Annex W in TR 33.926 [2] describing the associated assets and threats for AAnF network products.

It is part of SA3's regular activities related for the Network Equipment Security Assurance Scheme (NESAS), jointly defined by 3GPP and GSMA as described in SA3's Terms of Reference [3]. A SCAS specification defines the security assurance requirements and corresponding test cases for network equipment implementing one or more 3GPP NFs. For this particular work the target is the AAnF(AKMA Anchor Function) as specified in TS 33.535 [4].

The new SCAS AAnF specification in TS 33.537 [1] describes the specific security assurance requirements and related test cases that are specific to the AAnF network product class. The functionality of AAnF is specified in TS 33.535[4]. As for any other SCAS specification, this is done with reference to the generic requirement and test catalogue in TS 33.117 [5]. For the AAnF product class, most of these generic requirements and tests cases could be reused except for few network features and interfaces where they were deemed not applicable for AAnF products.

The new Annex W of TR 33.926 [2] for the AAnF class of network products describes the assets and identifies three new specific threats to such products in addition to the ones pertaining to the generic network product model of [2].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950019

[1] TS 33.537: "Security Assurance Specification (SCAS) for the Authentication and Key Management for Applications (AKMA) Anchor Function (AAnF)"
[2] TR 33.926: "Security Assurance Specification (SCAS) threats and critical assets in 3GPP network product classes"
[3] SP-201085 "Terms of Reference (ToR) for TSG SA WG3 (SA3)"
[4] TS 33.535: "Authentication and Key Management for Applications (AKMA) based on 3GPP credentials in the 5G System (5GS)"
[5] TS 33.117: "Catalogue of general security assurance requirements"

22.9 Other security-centric items

1010013	**Security Assurance Specification for 5G Phase 3**	SCAS_5G_Ph3	S3	SP-230867	**Wu, Rong, Huawei Technologies Co., Ltd.**

23 NR-only items

23.1 Not band-centric

23.1.1 NR network-controlled repeaters

970079	**NR network-controlled repeaters**	**NR_netcon_repeater**		RP-230175	**Nan Zhang, ZTE**
970179	Core part: NR network-controlled repeaters	NR_netcon_repeater-Core	R1	RP-230175	**Nan Zhang, ZTE**
970279	Perf. part: NR network-controlled repeaters	NR_netcon_repeater-Perf	R1	RP-230175	**Nan Zhang, ZTE**
940083	*Study on NR network-controlled repeaters*	FS_NR_netcon_repeater	R1	RP-221229	**Nan Zhang, ZTE**

Summary based on the input provided by ZTE in RP-232884.

To improve performance of conventional RF repeaters with the capability to receive and process side control information from the network, the Rel-17 study item 940083 “Study on NR Network-controlled Repeaters” identified the necessary enhancement with candidate solutions [1]. This work item [2] specifies the signalling and behaviour for side control information i.e., beamforming, UL-DL TDD operation and ON-OFF information, control plane signalling and procedures, and solutions for network-controlled repeater management.

Structure of Network-controlled repeater

The network-controlled repeater comprises a NCR-MT and a NCR-Fwd as depicted in Figure 1.

The NCR-MT is an entity with partial UE functionality, to communicate with the gNB (e.g., receiving side control information, SCI) via a control link based on the NR Uu interface. A list of allowed gNB cell(s) or forbidden gNB cell(s) may be configured to the NCR-MT. According to the received side control information from the gNB, the NCR-Fwd is to perform amplifying-and-forwarding of signals between the gNB and a UE via the backhaul link and access link, respectively.

In addition, as an in-band repeater, only the NCR-Fwd’s operation on signals associated to the cell that the NCR-MT is connected is intended to be controlled by the gNB via the SCI.

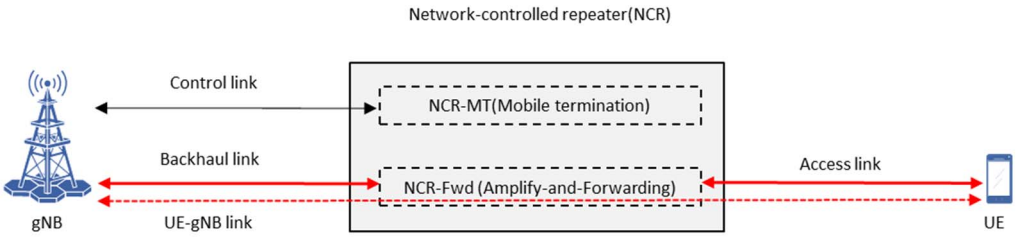

Figure 1: Conceptual model of network-controlled repeater.

Side control information indication

For DL-UL TDD information

The DL-UL configuration of the NCR-Fwd follows the DL-UL configuration (i.e., DL or UL slots/symbols determined by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated, if configured) of the control link of the NCR-MT. For timing determination of the backhaul link, the NCR-Fwd’s backhaul link DL/UL timing follows the NCR-MT’s DL/UL frame timing

For beam indication

For the access link, the beam used by the NCR-Fwd is represented by the “beam index” in the received signalling either periodically, semi-persistently or aperiodically. The time resource when the associated beam is applied is indicated together with the beam information. For periodic and semi-persistent beam indication, this information is configured by RRC signalling. Additional MAC CE signalling is used to activate or deactivate indications for semi-persistent beam indication. For aperiodic indication, the DCI format 2-8 is used to indicate beam index directly with the associated time resource, which is based on the RRC configuration. In addition, the details (e.g., characteristics) of physical beam(s) may be provided by OAM to the gNB and the NCR for operation.

For simultaneous operation of control and backhaul link, the beam of backhaul link is identical to the beam used on the control link. For non-simultaneous operation of control and backhaul link, the beam of backhaul link is determined by the specified rules unless the dedicated beam configuration (i.e., MAC CE) is indicated.

For ON-OFF information

The “ON-OFF” information is implicitly determined by received beam indication. The NCR-Fwd is assumed in “ON” state, i.e., performing the amplifying-and-forwarding in access link and backhaul link, only over the time resources when the corresponding beam information is received by the NCR-MT. In addition, the NCR-Fwd is assumed in “OFF” state if specific conditions (e.g., beam failure or RLF on the control link occurs) are satisfied.

Repeater management

For the repeater management, the NCR identification and authorization are supported.

NCR identification is performed in RAN by sending the NCR indication information to the serving gNB. The AMF (e.g., selected by gNB) provides NCR authorization information to the gNB.

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970079,970179,970279

[1] TR 38.867 Study on NR network-controlled repeaters (Rel-18).
[2] RP-232886 WI on NR network-controlled repeaters
[3] RP-232854 Status report of WI NR network-controlled repeaters

23.1.2 Enhancement of MIMO OTA requirement for NR UEs

970081	**Enhancement of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirement for NR UEs**	**NR_MIMO_OTA_enh**	**R4**	RP-232679	**Zhu, Siting, CAICT**
970181	Core part: Enhancement of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirement for NR UEs	NR_MIMO_OTA_enh-Core	R4	RP-232679	**Zhu, Siting, CAICT**
970281	Perf. part: Enhancement of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirement for NR UEs	NR_MIMO_OTA_enh-Perf	R4	RP-232679	**Zhu, Siting, CAICT**

Summary based on the input provided by CAICT in RP-233743.

Radiated multi-antenna reception performance is one of the most important characteristics to verify the MIMO receiver of the UE under conditions more closely resembling the end user's interaction with the device. This Rel-18 NR_MIMO_OTA_enh core part WI further enhanced NR MIMO OTA test methodologies based on the outcome of Rel-17 NR_MIMO_OTA WI in TS 38.151. The outcome of this WI impacts TS 38.151, and the analysis and measurement results of MIMO OTA are captured in a new internal technical report TR 38.761.

The objective of this core part WI is to further investigate and enhance NR MIMO OTA test methodologies defined in TS 38.151, including both FR1 and FR2. The following aspects in this core part WI have been investigated and specified:

- FR1 MIMO OTA test methodology enhancement:
  - Specify necessary enhancements of the FR1 MIMO OTA test methodology for tablet device types in free space, with the 20-cm quiet zone and the 16-probe MPAC system unchanged
  - Test time reduction methodology for FR1 MIMO OTA
    - For bands < 1GHz, the test parameter Minimum Number of Slots per Stream can be reduced to 10k for FR1 MIMO OTA measurement campaign and conformance testing for 15kHz SCS.
  - Refine FR1 channel model validation pass/fail limits
    - Pass/fail criteria of power validation is defined as ± 1.5 dB.
- FR2 MIMO OTA test methodology enhancement:
  - Define the framework for FR2 MIMO OTA requirement development
    - Pure measurement approach is adopted for FR2 requirement definition
  - Further refine the FR2 channel model validation pass/fail limits based on practical measurement results
    - Tighter pass/fail limit for temporal correlation is not necessary
    - Pass/fail criteria of power validation is defined as ± 1.5 dB.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970081,970181,970281

[1] RP-232679, Last approved WID: Enhancement of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) test methodology and requirements for NR UEs, CAICT.
[2] TR 38.761, Measurements of Multiple Input Multiple Output (MIMO) Over-the-Air(OTA) performance of User Equipment (UE)
[3] RP-233741, Last Status Report for WI: Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) requirements for NR UEs, RAN4

23.1.3 NR MIMO evolution for downlink and uplink

940096	**NR MIMO evolution for downlink and uplink**	**NR_MIMO_evo_DL_UL**		RP-223276	**Eko Onggosanusi, Samsung**
940196	Core part: NR MIMO evolution for downlink and uplink	NR_MIMO_evo_DL_UL-Core	R1	RP-223276	**Eko Onggosanusi, Samsung**
940296	Perf. part: NR MIMO evolution for downlink and uplink	NR_MIMO_evo_DL_UL-Perf	R1	RP-223276	**Eko Onggosanusi, Samsung**
940082	*Study on evolution of NR duplex operation*	FS_NR_duplex_evo	R1	RP-223041	**Fei WANG, CMCC**

Summary based on the input provided by Samsung in RP-232914.

This work item specifies enhanced support for several key aspects on multi-input multi-output (MIMO) operation where Rel-15, 16, and 17 NR were found deficient in terms of signalling latency, overhead, as well as spectral efficiency and coverage.

First, while Rel-17 NR introduces the unified TCI (Transmission Configuration Indicator) framework which alleviates high signalling latency and overhead especially for beam indication in FR2, it is limited to single-TRP (transmit-receive point) deployments with single-panel UEs (user equipments). Extensions to accommodate multi-TRP and/or multi-panel UEs are needed along with enhancement on UL (uplink) power control for multi-DCI (downlink control information). In addition, the support for 2TA (dual Timing Advance) for multi-DCI would be beneficial for multi-TRP (transmit-receive points).

Second, while Rel-16 eType-II and Rel-17 FeType-II port selection codebooks offer significant improvement in performance-overhead trade-off over their Rel-15 counterparts, further extending those two codebooks to support coherent joint transmission (CJT) multi-TRP and high/medium UE speed would extend the utility of Type-II CSI, especially in multi-user MIMO (MU-MIMO) scenario. In addition, a stand-alone time-domain channel property (TDCP) reporting can potentially aid network in selecting the best type of configuration for, e.g. codebook types, SRS (sounding reference signal) periodicity, or link adaptation/prediction.

Third, Rel-15 NR supports spatial multiplexing via DMRS (demodulation reference signal) for both DL (downlink) and UL with up to 8 and 12 orthogonal ports for DMRS configuration type 1 and type 2, respectively. To increase MU-MIMO scheduling capacity for both UL and DL, the number of orthogonal ports is doubled. Also, for supporting high-end UEs (e.g., CPE, FWA, vehicle, industrial devices) equipped with 8TX antennas, the corresponding RS enhancement for UL transmission are introduced. In addition, mechanisms to randomize interference among different TRPs are introduced for SRS.

Fourth, Rel-15 NR supports one transmission precoding matrix indication (TPMI)/SRS resource indicator (SRI) or one spatial-relation-based uplink transmission. To facilitate simultaneous UL transmission across two panels (STx2P), the support of two TPMI/SRIs and/or TCIs is introduced. Each TPMI/SRI and/or TCI can be applied for UL transmission associated with each panel. In addition, extension of the existing UL transmission schemes to support 8TX UL transmission (with up to 8 layers) is introduced for enhancing UL peak rate and throughput.

Enhancements for multi-TRP operation

The use of common beam for UE-dedicated receptions of PDCCH (physical DL control channel) and the associated PDSCH (physical DL shared channel) has been specified in Rel-17 under the unified TCI framework. In particular, with the introduction of the DCI-based beam indication for the UE-dedicated PDCCH and the associated PDSCH – via the TCI field in DCI formats 1_1/1_2 with or without DL assignment, the corresponding beam indication latency and overhead can be reduced. The Rel-17 unified TCI framework, however, is tailored for single-TRP (sTRP) operation. In Rel-18, the unified TCI framework is extended to multi-TRP (mTRP) operation (termed the Rel-18 eUTCI), where a UE can receive/transmit various DL/UL channels or signals from/to more than one TRPs.

To support beam indication/update for the mTRP operation, enhancements related to TCI signalling enhancements are introduced for single-DCI (sDCI)-based mTRP. Here, an activated TCI codepoint can correspond to one or two sets of TCI states with each set corresponding to a TRP and comprising of one joint/DL/UL TCI state or a pair of separate DL and UL TCI states. This would require a new MAC CE activation command customized for the Rel-18 sDCI-based mTRP operation, where a TCI codepoint activated in the MAC CE command also provides information related to the association between the TCI state(s) mapped to the TCI codepoint and the TRP(s) in the mTRP system. Some enhancements are also introduced for mDCI-based mTRP. Here, an activated TCI codepoint can correspond to a joint/DL/UL TCI state or a pair of separate DL and UL TCI states, where each activated TCI codepoint in a mDCI based mTRP system is specific to a configured value of coresetPoolIndex.

For both sDCI- and mDCI-based mTRP operations, the Rel-18 eUTCI also specifies various rules and the corresponding signaling designs for associating between the indicated TCI states and TRP-specific DL/UL channels and/or signals.

- For sDCI-based mTRP, RRC configuration can be provided for a CORESET to determine which one of the two indicated TCI states is used for monitoring the corresponding PDCCH candidates. Optionally, to support dynamic TRP(s) selection/switching, a TCI selection field is introduced in DCI format 1_1/1_2 to inform the UE which one or two of the indicated TCI states to use for receiving the corresponding PDSCH. Similar design mechanisms also apply to the UL counterparts and various reference signals.

- For mDCI-based mTRP, RRC configuration is provided to determine the TCI state association with to (most) channels/signals and whether they are associated the same value of coresetPoolIndex.

Moreover, the Rel-18 eUTCI also specifies rules for, e.g., determining the TCI state assumed for buffering PDSCH and/or aperiodic CSI-RS, operating inter-cell mDCI-based mTRP, resetting common beam for beam failure recovery, enhancing power control for STx2P. In summary, the Rel-18 eUTCI applies to all the sDCI- and mDCI-based mTRP schemes specified in Rel-16 and Rel-17 (e.g., repetition schemes and SFNs).

Rel-18 also introduces the support of 2TA for UL mDCI-based mTRP operation with the Rel-17/18 unified TCI state framework. With CP-OFDM waveform, UL transmissions from UEs are expected to arrive within a small window around its UL reference time. This is achieved by the network sending a timing advance command (TAC) to the UE to adjust its UL transmission time. In multi-TRP-based systems, the UL transmissions to different TRPs can require different UL timing advances due to synchronization mismatches between the TRPs and different round-trip propagation times between the TRPs and the UE. Evidently, 2TA is needed when the UE is communicating with two TRPs.

For inter-cell and intra-cell mDCI-based mTRP operation, a UE can support two TA groups (TAGs), each associated with a TAG ID. Each TAG is associated with a DL reference time and has a corresponding TA value obtained from the TAC. Each UL/joint TCI state is associated with a TAG ID and the UE applies the TA value of the TAG ID associated with the UL/joint TCI state utilized for UL transmission. Contention-free random access (CFRA) triggered by PDCCH order is used to acquire a TA value associated with a TAG ID. A PDCCH order can trigger a physical random-access channel (PRACH) transmission towards the same TRP or towards a different TRP. When this occurs, the associated pathloss reference signal (PLRS) is determined based on whether the TRP to which the PRACH is transmitted is the same as or different from that of the PDCCH order.

Enhancements for CSI

First, to better support CJT multi-TRP, the Rel-16 eType-II and Rel-17 FeType-II port selection codebooks are extended in Rel-18 to support up to 4 NZP CSI-RS resources (therefore, up to a total of 4x32 = 128 ports) as the Channel Measurement Resource (CMR) where each NZP CSI-RS resource can represent a TRP. While most codebook components and CSI/UCI designs are inherited from Rel-16 and Rel-17 (e.g. DFT-based spatial- and frequency-domain bases, W2 coefficient quantization, bitmap to indicate non-zero coefficients), a few notable enhancements (some of which optional) include the following:

- TRP-specific spatial-domain (SD) basis selection

- TRP-common frequency-domain (FD) basis selection, with (mode-1) and without (mode-2) TRP-specific phase offset

- Dynamic TRP selection where N out of NTRP configured CSI-RS resources are selected and reported
- Dynamic selection of the number of SD basis vectors per TRP where one out of NL configured NTRP-tuples is selected and reported
- NTRP-dependent Parameter Combinations

Second, to better support high/medium-speed, the Rel-16 eType-II and Rel-17 FeType-II port selection codebooks are extended in Rel-18 to support UE-side prediction and, for Rel-16-based design, Doppler-domain (DD) compression. While most codebook components and CSI/UCI designs are inherited from Rel-16 and Rel-17 (e.g. DFT-based spatial- and frequency-domain bases, W2 coefficient quantization, bitmap to indicate non-zero W2 coefficients), a few notable enhancements (some of which optional) include the following:

- Framework for UE-side prediction including CSI reporting window with the reference resource slot (n–nCSI,ref) or reporting slot (plus an offset, n+ □) as the starting slot, where the PMI calculation corresponds to
- For Rel-16-eType-II-based design, DFT-based DD basis providing a third dimension (in addition to SD and FD) for PMI compression

- Inclusion of one or two time-domain (TD) CQIs in one CSI report (together with PMI and RI)
- Aperiodic CSI-RS consisting of multiple NZP CSI-RS resources as the CMR

Third, to better facilitate network in configuring a UE with the best setting for CSI acquisition (such as codebook type, CSI-RS periodicity, SRS periodicity) which largely depends on the UE speed, as well as performing link adaptation and CSI prediction, a stand-alone aperiodic time-domain channel property (TDCP) report on PUSCH is introduced in Rel-18. The report includes the following (some of which are optional):

- Normalized wideband amplitude of time-domain auto-correlation, calculated for each of the Y configured delay values {D1, D2, …, DY} with Y=1 as the basic feature, Dn=n.D, uniformly quantized in logarithmic domain in 4 bits
- Phase of time-domain auto-correlation, calculated for each of the Y configured delay values {D1, D2, …, DY}, uniformly quantized in linear domain in 4 bits
- The supported values of D={4 symbols, 1 slot, 2 slots, 3 slots, 4 slots, 5 slots, 6 slots, 10 slots (only for SCS $\geq$ 30kHz)} and Y={1, 2, 3, 4}
- For TDCP measurement, KTRS={1,2,3} CSI-RS resource sets for tracking can be configured

Enhancements for Reference Signals

In Rel-15 NR, DMRS for PDSCH and CP-OFDM-based PUSCH, the number of available orthogonal ports for spatial multiplexing (SU- or MU-MIMO) is as follows:

- DMRS configuration type 1: up to 4 for 1 front-loaded (FL) DMRS symbol, up to 8 for 2 FL DMRS symbols
- DMRS configuration type 2: up to 6 for 1 FL DMRS symbol, up to 12 for 2 FL DMRS symbols

To increase MU-MIMO multiplexing capacity, enhanced DMRS configuration type 1 and 2 are defined, and the number of orthogonal ports is doubled from Rel-15 DMRS:

- Enhanced DMRS configuration type 1: up to 8 for 1 FL DMRS symbol, up to 16 for 2 FL DMRS symbols
- Enhanced DMRS configuration type 2: up to 12 for 1 FL DMRS symbol, up to 24 for 2 FL DMRS symbols

To support enhanced DMRS configuration type 1 and 2, the following rules are introduced:

- Time/frequency resource mapping and the number of code-division multiplexing (CDM) groups for enhanced DMRS configuration type 1 and 2 are same as those of DMRS configuration type 1 and 2, respectively.
- The length-4 frequency-domain orthogonal-cover-code (FD-OCC) is adopted for both enhanced DMRS configuration type 1 and 2 which is length-2 for DMRS configuration type 1 and 2. Hence, half of DMRS ports have same FD-OCC pattern as legacy but with different length, and the other half of DMRS ports have newly defined FD-OCC pattern.

Rel-15 NR supports up to 4 layers for PUSCH transmission. For supporting up to 8 layers, both DMRS configuration type and enhanced DMRS configuration type are supported for UL 8TX SU-MIMO-based PUSCH. Likewise, 8-port SRS resource is defined for usage of codebook and antenna switching (i.e., 8T8R), and SRS resource set with up to 8 resources (with one port per resource) is defined for usage of non-codebook. There are two types of 8-port SRS resource as follows:

- Non-TDMed SRS: All 8 ports are transmitted in every symbol which is same as legacy 1/2/4-port SRS.
- TDMed SRS: Among 8 ports, the 1st and 2nd set of 4 ports are transmitted separately in the 1st and 2nd symbol, respectively, and 1st and 2nd set of 4 ports are disjoint, and 1st and 2nd symbols are consecutive.

For interference randomization across different TRPs, two hopping schemes (i.e., cyclic shift hopping and comb offset hopping) are adopted for SRS used for codebook-based UL transmission and antenna switching. Also, considering coexistence between legacy UEs and Rel-18 UEs, a hopping subset can be configured for cyclic shift hopping or comb offset hopping so that the hopping region can be restricted and interference from hopping UEs to non-hopping legacy UEs can be controlled.

Enhancements for UL transmissions

For UEs supporting two panels, two separate TPMI/SRI indications and/or TCI applications are introduced in Rel-18 to enable simultaneous UL transmission across two panels (STx2P). For the sDCI-based mTRP, the following are supported:

- Spatial-division multiplexing (SDM) PUSCH transmission where the two subsets of layers of one PUSCH are separately precoded and simultaneously transmitted from two panels
- Single-frequency network (SFN) PUSCH transmission where the same PUSCH signal is separately precoded and simultaneously transmitted on two panels

- SFN PUCCH transmission where the same PUCCH is transmitted with two TCI states on two panels

For the mDCI based mTRP transmission scheme, the two DCIs associated with different coresetPoolIndex values can schedule two separate PUSCH transmissions (each from a panel and separately precoded, with its own beam) which can be transmitted simultaneously.

To increase UL throughput, the maximum number of uplink transmission ports is increased to 8 ports in Rel-18 with up to 8 layers using the legacy DL codeword-to-layer mapping. Both codebook-based and non-codebook based PUSCH transmission schemes are extended to 8TX. For codebook-based PUSCH transmission scheme, 4 different antenna groups are defined including full-coherent antenna group (Ng=1, codebook1) where all 8 antennas are assumed coherent, two partial-antenna group (Ng=2, codebook2) where 4 antennas within a coherent group are assumed coherent, four partial-antenna group (Ng=4, codebook3) where 2 antennas within a coherent group are coherent, and non-coherent antenna group (Ng=8, codebook4) where all 8 antennas are assumed non-coherent. A codebook is specified for each coherence assumption and full power transmission mode. For non-codebook-based PUSCH transmission scheme, SRI indication is extended to indicate up to 8 transmission layers.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940096,940196,940296

23.1.4 Further NR mobility enhancements

940098	**Further NR mobility enhancements**	**NR_Mob_enh2**		RP-223520	**Li-Chuan Tseng, MediaTek**
940198	Core part: Further NR mobility enhancements	NR_Mob_enh2-Core	R2	RP-231475	**Li-Chuan Tseng, MediaTek**
940298	Perf. part: Further NR mobility enhancements	NR_Mob_enh2-Perf	R2	RP-231475	**Li-Chuan Tseng, MediaTek**

Summary based on the input provided by MediaTek, Apple in RP-240444.

This WI provides 7 main functionalies: 1) L1/L2-based inter-cell mobility, 2) NR-DC with selective activation of the cell groups, 3) CHO including target MCG and target SCG, 4) conditional handover with candidate SCGs, 5) RRM core requirements for L1/L2-based mobility and CHO enhancements, 6) RF requirements, and 7) SCell/SCG setup delay improvement by reusing IDLE/INACTIVE mode measurement results. Corresponding stage-2 descriptions are specified in TS38.300 and TS37.340 (for NR-DC part). Physical layer procedures are specified in TS 38.312, TS 38.213, and TS 38.214. MAC and RRC signalling are specified in are specified in TS 38.321 and TS 38.331, respectively. NG-RAN architecture and protocols are specified in TS 38.401, TS 38.423, TS 37.483, TS 38.470, and TS 38.473. Measurement requirements are specified in TS 38.133. UE capabilities are specified in TS 38.306.

1) L1/L2 based inter-cell mobility for mobility latency reduction
- Analysis of mobility latency components
- Introduced a L1/L2-triggered mobility procedure (LTM), where cell switch is based on L1 measurements and triggered by MAC CE, including the following enhancements
  - o RRC configuration of LTM candidates, applied when the candidate configuration is selected
    - The configuration can be provided as (1) a common reference configuration plus delta configuration for each candidate (a complete configuration is formed when applying the delta on top of reference), or (2) a complete configuration. Upon LTM cell switch, the complete configuration replaces UE's current RRC configurations
    - Configuration of other candidates are kept after LTM execution, so as to support subsequent LTM without another reconfiguration
  - o L1 measurements, reporting and TCI state activation for candidate cells
    - Reference signal, report configurations and TCI states are provided outside the RRC container of candidate configurations
    - MAC CE for candidate cell TCI state activation/deactivation
  - o Early timing advance acquisition for non-serving cells and RACH-less LTM
    - TA can be acquired via preamble triggered by PDCCH order, or UE-based TA measurement
    - LTM is RACH-less if TA value is available, either via early TA acquisition, or TA=0 or the same as serving cell
  - o LTM Cell Switch MAC CE carrying target cell (configuration), TA value, and TCI state indication

2) NR-DC with selective activation of the cell groups
- Introduced the subsequent conditional PSCell addition and change (CPAC) procedure
  - o A conditional PSCell addition or change procedure that is executed after a PSCell addition, a PSCell change, or a SCG release, based on pre-configured subsequent CPAC configuration of candidate PSCell(s).

- There is no reconfiguration and re-initiation of CPC/CPA.

• Defined subsequent conditional PSCell addition/change delay requirements.

3) CHO including target MCG and target SCG in NR-DC

• Introduced early data forwarding optimization.

4) Conditional handover with candidate SCGs

• Introduced a PCell change with PSCell addition/change procedure that is executed by the UE when the execution conditions for both PCell and the associated PSCell are met.

- The UE starts evaluating the execution conditions for candidate PCell(s) and candidate PSCell(s) simultaneously upon receiving the CHO with candidate SCG(s) configuration and stops evaluating the execution conditions once PCell change or PSCell change is triggered.

• Introduced support of CHO with multiple SCGs, and mechanisms to avoid forwarding the same data to the target SN over multiple target MN.

5) RRM core requirements for L1/L2-based mobility and CHO enhancements

• Defined cell switch delay and interruption requirements

• Defined interruption requirements for PDCCH-ordered RACH on target cell

• Defined L1-RSRP measurement requirements for LTM neighbour cell

- Intra-frequency L1-RSRP measurement, including RTD of serving cell and neighbour cell is within or larger than CP
- Inter-frequency L1-RSRP measurement with Type 1 MG
- Inter-frequency L1-RSRP measurement without gap

• Defined requirements on PCell conditional handover delay and PSCell change for NR Conditional Handover including target MCG and target SCG

- From FR1-FR1 NR-DC to FR1-FR2 NR-DC,
- From FR1-FR2 NR-DC to FR1-FR2 NR-DC,
- From FR1-FR1 NR-DC to FR1-FR1 NR-DC,
- From FR1-FR2 NR-DC to FR1-FR1 NR-DC

• Defined requirements on PCell conditional handover delay and PSCell conditional change delay, for NR Conditional Handover including target MCG and candidate SCG

- From FR1-FR1 NR-DC to FR1-FR2 NR-DC,
- From FR1-FR2 NR-DC to FR1-FR2 NR-DC,
- From FR1-FR1 NR-DC to FR1-FR1 NR-DC,
- From FR1-FR2 NR-DC to FR1-FR1 NR-DC

6) RF requirements for inter-frequency L1/L2-based mobility

• Currently, no RF impact has been identified

7) SCell/SCG setup delay improvement by reusing IDLE/INACTIVE mode measurement results

• IDLE/INACTIVE mode measurement results are reported during and/or after RRC connection setup/resume in order to improve SCell/SCG setup delay. Two mechanisms have been defined:

- Rel-18 eEMR: Rel-16 EMR plus a validity duration
- Rel-18 IMR: Reporting of available IDLE/INACTIVE mode cell reselection measurements with a validity duration.

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List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940098,940198,940298

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[3] R1-2308699, (TS38.213 CR) Introduction of further mobility enhancements Samsung, Sept. 2023

[4] R1-2308718, (TS38.214 CR) Introduction of specification support for mobility enhancements, Nokia, Sept. 2023

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[14] R3-238154, (CR to 38.423) Introduction of L1/L2 triggered mobility, CATT, ZTE, Nokia, Nokia Shanghai Bell, Ericsson, CMCC, LG Electronics, Huawei, NEC, Lenovo, Nov. 2023
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23.1.5 In-Device Co-existence (IDC) enhancements for NR and MR-DC

941003	**In-Device Co-existence (IDC) enhancements for NR and MR-DC**	**NR_IDC_enh**		RP-221281	**Yumin Wu, Xiaomi**
941103	Core part: In-Device Co-existence (IDC) enhancements for NR and MR-DC	NR_IDC_enh-Core	R2	RP-221281	**Yumin Wu, Xiaomi**

Summary based on the input provided by Xiaomi in RP-233486.

The work item of Rel-18 IDC enhancements targets at resolving the UE's internal interference (i.e. from the UE's Tx to the UE's Rx) between NR and other RATs (e.g. WLAN, BlueTooth, UWB and so on), by using FDM solution, TDM solution and autonomous denial solution. The UE's internal interference to be resolved can be from the Tx of NR to the Rx of other RATs, or from the Tx of other RATs to the Rx of NR. Regarding the interference from the Tx of NR to the Rx of other RATs, the number of attacking NR frequencies can be one (i.e. the interference caused by the harmonic wave of one NR frequency) or more than one (i.e. the interference caused by the intermodulation of multiple NR frequencies.). Thus, the IDC interference can happen when the UE is configured with a single NR frequency or CA or DC. The work item objectives of NR IDC enhancements can be found in [1].

FDM solution: For the FDM solution, when the gNB enables the FDM solution for the UE via RRC configuration, the UE is allowed to report its affected NR frequencies, which can be either attacking frequencies or victim frequencies, via UEAssistanceInformation. When the affected NR frequency is the attacking frequency, the UE can indicate the victim system type (e.g. WLAN, BlueTooth, UWB and so on) of other RATs. When the interference type from NR to other RATs is the harmonic interference, the UE can indicate a list of affected NR frequencies, and each entry of the list includes only one NR frequency and the bandwidth around the NR frequency. When the interference type from NR to other RATs is the IMD (Inter-Modulation Distortion) interference, the UE can indicate a list of affected NR frequency combinations, and each NR frequency combination includes more than one NR frequencies and the bandwidth around the NR frequency. It is up to the network implementation on how to use the frequency information reported by the UE, so that the IDC interference can be resolved.

TDM solution: For the TDM solution, when the gNB enables the TDM solution for the UE via RRC configuration, the UE is allowed to report its preferred TDM pattern, which includes the UE's preference on the active duration, cycle and starting offset for the affected frequency. It is up to the network implementation on how to stop/start scheduling the UE's transmission/reception for the affected frequency, by using the TDM pattern reported by the UE.

Autonomous denial solution: For the autonomous denial solution, the gNB can provide the autonomous denial configuration to the UE per cell group. Based on the autonomous denial configuration, the UE is allowed to deny the uplink transmission in some slots for a cell group (e.g. MCG or SCG), without exceeding the maximum number of uplink transmission slots permitted by the network. When the UE counts the number of denied uplink transmission, the

number of slots denied by the UE within a validity period shall be less than the maximum number of slots allowed (i.e. configured by the network) to be denied within the validity period. The UE by implementation can decide which uplink transmission can be denied so that the interference to other RATs can be mitigated.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941003,941103

23.1.6 Even Further RRM enhancement for NR and MR-DC

950078	**Even Further RRM enhancement for NR and MR-DC**	**NR_RRM_enh3**		RP-221696	**Jie Cui, Apple**
950178	Core part: Even Further RRM enhancement for NR and MR-DC	NR_RRM_enh3-Core	R4	RP-221696	**Jie Cui, Apple**
950278	Perf. part: Even Further RRM enhancement for NR and MR-DC	NR_RRM_enh3-Perf	R4	RP-221696	**Jie Cui, Apple**

Summary based on the input provided by Apple in RP-233495.

This work item defines the RRM requirements for “FR2 and FR1 unknown SCell activation delay reduction” and for “RRM requirements for FR1-FR1 NR-DC scenarios”

The RRM requirements were missing for the above UE features in the TS38.133/TS36.133 before this WI, and the corresponding delay requirements have been specified in this WI to verify corresponding UE behavior.

FR2 and FR1 unknown SCell activation delay reduction

RAN4 has specified the RRM requirement for FR2 and FR1 unknown SCell activation enhancement in TS38.133. Following UE features were introduced in this enhancement:

- Feature 1: Support of reporting valid L3 measurement results triggered by the SCell activation command.
- Feature 2: Support of reducing beam sweeping factor for cell detection if UE has full set (N=8) of beam sweeping during AGC settling part during FR2-1 unknown SCell activation procedure. Support of reducing beam sweeping factor for SSB based L1-RSRP measurement if UE has full set (N=8) of beam sweeping during AGC settling part during FR2-1 unknown SCell activation procedure
- Feature 3: Support of using SSB periodicity instead of SMTC periodicity for the measurement interval during unknown SCell activation when the SMTC is only configured in measurement object for enhanced unknown SCell activation requirement. Support of performing L1-RSRP measurement in non-DRX mode even DRX is configured during unknown SCell activation

RAN4 specified the Requirement of SCell activation delay reduction for: Single SCell activation; Single PUCCH SCell activation and for Multiple SCell activation with/without PUCCH SCell.

RAN2 has specified the corresponding signalling for FR2 and FR1 unknown SCell activation enhancement in TS38.331 and TS38.321.

RRM requirements for FR1-FR1 NR-DC scenarios

RAN4 has specified RRM requirement for FR1-FR1 NR-DC scenarios:

- Number of serving carriers for NR-DC
- Interruption requirement
- PSCell Addition Delay Requirement
- Carrier-specific scaling factor
- Scheduling availability
- HO with PSCell
- SCG Activation and Deactivation Delay

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950078,950178,950278

23.1.7 Dual Transmission Reception (TxRx) Multi-SIM for NR

941001	**Dual Transmission/Reception (Tx/Rx) Multi-SIM for NR**	**NR_DualTxRx_MUSIM**	**R2**	RP-233071	**Vivo**
941101	Core part: Dual Transmission/Reception (Tx/Rx) Multi-SIM for NR	NR_DualTxRx_MUSIM-Core	R2	RP-233071	Xiaodong Yang, vivo
950283	Perf. Part: Dual Transmission/Reception (Tx/Rx) Multi-SIM for NR	NR_DualTxRx_MUSIM-Perf	R2	RP-233071	Xiaodong Yang, vivo

Summary based on the input provided by vivo in RP-233072.

For dual-Tx/dual-Rx multi-USIM (MUSIM) device, to use the hardware efficiently and economically, the hardware of the device can be shared between the USIMs, leading to a temporary hardware conflict of the UE(s) in case of dual active connections, which may require the UE to report its temporary capability restriction to the network. This work item specifies solutions to address the temporary capability restriction issue for dual-Tx/dual-Rx MUSIM device.

Moreover, for single-Tx/ (single-Rx or dual-Rx) MUSIM device, per-UE MUSIM gap was introduced in NR Rel-17. This work item also specifies the corresponding RRM requirements and the signalling support of MN-SN coordination for Rel-17 MUSIM gap.

The following schemes were introduced as part of the Work Item:

Temporary capability restriction reporting in RRC_CONNECTED (Scenario 1)

When the USIM A is in RRC_CONNECTED in network A while the USIM B is in RRC_IDLE/INACTIVE in network B, full capabilities will be occupied by the USIM A for the communication. Once the USIM B enters RRC_CONNECTED, part of the capabilities needs to be switched to USIM B. In this case, the UE of USIM A needs to indicate its temporary capability restriction to the network. Moreover, band conflict may occur when both USIMs are in RRC_CONNECTED, and this issue can be also solved by the solutions addressing temporary capability restriction issue.

If allowed by the network, reporting temporary capability restriction information is via UE assistant information (UAI) procedure. In the UAI, the UE can indicate its temporary capability restriction information for the following types of UE capabilities:

- CA/DC capabilities;
- Maximum MIMO layer;
- Maximum channel bandwidth;
- Measurement gap requirement;
- The maximum CC numbers.

The reporting of these changed capabilities can be used by the UE to request the release of the specific configurations, or to avoid receiving an unexpected configuration in the future. Therefore, “reactive” and “proactive” approaches for the mentioned two cases are introduced. For the two cases, the content of the UAI and the UE behaviour after sending the UAI are different.

“Proactive” approach: The UE can indicate its forbidden and/or affected BC(s)/band(s) to the network. The forbidden BC(s)/band(s) means the UE does not prefer the network to configure these BC(s) or the band(s) to the UE. For the affected BC(s)/band(s), the UE will additionally indicate the current maximum MIMO layer/bandwidth on these BC(s)/band(s), which means the UE does not prefer the network to send the configuration that exceeds this maximum MIMO layer/bandwidth on these BC(s) or the band(s). To reduce the signalling overhead, a network configured band-filter list and normal prohibit timer are introduced for controlling the UE’s reporting.

“Reactive” approach: If the UE has constrained capability related to the current configuration, serving cell index can be used for setting the content of the UAI. The UE can indicate its preference on the release of specific serving cells, or indicate the temporary maximum MIMO layers/channel bandwidth for specific serving cells. The UE can also indicate its measurement gap requirement change due to dual active MUSIM operation. If the UE requests a change of capabilities reactively, the UE is expected to receive a new RRC configuration from the network immediately. However, the network may still want to use the requested resource for transmission for a short time. As a compromise, a wait timer is introduced for waiting the subsequent RRC reconfiguration. If the UE does not receive the reconfiguration that matches the UE’s current capabilities indicated in the MUSIM UAI in a certain time, the UE is allowed to switch its capabilities locally.

MN-SN coordination: When the UE is configured with NR-DC, UE's temporary capability restriction reporting via SRB3 is not supported in this release. After receiving the temporary capability restriction reporting from the UE via SRB1, the MN can indicate the proactive/reactive temporary capability restriction information to the SN via inter-node message.

Early indication of temporary capability restriction during RRC setup/resume (Scenario 2)

When the USIM A initiates RRC setup/resume from RRC_IDLE/INACTIVE while the USIM B is already in RRC_CONNECTED, the USIM A has temporary capability restriction issue during RRC setup/resume. The UE can send early indication of MUSIM temporary capability restriction in RRC setup complete or RRC resume complete messages. For both RRC_IDLE/INACTIVE, UE can send this early indication only if the indication is allowed by the network in SIB1. The early indication is only one-bit indication for reporting its capability is currently in constraint status. It is up to the network on how to configure and schedule the UE before receiving the detailed temporary capability restriction information reported in MUSIM UAI.

Rel-17 MUSIM gap leftovers

MUSIM gap priority and keep solution: To address the collisions between MUSIM gap and legacy measurement gap (i.e., Rel-15 to Rel-17 measurement gaps) and the collisions among MUSIM gap(s), gap priority is introduced for periodic MUSIM gap. In addition, for the collision among MUSIM gap(s), the UE is allowed to keep all the collided MUSIM gaps (called "keep solution"). For aperiodic MUSIM gap, it is always kept at the UE in case of collisions with other gaps (i.e. all gaps including MUSIM gaps, etc).

If allowed by the network, the UE can indicate its preference on the MUSIM gap priority(s) and "keep solution". The network may configure MUSIM gap priority(s) and the grant of "keep solution" based on the UE's preference. When "keep solution" is not indicated or not granted, the UE uses priority-based solution to solve the collision among periodic MUSIM gap(s).In a collision occasion, gap with lower priority will be dropped.

MN-SN coordination: When the UE is configured with NR-DC, the MN can transfer the configured MUSIM gap pattern(s), the configured MUSIM gap priority, the network indication of keeping all collided MUSIM gap(s) to the SN via the inter-node message.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941001,941101,950283

23.1.8 NR support for dedicated spectrum less than 5MHz for FR1

941012	**NR support for dedicated spectrum less than 5MHz for FR1**	**NR_FR1_lessthan_5MHz_BW**		RP-231713	**Man Hung Ng, Nokia**
941112	Core part: NR support for dedicated spectrum less than 5MHz for FR1	NR_FR1_lessthan_5MHz_BW-Core	R4	RP-231713	**Man Hung Ng, Nokia**
941212	Perf. part: NR support for dedicated spectrum less than 5MHz for FR1	NR_FR1_lessthan_5MHz_BW-Perf	R4	RP-231713	**Man Hung Ng, Nokia**

Summary based on the input provided by Nokia in RP-234062.

The Work Item on NR support for dedicated spectrum less than 5MHz for FR1 specifies a new 3 MHz channel bandwidth with 15 PRB, and provides support for 12 and 20 PRB transmission bandwidths for 3 and 5 MHz channel bandwidth, respectively, on band n100. The 3 MHz channel bandwidth helps in utilizing small spectrum allocations on various bands, for example, electric utilities such as smart grids. The 12 and 20 PRB transmission bandwidths are designed specifically for rail communications in Europe, where Future Railway Mobile Communication System (FRMCS) forms the basis for digitizing rail operations. The new 3 MHz channel bandwidth, as well as the 12 and 20 PRB transmission bandwidths allow for gradual migration from the present GSM-R systems to 5G NR, while leaving room for a necessary number of GSM-R carriers on the same band (n100).

The work item specifies support for 3 MHz (15 PRB) channel bandwidth for FR1. The only supported subcarrier spacing (SCS) is 15 kHz, and only normal CP is considered. Furthermore, 12 and 20 PRB transmission bandwidths are supported for 3 and 5 MHz channel bandwidths, respectively, for band n100.

The work item considers single-carrier operation, excluding RedCap.

Reduced bandwidth requires changes to some of the physical channels, that would otherwise occupy a larger number of PRBs:

- The bandwidth of PBCH is reduced to 12 PRBs for 3 MHz channel bandwidth by puncturing the lower and the upper 4 RBs of the 20 RB PBCH.
- The bandwidth of CORESET#0 is reduced to match the transmission bandwidths of 12, 15 and 20 PRB. Table 13-0 in TS 38.213 [1] includes the supported CORESET#0 sizes for dedicated spectrum less than 5MHz.
  - The 12 PRB CORESET#0 is directly mapped to 12 PRBs.
  - The 15 PRB CORESET#0 is obtained by puncturing the nine highest PRBs of the 24 PRB CORESET#0. Both interleaved and non-interleaved REG-to-CCE mapping is supported for the 15 PRB CORESET#0.
  - The 20 PRB CORESET#0 is obtained by puncturing the four highest PRBs of the 24 PRB CORESET#0.

For dedicated spectrum less than 5 MHz, the frequency position and bandwidth of the initial downlink bandwidth part (BWP) are equal to the CORESET#0 transmission bandwidth (after puncturing, if any) if UE is not provided with initialDownlinkBWP IE. Moreover, a UE supports a BWP size equal to the applicable transmission bandwidth configuration of 12, 15 or 20 PRBs.

Short PRACH formats with 15kHz SCS, and long PRACH formats with 1.25kHz SCS are supported for transmission bandwidths below 5 MHz channel bandwidth. The PRACH formats and configurations not fitting into the transmission bandwidth are not applicable.

New synchronization raster points are defined for 15 PRB transmission bandwidth in 3MHz channel bandwidth to avoid the UE not supporting 3MHz channel bandwidth to unintentionally sync-up with these raster points for system acquisition. Denser synchronization raster points are defined compared to those for 5MHz and above channel bandwidth to have at least one synchronization raster for each 100kHz channel raster. Synchronization raster points are defined for below 1GHz bands n100, n106, n26, n28 and n85 using the equation:

$$N * 600\ kHz + M * 50\ kHz + 300\ kHz,\ N = 1{:}1665,\ M \in \{1,3,5\}$$

For band n100, one additional synchronization raster point at 920.73MHz is defined for 12 PRB transmission bandwidth configuration in 3MHz channel bandwidth, and one additional synchronization raster point at 921.45MHz is defined for 20 PRB transmission bandwidth configuration in 5MHz channel bandwidth. The synchronization raster point at 921.45MHz is skipped for 15 PRB transmission bandwidth configuration in 3MHz channel bandwidth to avoid the UE supporting 3MHz channel bandwidth to unintentionally sync-up with this raster point for system acquisition. Note that 12 PRB transmission bandwidth configuration only uses the synchronization raster point at 920.73MHz and 20 PRB transmission bandwidth configuration only uses the synchronization raster point at 921.45MHz, but not the other synchronization raster points defined for 3MHz and 5MHz channel bandwidths.

RF and RRM requirements are specified for optional 3 MHz channel bandwidth in bands n100, n106, n26, n28 and n85. The requirements are specified for UE speeds up to 500km/h for Band n100.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=991042,991142,991242

[1] TS 38.213 v18.0.0: “NR; Physical layer procedures for control”

23.1.9 Enhancement of NR Dynamic Spectrum Sharing (DSS)

940093	**Enhancement of NR Dynamic Spectrum Sharing (DSS)**	**NR_DSS_enh**		RP-221622	**Ravikiran Nory, Ericsson**
940193	Core part: Enhancement of NR Dynamic Spectrum Sharing (DSS)	NR_DSS_enh-Core	R1	RP-221622	**Ravikiran Nory, Ericsson**
940293	Perf. part: Enhancement of NR Dynamic Spectrum Sharing (DSS)	NR_DSS_enh-Perf	R1	RP-221622	**Ravikiran Nory, Ericsson**

Summary based on the input provided by Ericsson in RP-233808.

Dynamic spectrum sharing (DSS) provides a very useful migration path from LTE to NR by allowing LTE and NR to share the same carrier. DSS was included in Rel-15 and additional features related to it were specified in Rel-16 and Rel17. LTE UEs are likely to be around for a long time and hence it is important to continue to evolve DSS, especially there is room for performance improvements in scenarios where NR traffic starts to dominate with very low LTE traffic.

NR PDCCH control signalling would be a bottleneck of DSS with increasing NR traffic. To maximize the resource utilization and increase the PDCCH capacity for DSS, UE reception of NR PDCCH candidates overlapping with LTE CRS is specified in this Rel18 WI.

Transmission of LTE CRS from neighbouring LTE cells can cause interference to NR cells. In order to mitigate this interference, it would be useful to have multiple LTE CRS rate matching patterns. However, so far two overlapping LTE rate matching patterns are only supported by UEs together with support and configuration of multi-TRP transmissions. UE support for two overlapping CRS rate matching patterns regardless of support or configuration of multi-TRP is specified in this Rel18 WI.

The work item introduces the following:

- UE reception of NR PDCCH candidates that overlap with LTE CRS REs

- UE support, and configuration with, two overlapping CRS rate matching patterns regardless of support or configuration of multi-TRP

Changes triggered by the work item are captured into TS 38- series specifications [3]-[8].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940093,940193,940293

[1] RP-232957 - “Revised WID on Enhancement of NR Dynamic spectrum sharing (DSS)”, Ericsson, RAN#102.
[2] RP-232956 – Status report for WI: Enhancement of NR Dynamic spectrum sharing (DSS), Ericsson, RAN#102.
[3] R1-2308727 – “Introduction of dynamic spectrum sharing enhancements”, Ericsson, CR0112 to 38.211, RAN1#114.
[4] R1-2308694 – “Introduction of dynamic spectrum sharing (DSS) enhancements”, Samsung, CR0500 to 38.213, RAN1#114.
[5] R1-2308724 – “Introduction of dynamic spectrum sharing enhancements”, Nokia, CR0443 to 38.214, RAN1#114.
[6] R2-2132995 – “Introduction of R18 DSS”, Ericsson, ZTE Corporation, CR4360 to 38.331, RAN2#124
[7] R2-2313676 - “Introduction of Rel-18 UE capabilities”, Intel Corporation, CR4510 to 38.331, RAN2#124
[8] R2-2313677 – “Introduction of Rel-18 UE capabilities”, Intel Corporation, CR1015 to 38.306, RAN2#124

23.1.10 Multi-carrier enhancements for NR

940094	**Multi-carrier enhancements for NR**	**NR_MC_enh**		RP-222251	**Hiroki Harada, NTT DOCOMO, INC.**
940194	Core part: Multi-carrier enhancements for NR	NR_MC_enh-Core	R1	RP-222251	**Hiroki Harada, NTT DOCOMO, INC.**
940294	Perf. part: Multi-carrier enhancements for NR	NR_MC_enh-Perf	R1	RP-222251	**Hiroki Harada, NTT DOCOMO, INC.**

Summary based on the input provided by NTT DOCOMO, INC. in RP-233547.

This WI introduces 1) multi-cell PDSCH/PUSCH scheduling with a single DCI and 2) UL Tx switching scheme across 3 or 4 bands with restriction of up to 2 Tx simultaneous transmission for FR1 UE.

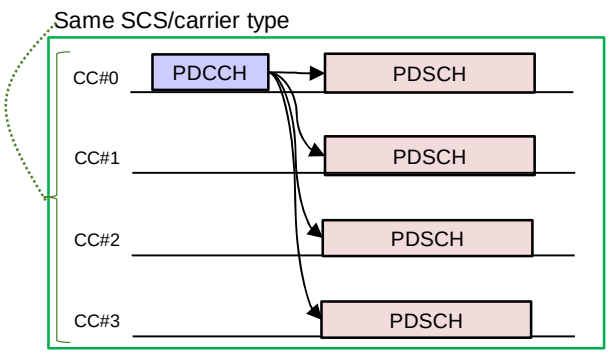
The multi-cell PDSCH/PUSCH scheduling with a single DCI is to reduce the control overhead for scheduling data on multiple cells in intra-band or inter-band multi-carrier operation. In Rel-17 WI on NR Dynamic spectrum sharing (DSS), it was studied but was not specified due to scenario limitations such as number of co-scheduled cells limited to 2. In Rel-18, such limitation is removed so that the single DCI scheduling more than 2 cells can achieve the reasonable gain of the control overhead reduction.

Regarding UL Tx switching schemes, UL Tx switching schemes across 2 bands were introduced in Rel-16 WI on RF requirements for NR frequency range 1 (FR1) and Rel-17 WI on RF requirements enhancement for NR frequency range 1 (FR1). In Rel-18, it is extended to UL Tx switching schemes across 3 or 4 bands so that higher UL data rate, spectrum

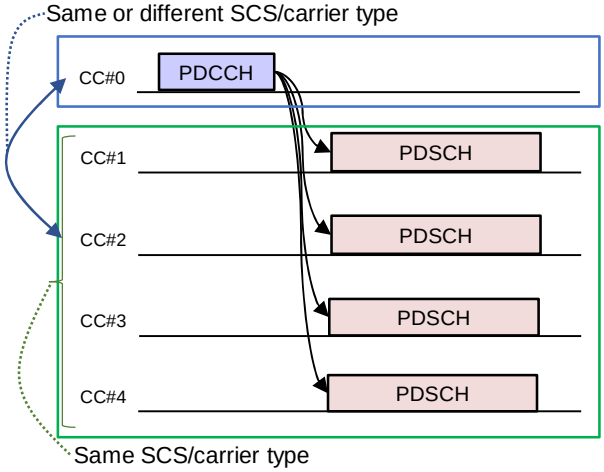
utilization and UL capacity can be achieved by dynamically selecting transmitting carrier(s) across 3 or 4 bands based on the data traffic, TDD DL/UL configuration, bandwidths and channel conditions of each band.

Multi-cell PDSCH/PUSCH scheduling with a single DCI

One of the key functionalities introduced in this WI is multi-cell PDSCH/PUSCH scheduling with a single DCI. The new non-fallback DCI formats 1_3 and 0_3 are introduced to schedule PDSCH or PUSCH on up to 4 intra-band and/or inter-band cells simultaneously. All co-scheduled cells have same SCS and carrier type (licensed or unlicensed, FR1 or FR2-1 or FR2-2), while scheduling cell can have different SCS and/or carrier type from those of co-scheduled cells if scheduling cell is not included in the co-scheduled cells. UE can be configured with only one scheduling cell for each scheduled cell, and UE can be configured to monitor DCI format 1_3/0_3 and legacy DCI format 0_0/1_0/0_1/1_1 and/or 0_2/1_2 (if supported by the UE) on the same scheduling cell. For some of fields in DCI format 1_3/0_3, a single indication is commonly applied to all co-scheduled cell(s) so that the payload size of DCI format 1_3/0_3 could be compact while some other fields in DCI format 1_3/0_3 have separate indication for each of co-scheduled cell(s) for flexibility.



(a) Scheduling cell is included in the set of co-scheduled cells



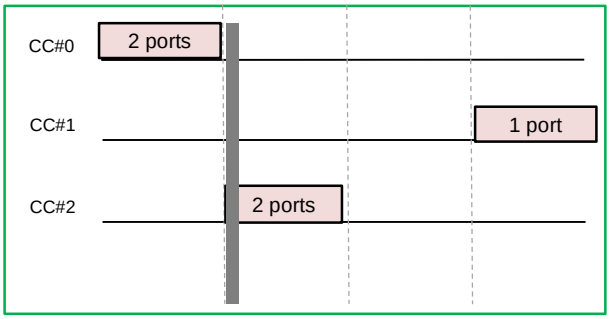
(b) Scheduling cell is not included in the set of co-scheduled cells

UL Tx switching schemes across 3 or 4 bands with restriction of up to 2 Tx simultaneous transmission for FR1 UE

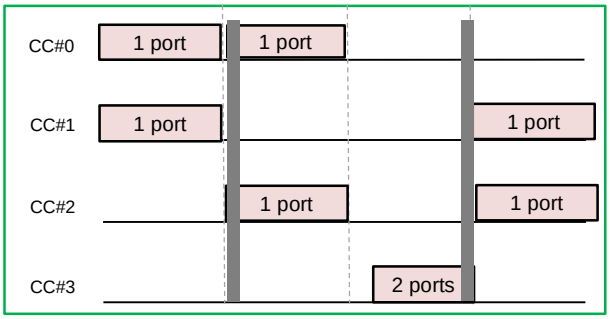
Another one of the key functionalities introduced in this WI is UL Tx switching schemes across 3 or 4 bands with restriction of up to 2 Tx simultaneous transmission for FR1 UE. The UE can be configured with 3 or 4 UL bands, and Tx carrier can be dynamically switched across carriers in 3 or 4 UL bands according to dynamic grant and/or RRC configuration for UL transmission. In Rel-18, following scenarios are supported:

- Inter-band CA with 3 or 4 UL bands without SUL band: For each pair of two UL bands among 3 or 4 UL bands, either switchedUL mode (where transmission is performed only on one of UL bands at a time) or dualUL mode (where transmission is performed on one of UL bands or on two UL bands simultaneously at a time) is configured according to UE capability.
- Inter-band CA with 3 or 4 UL bands including SUL band(s): for each pair of two non-SUL bands, either switchedUL mode or dualUL mode is configured according to UE capability; for each pair of two SUL bands (if any), switchedUL mode is configured; for each pair of non-SUL band and SUL band, switchedUL mode is configured.

UE reports required switching period length for each pair of two UL bands, and required switching period length is determined based on reported switching period length for each pair of two UL bands that are involved in the switching, configured switching scheme for each pair of two UL bands, and some other advanced capabilities if reported. If an uplink switching is triggered for uplink transmission(s) with a gap between the start of the first uplink transmission(s) and the end of the last preceding uplink transmission(s) that is smaller than the determined switching period length, UE determines the band of the switching period location based on the priority of the bands configured by gNB, and UE is not required to transmit for the duration of the determined switching period. The affected carrier(s), whether some or all of carriers, are determined according to UE capability.



Example 1: switchedUL mode is configured for each pair of 3 UL bands, priority is 0>1>2



Example 2: dualUL mode is configured for each pair of 4 UL bands, priority is 0>1>2>3

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940094,940194,940294

[1] RP-222251 Revised WID on Multi-carrier enhancements for NR
[2] RP-232089 Status report for WI: Multi-carrier enhancements for NR
[3] RP-232471 Introduction of Rel-18 - Multi-carrier enhancements
[4] R1-2310749 Corrections on Rel-18 Multi-carrier enhancements in 38.212
[5] R1-2310733 Maintenance of multi-carrier enhancements for NR
[6] R1-2310769 Introduction of UL Tx switching across up to 4 bands
[7] R2-2313674 Introduction of Multi-carier enhancements
[8] R2-2313967 Introduction of Rel-18 Multi-carrier enhancements
[9] R2-2313676 Introduction of Rel-18 UE capabilities
[10] R2-2313677 Introduction of Rel-18 UE capabilities
[11] R4-2310270 CR for 38.101-1: Time mask for switching across three or four uplink bands
[12] R4-2310503 CR for 38.101-1 to clarify the time mask for switching with multiple TAGs
[13] R4-2310142 DL interruption for Tx switching across 3/4 bands
[14] R4-2314428 CR on DL interruption for Tx switching across 3/4 bands
[15] R4-2314674 Correction of applicability of time mask for Tx swtiching with dual TAG
[16] R4-2319110 CR for 38.101-1: Time mask for switching across three or four uplink bands
[17] R4-2319447 [NR_MC_enh-Core]CR for DL interruption note improvement
[18] R4-2320680 Implementation of two-band Tx switching with dual TAG in an earlier release
[19] R4-2321754 CR for Tx switching with dual TAG
[20] R4-2319376 Modification on DL interruption for Tx switching across 3/4 bands

23.1.11 NR RF requirements enhancement for frequency range 2 (FR2), Phase 3

950076	**NR RF requirements enhancement for frequency range 2 (FR2), Phase 3**	**NR_RF_FR2_req_Ph3**		RP-222909	**Hisashi Onozawa, Nokia**
950176	Core part: NR RF requirements enhancement for frequency range 2 (FR2), Phase 3	NR_RF_FR2_req_Ph3-Core	R4	RP-222909	**Hisashi Onozawa, Nokia**
950276	Perf. part: NR RF requirements enhancement for frequency range 2 (FR2), Phase 3	NR_RF_FR2_req_Ph3-Perf	R4	RP-222909	**Hisashi Onozawa, Nokia**

Summary based on the input provided by Nokia, Xiaomi in RP-232792.

This Rel-18 work item introduces UL 256 QAM requirement and UE beam correspondence requirement in inactive and initial states as FR2 UE RF requirement enhancement features.

NR FR2-1 bands are new frequency bands introduced for the first time in Rel-15 specifications. Since then, UE RF requirement enhancements for FR2-1 bands have been introduced in Rel-16 WI on NR RF Requirement Enhancements for FR2 (WI code: NR_RF_FR2_req_enh) and Rel-17 WI on Further enhancements of NR RF requirements for frequency range 2 (WI code: NR_RF_FR2_req_enh2).

In earlier work items in Rel-16 and Rel-17, to enhance uplink data throughput, wider bandwidth by carrier aggregation was targeted but is now uplink higher modulation up to 256QAM is in Rel-18. The beam correspondence requirement enhancement was targeted for the connected state only earlier and is now for the inactive and initial states in Rel-18.

For power class 1/2/5 UE in FR2-1 bands, the following UL 256 QAM requirements are specified.

- EVM requirement is 3.5%.
- MPR requirement for single CC and intra-band CC

o MPRWT is 3 larger than 64QAM for single carrier or inter-band CA and 3.5 to 4 dB larger than 64QAM for intra-band CA for 28GHz bands

o additionally, 1 dB extra for 39 GHz bands as ΔMPR.

For power class 3 UE in FR2-1 bands, the following beam correspondence requirements in initial access and RRC_Inactive are specified.

- For spherical coverage EIRP in beam correspondence, minimum EIRP requirement at 50%-tile CDF is specified 2 dB lower in initial access and RRC_INACTIVE than RRC_CONNECTED.
- Side conditions are the same as SSB based enhanced beam correspondence requirement introduced in Rel-16.
- Minimum peak EIRP requirement is not applicable in initial access and RRC_INACTIVE.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950076,950176,950276

[1] R4-232791Revised WID: NR RF requirements enhancement for frequency range 2 (FR2), Phase 3
[2] TR38.891 NR RF requirements enhancement for frequency range 2 (FR2), Phase 3
[3] RP-232790 Status report for WI NR RF requirements enhancement for frequency range 2 (FR2), Phase 3; rapporteur: Nokia, Xiaomi
[4] R4-2321984 Introducing beam correspondence requirement for initial access and RRC_INACTIVE, Nokia, Nokia Shanghai Bell , Apple, CMCC, Huawei, HiSilicon, MediaTek inc., OPPO, Qualcomm, Samsung, Sony, Vivo, Xiaomi, ZTE Corporation
[5] R4-2318632 On beam correspondence requirement for EN-DC/NE-DC, Apple
[6] R4-2321718 CR for Rel-18 38.101-2 to introduce FR2-1 UL 256 QAM RF requirements, Xiaomi, Nokia, vivo, LG Electronics, ZTE, Qualcomm, Sony, MediaTek, Huawei, Apple, Ericsson

23.1.12 Requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception

950077	**Requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception**	NR_FR2_multiRX_DL		RP-231714	**Bin Han, Qualcomm**
950177	Core part: Requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception	NR_FR2_multiRX_DL-Core	R4	RP-231714	**Sumant Iyer, Qualcomm**
950277	Perf. part: Requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception	NR_FR2_multiRX_DL-Perf	R4	RP-231714	**Sumant Iyer, Qualcomm**

Summary based on the input provided by Qualcomm Incorporated in RP-233926.

New RF core requirements were specified for a UE configured for reception from two different directions with different QCL-D reference signals, along with RRM requirement enhancements by specifying dual-TCI switch delay, fast beam sweeping and scheduling restrictions.

RAN4 UE RF requirements were specified for:

Spherical coverage for devices with simultaneous reception from different directions with different QCL TypeD RSs

A suitable metric of RF performance was derived based on the conclusions pertaining to the test grid made in the parallel study item ‘Study on NR frequency range 2 (FR2) Over-the-Air (OTA) testing enhancements’. The metric quantifies the probability that the UE can support simultaneous reception from different directions with different QCL TypeD RSs for a chosen angular separation between the directions. Sources of uncertainty in the metric value for a

given UE were identified and corresponding strategies were adopted in the core requirement specification to circumvent those uncertainties. The minimum requirement in terms of the metric were derived for power class 3 UEs. The legacy UE RF spherical coverage requirements were retained as outlined in the WID. Requirements for UEs configured with a single TCI state (a second priority) or for UEs other than power class 3 were not specified.

RAN4 RRM requirements were enhanced considering the following aspects for UE capable of FR2 multi-Rx chain DL reception:

Dual TCI state switch delay

To support 4-layer MIMO in FR2, dual TCI state switch is essential and corresponding requirements are specified:
- MAC-CE based dual DL TCI state switch delay for s-DCI and m-DCI
- DCI based dual DL TCI state switch delay for s-DCI and m-DCI
- RRC based dual DL TCI state switch delay
- Active DL TCI state list update delay

Scheduling restriction /measurement restriction enhancement (relaxation)

In multi-TRP operation scenario, for the case PDCCH/PDSCHs are transmitted from two TRPs simultaneously, and CSI-RS is transmitted from anyone of the TRPs, scheduling restriction relaxation can be made for CSI-RS based L1 measurements with multi-Rx when specified conditions are met.

In multi-TRP operation scenario, when two CSI-RSs are transmitted from two TRPs, measurement restriction relaxation can be made for CSI-RS based L1 measurements with multi-Rx when specified conditions are met.

The applicable CSI-RS based L1 measurements include:
- L1-RSRP measurement with group-based beam reporting
- L1-RSRP measurement without group-based beam reporting
- BFD and CBD for link recovery
- BFD and CBD for TRP specific link recovery
- RLM
- L1-SINR

In addition, for TRP specific link recovery, PTRP can be 1 for multi-Rx if specified conditions are met.

Fast beam sweeping

Fast beam sweeping with multi-Rx chain DL reception is based on UE capabilities. Candidate values for beam sweeping factor reduction are {2, 4, 6} for FR2-1.

Fast beam sweeping for multi-Rx can be applicable for SSB-based L1 measurements and CSI-RS based L1 measurements except RLM and BFD/CBD. The reduced beam sweeping factor is used for defining the evaluation period of SSB based and CSI-RS based L1 measurements in FR2-1.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950077,950177,950277

[1] RP-231714, ‘Revised WID: Requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception’, Qualcomm, RAN #101
[2] TR38.751, ‘UE RF and demodulation requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception’
[3] RP-232077, ‘Status report for WI NR_FR2_multiRx_DL; rapporteur: Qualcomm, vivo’, RAN4, RAN#102
[4] R4-2321722, ‘Feature CR for FR2 multi-Rx’, Qualcomm et al., RAN4#109

23.1.13 Support of intra-band non-collocated EN-DC/NR-CA deployment

950081	**Support of intra-band non-collocated EN-DC/NR-CA deployment**	**NonCol_intraB_ENDC_NR_CA**		RP-233513	Yasuki Suzuki, KDDI
950181	Core part: Support of intra-band non-collocated EN-DC/NR-CA deployment	NonCol_intraB_ENDC_NR_CA-Core	R4	RP-233513	**Yasuki Suzuki, KDDI**

950281	Perf. part: Support of intra-band non-collocated EN-DC/NR-CA deployment	NonCol_intraB_ENDC_NR_CA-Perf	R4	RP-233513	**Yasuki Suzuki, KDDI**

Summary based on the input provided by KDDI Corporation in RP-240100.

This work item specifies necessary RAN4 and RAN2 requirements to support of non-collocated scenarios for both FR1 inter-band non-contiguous EN-DC with overlapping or partially overlapping bands and FR1 intra-band non-contiguous NR-CA deployment using bands B42, n77/n78 for 2-layer MIMO case. Until Rel-17, only collocated requirements have been specified for FR1 intra-band non-contiguous NR-CA, but from operators' C-band deployment perspective UE requirements for non-collocated deployment is essential to enhance EN-DC/NR-CA available service areas. In other words, Tx antenna collocation at network side is not always available, since the co-existence conditions for satellite service etc. are not always same for all the bands. For some operators, three blocks in C-band were allocated at different time, which makes Tx antenna collocation cost-inefficient sometimes infeasible. It is noted that UE requirements for non-collocated deployment for FR1 inter-band non-contiguous EN-DC with overlapping or partially overlapping bands was introduced, but no requirements for NR-CA deployment in Rel-16 and 17.

RAN4 specifies the two series of relevant requirements for this work item, one is for the requirement assuming Type 1 (legacy) UE having common Rx-chains to handle the carriers from the different locations, the other is for the requirement assuming Type 2 UE having separated Rx-chains to handle the carriers from the different locations separately. Specified relevant requirements are for both EN-DC and NR-CA scenarios as follows. And they are applicable for only EN-DC/NR-CA bands (DC_42_n77, DC_42_n78, CA_n77, CA_n78).

- UE RF requirement: Rx Power imbalance requirement
- RRM requirement: Maximum uplink transmission timing difference requirement (MTTD) and Maximum uplink transmission timing difference requirement (MRTD)

RAN2 specifies following two BS signalling and two UE capacities for this feature.

- nonCollocatedTypeMRDC-r18: new BS signalling to indicate whether Type 1 (legacy) UE or Type 2 UE requirements will be applied by a UE for EN-DC case.
- nonCollocatedTypeNR-CA-r18: new BS signalling to indicate whether Type 1 UE or Type 2 UE requirements will be applied by a UE for NR-CA case.
- intraBandNR-CA-non-collocated-r18: new capability which indicates the UE supports TDD-TDD intra-band non-collocated NR-CA operation (Type2 UE requirements)
- requirementTypeIndication-r18: new capability for the UE indicating interBandMRDC-WithOverlapDL-Bands-r16 (i.e. UE support type2 UE requirements for EN-DC), the capability indicates whether the UE supports network controlled indication (new BS signalling).

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950081,950181,950281

23.1.14 Further enhancements on NR and MR-DC measurement gaps and measurements without gaps

950082	**Further enhancements on NR and MR-DC measurement gaps and measurements without gaps**	**NR_MG_enh2**		RP-232440	**Tsang-Wei (Ato) YU, MediaTek,**
950182	Core part: Further enhancements on NR and MR-DC measurement gaps and measurements without gaps	NR_MG_enh2-Core	R4	RP-232440	**Tsang-Wei (Ato) YU, MediaTek,**
950282	Perf. part: Further enhancements on NR and MR-DC measurement gaps and measurements without gaps	NR_MG_enh2-Perf	R4	RP-232440	**Tsang-Wei (Ato) YU, MediaTek,**
981035	UE Conformance - NR and MR-DC measurement gap enhancements	NR_MG_enh-UEConTest	R5	RP-223246	**Daiwei Zhou, MediaTek**

Summary based on the input provided by MediaTek inc., Intel Corporation in RP-233257.

This summary provides the main functionality achieved for the 2 objectives of this WI: 1) Enhancements of pre-configured MGs, multiple concurrent MGs and NCSG, 2) RRM requirements for measurements without gaps.

Corresponding network RRC signalling and measurement requirements are specified in TS38.331 and TS38.133, respectively.

1) Enhancements of pre-configured MGs, multiple concurrent MGs and NCSG
   - Concurrent gaps with Pre-MG
     - Introduced multiple two gap occasions configurations with Pre-MG and corresponding UE capability
       - Pre-MG + Pre-MG
       - Pre-MG + Rel-16/Rel-17 MG
     - Introduced additional delay for activation/deactivation delay requirements for fully overlapped activation/deactivation of multiple pre-configured measurement gaps, which is 2ms on top on the legacy activation/deactivation delay requirements.
     - Define requirements for colliding gap occasions when the Pre-MG is activated.
     - Define requirements for collision between Pre-MG activation/deactivation and measurement gap
   - Concurrent gaps with NCSG
     - Introduced multiple two gap occasions configurations with NCSG and corresponding UE capability
       - NCSG + NCSG
       - NCSG + Rel-16/Rel-17 MG
     - Updating a definition for the proximity condition of colliding gap occasions to consider the NCSG occasion. The ending point is the end of VIL2 and/or when the second occasion is NCSG, the starting point is the start of VIL1.
   - Updated the corresponding UE requirements regarding gap interruption, measurement delay and L1 measurement impact.
2) RRM requirements for measurements without gaps
   - RAN4 specified the measurement and interruption requirements for NR SSB-based measurements without gaps for UEs supporting *NeedForInterruptionInfoNR-r18*. Interruption is allowed for UEs indicating *interruption* when the UE measures the target SSB without gap.
     - RAN2 introduced the UE reporting signalling for *NeedForInterruptionInfoNR-r18*.
   - RAN4 specified the measurement and interruption requirements for inter-RAT EUTRAN measurements without gaps. Effective measurement window configurations are introduced for inter-RAT EUTRAN measurements. Scheduling availability requirements are defined.
     - RAN2 introduced UE capability for effective measurement window.
   - RAN4 specified the measurement requirements for inter-RAT NR measurements without gaps for UEs supporting *interRAT-NeedForIntrNR-r18*. Scheduling availability requirements are defined.
     - RAN2 introduced the UE reporting signalling for *interRAT-NeedForIntrNR-r18*.

RAN4 updated the carrier specific scaling factor (CSSF) to reflect the introduced measurement requirements for measurements without gaps.scaling factor (CSSF) to reflect the introduced measurement requirements for measurements without gaps.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950082,950182,950282,981035

23.1.15 Further RF requirements enhancement for NR and EN-DC in frequency range 1 (FR1)

950080	**Further RF requirements enhancement for NR and EN-DC in frequency range 1 (FR1)**	**NR_ENDC_RF_FR1_enh2**		RP-232366	**Ye Liu Huawei**
950180	Core part: Further RF requirements enhancement for NR and EN-DC in frequency range 1 (FR1)	NR_ENDC_RF_FR1_enh2-Core	R4	RP-232366	**Ye Liu Huawei**
950280	Perf. part: Further RF requirements enhancement for NR and EN-DC in frequency range 1 (FR1)	NR_ENDC_RF_FR1_enh2-Perf	R4	RP-232366	**Ye Liu Huawei**

Summary based on the input provided by Huawei, HiSilicon, NTT DOCOMO, INC. in RP-233188.

This work item developed several enhancement aspects for UE RF FR1. The following new RF requirements, corresponding new feature groups and functionalities are introduced:

- Requirements to enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices are specified. UE power class is PC1.5, and possible UE PA configurations assumed during the discussion are 4x23dBm, 2x23dBm + 2x26dBm

and 4x26dBm. The main requirements include MPR, Pcmax,c tolerance, MIMO configurations including those for ULFPTx with 4 layers and coherent UL MIMO for 4Tx. In addition, new per FS TxD capability was introduced for 4Tx, which is the indication for UE to apply the Tx diversity requirements. No release independent is considered for UE supporting 4Tx. Power scaling issue also has been discussed under 4Tx topic, but from confirmation by RAN1 and discussion in RAN4, there would be no impact for both RAN1 and RAN4 specs.

- Requirements to enable 8Rx for CPE/FWA/vehicle/industrial devices are specified, which include both single carrier and CA cases. The main requirements for UE supporting 8 Rx include ΔTRxSRS values for 8Rx UE supporting SRS antenna switching capability, band specific ΔRIB,8R values for eight antenna port reference sensitivity as well as applicability of the value for reference sensitivity exceptions. It was also clarified verification cases in the spec of Rx requirements with eight Rx antenna ports in relationship with four and two Rx antenna ports. Additionally, supporting 8Rx can be release independent from Rel-17. Moreover, SRS IL indication has been discussed a lot during the WI phase, however, no consensus was reached in the end for the reporting mechanism, e.g. static and/or dynamic reporting, UE behaviour and/or NW compensation for the power imbalance, etc. Without conclusion of SRS IL indication has no impact on the competition of the WI.

- Regarding lower MSD capability, the group firstly justified that MSD improvement is feasible based on detailed analysis for the selected example band combinations, upon that the essential info composed for the lower MSD capability are reached, which include MSD types (harmonic, harmonic mixing, crossband isolation, IMD with order=2/3/4/5 as well “ALL” for Rel-18, new MSD types may be added later), victim band, power class and lower MSD capability classes (maximum value of threshold is 22 dB). Conformance test for lower MSD is one important aspect considered in the group. It was agreed that lower MSD capability shall not result in additional MSD test points, and conformance test reuses the RAN4 MSD test point parameters and only changes the MSD value by the upper bound of the declared lower MSD class.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950080,950180,950280

23.1.16 Other non-band related items

The following items were covered in Release 18:

981042	**Rel-18 4Rx for NR bands for FWA (Fixed Wireless Access) UEs (<2.6GHz) and handheld UEs (1GHz to 2.6GHz)**	**4Rx_NR_bands_R18**		RP-231844	**Wubin, Zhou, ZTE**
981142	Core part: Rel-18 4Rx for NR bands for FWA (Fixed Wireless Access) UEs (<2.6GHz) and handheld UEs (1GHz to 2.6GHz)	4Rx_NR_bands_R18-Core	R4	RP-231844	**Wubin, Zhou, ZTE**
981242	Perf. part: Rel-18 4Rx for NR bands for FWA (Fixed Wireless Access) UEs (<2.6GHz) and handheld UEs (1GHz to 2.6GHz)	4Rx_NR_bands_R18-Perf	R4	RP-231844	**Wubin, Zhou, ZTE**
970085	**High power UE (power class 1.5) for NR FR1 TDD single band**	**HPUE_NR_FR1_TDD_R18**		RP-223499	**Chunxia Guo, CMCC**
970185	Core part: High power UE (power class 1.5) for NR FR1 TDD single band	HPUE_NR_FR1_TDD_R18-Core	R4	RP-223499	**Chunxia Guo, CMCC**
970285	Perf. part: High power UE (power class 1.5) for NR FR1 TDD single band	HPUE_NR_FR1_TDD_R18-Perf	R4	RP-223499	**Chunxia Guo, CMCC**
1000053	UE Conformance - High power UE (power class 1.5) for NR FR1 TDD single band	HPUE_NR_FR1_TDD_R18-UEConTest	R5	RP-231152	**Dan SONG (CMCC), Yuxin Hao (Huawei), CMCC, Huawei**
970086	**High power UE (power class 2) for NR FR1 FDD single band**	**HPUE_NR_FR1_FDD_R18**		RP-232216	**Basaier Jialade, China Unicom**

970186	Core part: High power UE (power class 2) for NR FR1 FDD single band	HPUE_NR_FR1_FDD_R18-Core	R4	RP-232216	**Basaier Jialade, China Unicom**
970286	Perf. part: High power UE (power class 2) for NR FR1 FDD single band	HPUE_NR_FR1_FDD_R18-Perf	R4	RP-232216	**Basaier Jialade, China Unicom**
1000051	UE Conformance - High power UE (power class 2) for NR FR1 FDD single band	HPUE_NR_FR1_FDD_R18-UEConTest	R5	RP-230869	**Shi, Yu, China Unicom**
970087	**High power UE (power class 1.5 or 2) for intra-band Carrier Aggregation combinations of a single NR FR1 TDD band**	**HPUE_NR_FR1_TDD_intra_CA_R18**		RP-232377	**Lingyu Kong, Huawei, HiSilicon**
970187	Core part: High power UE (power class 1.5 or 2) for intra-band Carrier Aggregation combinations of a single NR FR1 TDD band	HPUE_NR_FR1_TDD_intra_CA_R18-Core	R4	RP-232377	**Lingyu Kong, Huawei, HiSilicon**
970287	Perf. part: High power UE (power class 1.5 or 2) for intra-band Carrier Aggregation combinations of a single NR FR1 TDD band	HPUE_NR_FR1_TDD_intra_CA_R18-Perf	R4	RP-232377	**Lingyu Kong, Huawei, HiSilicon**
970089	**Rel-18 High power UE (power class 1,5 and 2) for a single FR1 NR TDD band in UL of NR inter-band CA/DC combinations with/without NR SUL (supplementary uplink) with y bands downlink (y=2,3,4,5,6) and x bands uplink (x=1,2)**	**HPUE_FR1_TDD_NR_CADC_SUL_R18**		RP-232256	**Lei GAO, China Telecom**
970189	Core part: Rel-18 High power UE (power class 1,5 and 2) for a single FR1 NR TDD band in UL of NR inter-band CA/DC combinations with/without NR SUL (supplementary uplink) with y bands downlink (y=2,3,4,5,6) and x bands uplink (x=1,2)	HPUE_FR1_TDD_NR_CADC_SUL_R18-Core	R4	RP-232256	**Lei GAO, China Telecom**
970289	Perf. part: Rel-18 High power UE (power class 1,5 and 2) for a single FR1 NR TDD band in UL of NR inter-band CA/DC combinations with/without NR SUL (supplementary uplink) with y bands downlink (y=2,3,4,5,6) and x bands uplink (x=1,2)	HPUE_FR1_TDD_NR_CADC_SUL_R18-Perf	R4	RP-232256	**Lei GAO, China Telecom**
970090	**Rel-18 High power UE (power class 2) for a single FR1 NR FDD band in UL of NR inter-band CA/DC combinations with y bands downlink (y=2,3,4,5,6) and x bands uplink (x=1,2)**	**HPUE_FR1_FDD_NR_CADC_R18**		RP-230354	**Basaier Jialade, China Unicom**
970190	Core part: Rel-18 High power UE (power class 2) for a single FR1 NR FDD band in UL of NR inter-band CA/DC combinations with y bands downlink (y=2,3,4,5,6) and x bands uplink (x=1,2)	HPUE_FR1_FDD_NR_CADC_R18-Core	R4	RP-231063	**Basaier Jialade, China Unicom**
970290	Perf. part: Rel-18 High power UE (power class 2) for a single FR1 NR FDD band in UL of NR inter-band CA/DC combinations with y bands downlink (y=2,3,4,5,6) and x bands uplink (x=1,2)	HPUE_FR1_FDD_NR_CADC_R18-Perf	R4	RP-231063	**Basaier Jialade, China Unicom**
970083	**Adding new channel bandwidth(s) support to existing NR bands**	**NR_bands_R18_BWs**		RP-231706	**Dominique Everaere, Ericsson**
970183	Core part: Adding new channel bandwidth(s) support to existing NR bands	NR_bands_R18_BWs-Core	R4	RP-231706	**Dominique Everaere, Ericsson**

981047	**Rel-18 NR Carrier Aggregation (CA) band combinations with two SUL cells**	**NR_2SUL_cell_combos_R18**		RP-232688	**Xiaoran ZHANG, CMCC**
981147	Core part: Rel-18 NR Carrier Aggregation (CA) band combinations with two SUL cells	NR_2SUL_cell_combos_R18-Core	R4	RP-232688	**Xiaoran ZHANG, CMCC**
981247	Perf. part: Rel-18 NR Carrier Aggregation (CA) band combinations with two SUL cells	NR_2SUL_cell_combos_R18-Perf	R4	RP-232688	**Xiaoran ZHANG, CMCC**

23.2 Band-centric

23.2.1 Enhancements of NR shared spectrum bands

960093	**Enhancements of NR shared spectrum bands**	**NR_unlic_enh**		RP-230730	**Daniel Popp, Apple**
960193	Core part: Enhancements of NR shared spectrum bands	NR_unlic_enh-Core	R4	RP-230730	**Daniel Popp, Apple**
960293	Perf. part: Enhancements of NR shared spectrum bands	NR_unlic_enh-Perf	R4	RP-230730	**Daniel Popp, Apple**

Summary based on the input provided by Apple Inc in RP-233859.

The WI introduces NR-U operation for SP, LPI and VLP based on regulatory requirements from several countries. Further improvements for network signalling capability and spectrum utilisation were made.

The WI introduces requirements on unlicensed operation for several countries. Those additional emission requirements can be signalled by the network. Each additional emission requirement is associated with a unique network signalling (NS) value indicated in RRC signalling by an NR frequency band number of the applicable operating band.

- New NS values were introduced for low power operation (LPI) and very low power (VLP). Table 1 provides a list of countries for which requirements were introduced and the associated NS value. Please note that the table does not provide an overview overall NS values and requirements as it focuses on newly introduced values only. A complete summary can be found in [2].

- NS value signalling capability was enhanced to allow the listing of more than eight NS values for a single band. This was required due to the larger number of different NS values needed to cover the diverse regulatory requirements of all the countries.

In Rel-17 it was not possible to utilise the lower 20MHz from the bands n96 and n102. This 20MHz slot was excluded due to several challenges with UL operation. This WI introduced DL only operation for the lower 20MHz to improve spectrum utilisation.

In addition, PC3 operation was introduced for band n46, n96 and n102. Consequently, several NS values were updated and PC3 A-MPR was included.

Table 1: Newly introduced NS values per country

Country	Mode	
	LPI	VLP
Region 1		
EU/CEPT		NS_64
UK	NS_01	NS_65
Morocco	NS_01	NS_65
UAE	NS_01	N/A
Saudi Arabia	NS_01	N/A
Kenya	NS_01	NS_68
Qatar	NS_01	NS_65
Jordan	NS_01	NS_65
Russian Federation	NS_01	NS_68
South Africa	NS_58	NS_64
Region 2		
US		NS_66
Canada		NS_66
Brazil		NS_67
Peru		N/A
Chile		N/A
Costa Rica		NS_65
Colombia		N/A
Dominican Republic	NS_60	NS_66
Argentina	NS_53	N/A
Region 3		
Hong Kong	NS_58	NS_64
Australia	NS_01	NS_68
New Zealand	NS_01	NS_68
Malaysia	NS_01	NS_65
Japan	NS_63	NS_69
Singapore	NS_01	NS_68

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960093,960193,960293

[1] RP-231177: “Status report on Enhancement of NR shared spectrum bands”
[2] TR 38.849: “Introduction of 6GHz NR unlicensed operation”

23.2.2 Addition of FDD NR bands using the uplink from n28 and the downlink of n75 and n76

991042	**Addition of FDD NR bands using the uplink from n28 and the downlink of n75 and n76**	**NR_FDD_ULn28_DLn75_n76**	**R4**	RP-232636	**Wael Boukley Hasan, Vodafone**
991142	Core part: Addition of FDD NR bands using the uplink from n28 and the downlink of n75 and n76	NR_FDD_ULn28_DLn75_n76-Core	R4	RP-232636	**Wael Boukley Hasan, Vodafone**
991242	Perf. part: Addition of FDD NR bands using the uplink from n28 and the downlink of n75 and n76	NR_FDD_ULn28_DLn75_n76-Perf	R4	RP-232636	**Wael Boukley Hasan, Vodafone**

Summary based on the input provided by Vodafone in RP- 233713.

This work item (WI # 991042) is completed at RAN#102 meeting. Though it is a spectrum related work item, due to its novel characteristics in introducing new FDD band with variable duplex distances, we see the necessity of having this work item summary. Furthermore, this summary clarifies why band n76 was excluded from this work.

In RAN #84 the work item in RP-191567 was approved and this led to the introduction of bands n91, n92, n93 and n94. These bands consist of the uplink frequency allocated to band n8 (880-915 MHz) or n20 (832-862 MHz), and, the downlink frequency of the Supplementary downlink (SDL) bands n75 (1432-1517 MHz) or n76 (1427-1432 MHz).

These bands are useful for “idle mode load balancing” and enable the resources of the SDL band to be effectively utilized by mobiles when transmitting short bursts of data (i.e. when there is insufficient time to activate CA/dual connectivity).

Over the last few years, operators have acquired spectrum in band 28 (703-733 MHz), thus the objective of this work item is to add bands equivalent to n91-n94 for the joint use of the n28 uplink with the SDL n75. This work item allows the uplink and downlink of the introduced band to be from 2 different licensed spectrum blocks, and the new paired band is defined in the RF specifications as n109.

At the beginning of this work item, it was proposed to add the following bands:

- Band nA: 703 – 733 MHz UL / 1432 – 1517 MHz DL (DL n28, UL n75)
- Band nB: 703 – 733 MHz UL / 1427 – 1432 MHz DL (DL n28, UL n76)

However, in the RAN4#107 meeting, it was agreed that CA_n28-n76 should be introduced first before starting the work on FDD band n28 UL/n76 DL. Therefore, the WID was modified to remove the FDD band of DL n28 & UL n76. However, the title of the WI was not changed to avoid introducing admin complexity.

System parameters

System parameters for the new FDD band are defined in all the related RAN4 specifications including, operating bands, channel bandwidth, rasters, Tx-Rx separation, etc.

Operating bands and NR-ARFCN

Newly introduced variable duplex band have the same UL frequency part of n28 band and DL frequency part as in SDL band n75.

n109	703 MHz – 733 MHz	1432 MHz – 1517 MHz	FDD[9]

A note 9 is specified in the table that says “Variable duplex operation does not enable dynamic variable duplex configuration by the network, and is used such that DL and UL frequency ranges are supported independently in any valid frequency range for the band”.

Channel bandwidth

Since the frequency parts of the variable duplex FDD bands are acquired independently, asymmetric bandwidths must be introduced to accommodate most of the desired deployments.

NR Band	Channel bandwidths for UL (MHz)	Channel bandwidths for DL (MHz)
n109[1]	5	10, 15, 20, 25, 30, 40, 50
	10	15, 20, 25, 30, 40, 1050
	15	20, 25, 30, 40, 50
	20	25, 30, 40, 50
	25	30, 40, 50
	30	40, 50
NOTE 1: The assignment of the paired UL and DL channels are subject to a TX-RX separation as specified in clause 5.4.4.		

Hence other bandwidth configurations of the variable duplex FDD bands follow what was defined for the corresponding UL or DL bands that are consisted of.

Tx-Rx separation

It is worth noting that Tx-Rx separation is defined in a different way for the variable duplex bands since the default separation no longer applies with them.

NR Operating Band	TX – RX carrier centre frequency separation
n109	704 MHz - 809 MHz (μ = 0) 709 MHz - 804 MHz (μ = 1) (NOTE 2)

Note 2 says that the range of Tx-Rx frequency separation given paired UL and DL channel bandwidths BW_{UL} and BW_{DL} is given by the respective lower and upper limit $F_{DL\_low} - F_{UL\_high} + 0.5(BW_{DL} + BW_{UL})$ and $F_{DL\_high} - F_{UL\_low} - 0.5(BW_{DL} + BW_{UL})$. The UL and DL channel bandwidth combinations specified in Table 5.3.5-1 and 5.3.6-1 depend on the subcarrier spacing configuration μ.

UE requirements

REFSENS and UL configurations

The new FDD n109 band is similar to the Bands n91, n92, n93 or n94 in that it associates and SUL band with the SDL Bands n75 and n76. This time with Band n28 as the UL and thus, results in a variable duplex operation. Most of time these combinations do not see any de-sense due to the large duplex gap. However, this time, a unique issue is present: the second harmonic of n28 UL overlaps with n75. Since the duplex is variable, the de-sense of the issue will depend on the UL and DL frequencies in operation and their CBW. Therefore, the following is the REFSENS for n109 band

Operating band / SCS / Channel bandwidth / REFSENS				
Operating band	**SCS kHz**	**Channel bandwidth (MHz)**	**REFSENS (dBm)[8]**	**Duplex Mode**
n109[11]	15	5,10,15,20,25,30,40,50	$-100 + 10\log_{10}(N_{RB}/25)$	FDD
	30	10,15,20,25,30,40,50	$-97.1 + 10\log_{10}(N_{RB}/24)$	
NOTE 11: Applies for DL channels for which channels edges are > 15 MHz away from $2xF_{UL}$ at 15 kHz SCS and > 30 MHz away from $2xF_{UL}$ at 30 kHz SCS. In case of UL second harmonic direct hit, the value is modified to -71.9 dBm for all channel bandwidths.				

,where the UL configuration is always 5MHz 25RB for 15kHz SCS and 10MHz 24RB for 30kHz SCS:

Operating band / SCS (kHz) / Channel bandwidth (MHz) / Duplex mode										
Operating Band	**SCS**	**5**	**10**	**15**	**20**	**25**	**30**	**40**	**50**	**Duplex Mode**
n109	15	25	Note 7	Note 7	Note 7	Note 7	Note 7	Note 7	Note 7	FDD
	30		24	Note 7	Note 7	Note 7	Note 7	Note 7	Note 7	
Note 7: For this DL channel bandwidth, the UL configuration of 5MHz for 15kHz SCS and 10MHz for 30kHz shall be used.										

BS requirements

In this work item, BS requirements span among a series of specifications such as 38.104, 38.141-1, 37.104, 37.105, 37.141, 37.145-1, 37.145-2, 36.104, 36.141, etc. Mainly coexistence requirements are defined in these specs.

Additional spurious emission requirements

Respective requirements which correspond to BS spurious limits for co-existence with systems operating in the new variable duplex FDD bands are introduced in the mentioned spec, with maximum measured spurious levels and bandwidth configurations.

Out of band blocking requirements

Another set of Tx requirements is also defined with the similar manner as the above one. The requirements apply when co-location with other BS-s operating in the variable duplex FDD bands is observed.

Receiver response under co-location requirements

Receiver response requirements are defined in the mentioned specifications that the BS operating in the introduced bands should have the ability to block unwanted interband interferences from any other collocated BS.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=991042,991142,991242

[1] RP-233245, revised WID: Addition of FDD bands using the uplink from n28 and the downlink of n75 and n76, RAN #102, Vodafone.
[2] RP-233244, Status report for WI Addition of FDD bands using the uplink from n28 and the downlink of n75 and n76, RAN #102, Vodafone.
[3] R4-2319594 CR to TS 38.106 - Introduction of band n109 Ericsson, Vodafone.
[4] R4-2318435 CR to 38.101-3 on introduction of band n109 Apple, Vodafone.
[5] R4-2319595 CR to TS 38.115-1 - Introduction of band n109 Ericsson, Vodafone.
[6] R4-2319596 CR to TS 38.133 - Introduction of band n109 Ericsson, Vodafone.
[7] R4-2320402 CR to 37.105 on introduction of Band n109 Nokia, Nokia Shanghai Bell, Vodafone.
[8] R4-2320403 CR to 37.141 on introduction of Band n109 Nokia, Nokia Shanghai Bell, Vodafone.
[9] R4-2320404 CR to 38.174 on introduction of Band n109 Nokia, Nokia Shanghai Bell, Vodafone.
[10] R4-2320405 CR to 38.176-1 on introduction of Band n109 Nokia, Nokia Shanghai Bell, Vodafone.
[11] R4-2320406 CR to 38.176-2 on introduction of Band n109 Nokia, Nokia Shanghai Bell, Vodafone.
[12] R4-2321689 CR to TS38.104: Introduction of n109 Vodafone.
[13] R4-2321690 CR to TS38.141-1 Introduction of n109 Huawei, HiSilicon, Vodafone.
[14] R4-2321691 CR to TS38.141-2 Introduction of n109 Huawei, HiSilicon, Vodafone.
[15] R4-2321692 CR to TS 37.104 Introduction of n109 Huawei, HiSilicon, Vodafone.
[16] R4-2321693 CR to TS 37.145-1 - Introduction of band n109 Ericsson, Vodafone.
[17] R4-2321694 CR to TS 37.145-2 - Introduction of band n109 Ericsson, Vodafone.
[18] R4-2321695 CR to TS36.104 Introduction of n109 Huawei, HiSilicon, Vodafone.
[19] R4-2321696 CR to TS36.141 Introduction of n109 Huawei, HiSilicon, Vodafone.
[20] R4-2321804 CR to TS38.101-1: Introduction of n109 Vodafone, Huawei, Skyworks Solutions, Murata Manufacturing Co Ltd.

23.2.3 Complete the specification support for BandWidth Part operation without restriction in NR

991044	**Complete the specification support for BandWidth Part operation without restriction in NR**	**NR_BWP_wor**	**R4**	RP-232677	**Diogo Martins, Vodafone**
991144	Core part: Complete the specification support for BandWidth Part operation without restriction in NR	NR_BWP_wor-Core	R4	RP-232677	**Diogo Martins, Vodafone**
991244	Perf. part: Complete the specification support for BandWidth Part operation without restriction in NR	NR_BWP_wor-Perf	R4	RP-232677	**Diogo Martins, Vodafone**

Summary based on the input provided by Vodafone, vivo in RP-234000.

Bandwidth Part (BWP) operation without Restriction (FG 6-1a as referred in TR 38.822) is an optional feature introduced in Rel-15 for non-Redcap UEs, for the support of BWP operation without a Cell-Defining Synchronization Signal Block (CD-SSB). Due to unclear UE behaviour on how to perform Beam Management (BM), Radio Link Monitoring (RLM) and Beam Failure Detection (BFD) operations, in the case where the UE was operating in a BWP that would not include the bandwidth (BW) of the CD-SSB, three options were specified to complete the support of this feature:

- Option A) Perform BM/RLM/BFD based on CSI-RS within active BWP
- Option B-1-1) Perform BM/RLM/BFD based on SSB outside active BWP without interruptions
- Option C) Perform BM/RLM/BFD based on NCD-SSB within active BWP for non-RedCap UEs

Additionally, for Option B-1-1 and C, it was specified requirements for L3 intra-frequency measurements without gaps. Moreover, for Option C, handover requirements based on existing RedCap handover requirements were specified.

Option A

RAN4 has agreed that existing legacy RRM requirements are applicable for UEs supporting Option A. No specification changes were made for this option apart from capability signalling aspects.

Option B-1-1

The SSB-based requirements for BM/RLM/BFD measurements, L3 intra-frequency measurements without measurement gaps, and timing, were updated to capture their applicability for UEs supporting Option B-1-1 if CD-SSB is within the channel bandwidth of the UE. Capability signalling aspects were specified to convey the support of this option.

Option C

The SSB-based requirements for BM/RLM/BFD measurements, L3 intra-frequency measurements without measurement gaps, and timing, were updated to capture their applicability for NCD-SSB for UEs supporting Option C.

Requirements for the transition between CD-SSB and NCD-SSB for BM/RLM/BFD measurements and L3 measurements were introduced for UEs supporting Option C based on the existing requirements from RedCap.

Handover requirements based on the existing requirements from RedCap were introduced for non-RedCap for the following scenarios:

- Intra frequency handover from NCD-SSB to NCD-SSB
- Inter frequency handover form NCD-SSB to CD-SSB
- Inter frequency handover from CD-SSB to NCD-SSB
- Inter frequency handover from NCD-SSB to NCD-SSB

Existing RRC configuration signalling for NCD-SSB was reused and the capability signalling aspects were specified to convey the support of this option.

References

Related CRs: set "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=991044,991144,991244

[1] RP-232677, Further revised WID: Complete the specification support for BandWidth Part operation without restriction in NR, RAN #101, Vodafone, vivo.
[2] RP-233039, Status report for WI Complete the specification support for BandWidth Part operation without restriction in NR, RAN #102, Vodafone.
[3] R4-2321647, Big CR to TS 38.133 on Completion of specification support for bandwidth part operation without restriction in NR, RAN4 #109, Vodafone, vivo.
[4] R1-2308723, Introduction of BWP operation without restriction, RAN1 #114, Samsung.
[5] R1-2308725, Introduction of specification support for BandWidth Part operation without restriction in NR, RAN1 #114, Nokia.
[6] R1-2312785, Maintenance of BWP operation without restriction, RAN1#115, Samsung.
[7] R2-2313690, Introduction of support for BWP operation without restriction, RAN2#124, vivo, Vodafone, ZTE Corporation, Sanechips, Ericsson.
[8] R2-2313677, Introduction of Rel-18 UE capabilities, RAN2 #124, Intel Corporation.
[9] R2-2313691, Introduction of support for BWP operation without restriction, RAN2#124, vivo, Vodafone, ZTE Corporation, Sanechips, Ericsson.
[10] R2-2313676, Introduction of Rel-18 UE capabilities, RAN2 #124, Intel Corporation.

23.2.4 Other NR band related topics

The following items were specified:

1010055	**Introduction of NR bands n31 and n72**	**NR_bands_n31_n72**	**R4**	RP-232691	**Nokia**
1011055	Core part: Introduction of NR bands n31 and n72	NR_bands_n31_n72-Core	R4	RP-232691	**Nokia**
1012055	Perf. part: Introduction of NR bands n31 and n72	NR_bands_n31_n72-Perf	R4	RP-232691	**Nokia**

991046	**Enhancement for 700/800/900MHz band combinations for NR**	**NR_700800900_combo_enh**	**R4**	RP-232680	**Shan Huiping, CATT**
991146	Core part: Enhancement for 700/800/900MHz band combinations for NR	NR_700800900_combo_enh-Core	R4	RP-232680	**Shan Huiping, CATT**
991246	Perf. part: Enhancement for 700/800/900MHz band combinations for NR	NR_700800900_combo_enh-Perf	R4	RP-232680	**Shan Huiping, CATT**
981044	**Introduction of NR TDD band in 1670-1675 MHz (n54)**	**NR_TDD_n54**		RP-230062	**Ligado Networks**
981144	Core part: Introduction of NR TDD band in 1670-1675 MHz (n54)	NR_TDD_n54-Core	R4	RP-230062	**Ojas Choksi, Ligado Networks**
981244	Perf. part: Introduction of NR TDD band in 1670-1675 MHz (n54)	NR_TDD_n54-Perf	R4	RP-230062	**Ojas Choksi, Ligado Networks**
981045	**Introduction of 900 MHz NR band in the US**	**NR_900MHz_US**		RP-230723	**Gene Fong, Qualcomm**
981145	Core Part: Introduction of 900 MHz NR band in the US	NR_900MHz_US-Core	R4	RP-230723	**Gene Fong, Qualcomm**
981245	Perf. part: Introduction of 900 MHz NR band in the US	NR_900MHz_US-Perf	R4	RP-230723	**Gene Fong, Qualcomm**
961010	**Rel-18 NR Inter-band Carrier Aggregation/Dual Connectivity for 2 bands DL with x bands UL (x=1,2)**	**NR_CADC_R18_2BDL_xBUL**		RP-231840	**Wubin, Zhou, ZTE**
961110	Core part: Rel-18 NR Inter-band Carrier Aggregation/Dual Connectivity for 2 bands DL with x bands UL (x=1,2)	NR_CADC_R18_2BDL_xBUL-Core	R4	RP-231840	**Wubin, Zhou, ZTE**
961210	Perf. part: Rel-18 NR Inter-band Carrier Aggregation/Dual Connectivity for 2 bands DL with x bands UL (x=1,2)	NR_CADC_R18_2BDL_xBUL-Perf	R4	RP-231840	**Wubin, Zhou, ZTE**
961011	**Rel-18 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with x bands UL (x=1,2)**	**NR_CADC_R18_3BDL_xBUL**		RP-231860	**Zhifeng Ma, ZTE**
961111	Core part: Rel-18 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with x bands UL (x=1,2)	NR_CADC_R18_3BDL_xBUL-Core	R4	RP-231860	**Zhifeng Ma, ZTE**
961211	Perf. part: Rel-18 NR Inter-band Carrier Aggregation/Dual Connectivity for 3 bands DL with x bands UL (x=1,2)	NR_CADC_R18_3BDL_xBUL-Perf	R4	RP-231860	**Zhifeng Ma, ZTE**
961013	**High Power UE support for NR bands n100 and n101 for Rail Mobile Radio (RMR) in Europe**	**NR_RAIL_HPUE_n100_n101**		RP-221878	**Union Internationale Chemins de Fer (UIC)**
961113	Core part: High Power UE support for NR bands n100 and n101 for Rail Mobile Radio (RMR) in Europe	NR_RAIL_HPUE_n100_n101-Core	R4	RP-221878	**Union Internationale Chemins de Fer (UIC)**
961007	**Rel-18 NR intra band Carrier Aggregation for xCC DL/yCC UL including contiguous and non-contiguous spectrum (x>=y)**	**NR_CA_R18_Intra**		RP-231623	**Per Lindell, Ericsson**
961107	Core part: Rel-18 NR intra band Carrier Aggregation for xCC DL/yCC UL including contiguous and non-contiguous spectrum (x>=y)	NR_CA_R18_Intra-Core	R4	RP-231623	**Per Lindell, Ericsson**
961207	Perf. part: Rel-18 NR intra band Carrier Aggregation for xCC DL/yCC UL including	NR_CA_R18_Intra-Perf	R4	RP-231623	**Per Lindell, Ericsson**

	contiguous and non-contiguous spectrum (x>=y)				
961008	**Rel-18 NR inter-band Carrier Aggregation/Dual Connectivity for y bands DL (y=4, 5, 6) with x bands UL (x=1, 2)**	**NR_CADC_R18_yBDL_xBUL**		RP-231738	**Reihaneh Malekafzaliardakani, Ericsson**
961108	Core part: Rel-18 NR inter-band Carrier Aggregation/Dual Connectivity for y bands DL (y=4, 5, 6) with x bands UL (x=1, 2)	NR_CADC_R18_yBDL_xBUL-Core	R4	RP-231738	**Reihaneh Malekafzaliardakani, Ericsson**
961208	Perf. part: Rel-18 NR inter-band Carrier Aggregation/Dual Connectivity for y bands DL (y=4, 5, 6) with x bands UL (x=1, 2)	NR_CADC_R18_yBDL_xBUL-Perf	R4	RP-231738	**Reihaneh Malekafzaliardakani, Ericsson**
960097	**APT 600MHz NR band**	**NR_600MHz_APT**		RP-230060	**Mansoor Shafi, Spark New Zealand**
960197	Core part: APT 600MHz NR band	NR_600MHz_APT-Core	R4	RP-221778	**Mansoor Shafi, Spark New Zealand**
960297	Perf. part: APT 600MHz NR band	NR_600MHz_APT-Perf	R4	RP-221778	**Mansoor Shafi, Spark New Zealand**
960098	**Introduction of additional 6GHz NR licensed bands**	**NR_6GHz_add_bands**		RP-222498	**Liehai Liu, Huawei**
960198	Core part: Introduction of additional 6GHz NR licensed bands	NR_6GHz_add_bands-Core	R4	RP-222498	**Liehai Liu, Huawei**
960298	Perf. part: Introduction of additional 6GHz NR licensed bands	NR_6GHz_add_bands-Perf	R4	RP-222498	**Liehai Liu, Huawei**
960095	**Additional NR bands for UL-MIMO in Rel-18**	**NR_bands_UL_MIMO_R18**		RP-232374	**Xiang Gao, Huawei**
960195	Core part: Additional NR bands for UL-MIMO in Rel-18	NR_bands_UL_MIMO_R18-Core	R4	RP-232374	**Xiang Gao, Huawei**
960295	Perf. part: Additional NR bands for UL-MIMO in Rel-18	NR_bands_UL_MIMO_R18-Perf	R4	RP-232374	**Xiang Gao, Huawei**
1000050	UE Conformance - Additional NR bands for UL-MIMO in Rel-18	NR_bands_UL_MIMO_R18-UEConTest	R5	RP-230868	**Shi, Yu, China Unicom**
950071	**Introduction of LTE TDD band in 1670-1675 MHz**	**LTE_TDD_1670_1675MHz**		RP-222831	**Ligado Networks**
950171	Core part: Introduction of LTE TDD band in 1670-1675 MHz	LTE_TDD_1670_1675MHz-Core	R4	RP-222831	**Ojas Choksi, Ligado Networks**
950271	Perf. part: Introduction of LTE TDD band in 1670-1675 MHz	LTE_TDD_1670_1675MHz-Perf	R4	RP-222831	**Ojas Choksi, Ligado Networks**
991032	UE Conformance - Introduction of LTE TDD band in 1670 – 1675 MHz	LTE_TDD_1670_1675MHz-UEConTest	R5	RP-231545	**Ojas Choksi, Ligado Networks**
960092	*Study on UE support of regionally-defined subsets of an NR band*	FS_NR_subset_band_support	RP	RP-223556	**Gene Fong, Qualcomm**
1000058	**UE Conformance - New Rel-18 NR licensed bands and extension of existing NR bands**	NR_lic_bands_BW_R18-UEConTest	R5	RP-232361	**Yuxin Hao, Huawei Technologies. Co., Ltd.**

24 LTE-only items

24.1 High Power UE (Power Class 2) for LTE FDD Band 14

1010054	**High Power UE (Power Class 2) for LTE FDD Band 14**	**HPUE_LTE_FDD_B14**	**R4**	RP-232676	**AT&T**
1011054	Core part: High Power UE (Power Class 2) for LTE FDD Band 14	HPUE_LTE_FDD_B14-Core	R4	RP-232676	**AT&T**

1012054	Perf. part: High Power UE (Power Class 2) for LTE FDD Band 14	HPUE_LTE_FDD_B14-Perf	R4	RP-232676	**AT&T**

Summary based on the input provided by AT&T in RP-240077.

This work item introduces the requirements for high power UE operation for Power Class 2 (PC2) for LTE FDD Band 14 to extend uplink coverage area and improve the experience of cell edge users. The extension of uplink coverage for this lower-frequency LTE FDD band is very important for operators and to support public safety scenarios.

In Rel-17, there was a Study Item on high power UE (power class 2) for one NR FDD band with its findings documented in TR 38.861 [1]. In the subsequent Rel-17 Work Item on High power UE (power class 2) for one NR FDD band, RF requirements including Tx power and tolerance, A-MPR and receiver sensitivity degradation requirements were specified for NR FDD bands n1 and n3 under PC2 operation. In the follow-on Rel-18 Work Item on High power UE (power class 2) for one NR FDD band, high power UE (power class 2) operation was further specified for lower-frequency NR FDD bands to fulfil the commercial deployment demands. The work and technical analysis for high power UE operation for LTE FDD Band 14 has leveraged the work done for lower-frequency NR FR1 FDD bands.

It includes the following:
- UE maximum output power and Tx power tolerance
- Additional Maximum Power Reduction (A-MPR) requirements to meet regulatory Spectrum Emission Mask requirements
- UE reference sensitivity degradation requirements due to PC2 operation

The work item considered only UE-implementation based methods (i.e., P-MPR) to comply with SAR regulations. Only one RF architecture (i.e. 1Tx×26dBm) was considered to align with LTE transmitter assumptions. It was found that FDD HPUE with 1Tx architecture may need to use newly designed components. However, the design and performance of the components were determined to be feasible.

The last approved WID, Technical Report, and last status report can be found in [2], [3], and [4], respectively. Changes triggered by the work item are captured into TS 36- series specifications in [5] and [6].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1010054,1011054,1012054

[1] TR 38.861: "Study on high power UE (power class 2) for one NR FDD band"
[2] RP-232946 "Revised WID on High Power UE (Power Class 2) for LTE FDD Band 14"
[3] TR 36.770: "High Power UE (Power Class 2) for LTE FDD Band 14"
[4] RP-240075 Status report for WI High Power UE (Power Class 2) for LTE FDD Band 14
[5] R4-2400702 "Big CR on High Power UE (Power Class 2) for LTE FDD Band 14", AT&T, CR6035 to 36.101, RAN4#110
[6] R4-2401529 "CR on the release independency of band 14 PC2 UE", vivo, CR4500 to 36.307, RAN4#110

24.2 Other LTE-only items

981048	**Additional LTE bands for UE categories M1/M2/NB1/NB2 in Rel-18**	**LTE_bands_R18_M1_M2_NB1_NB2**		RP-222824	**Chunhui Zhang, Ericsson**
981148	Core part: Additional LTE bands for UE categories M1/M2/NB1/NB2 in Rel-18	LTE_bands_R18_M1_M2_NB1_NB2-Core	R4	RP-222824	**Chunhui Zhang, Ericsson**
981248	Perf. part: Additional LTE bands for UE categories M1/M2/NB1/NB2 in Rel-18	LTE_bands_R18_M1_M2_NB1_NB2-Perf	R4	RP-222824	**Chunhui Zhang, Ericsson**
981046	**Introduction of 900 MHz LTE band in the US**	**LTE_900MHz_US**		RP-230722	**Emil Olbrich, Anterix**
981146	Core part: Introduction of 900 MHz LTE band in the US	LTE_900MHz_US-Core	R4	RP-230722	**Emil Olbrich, Anterix**
981246	Perf. part: Introduction of 900 MHz LTE band in the US	LTE_900MHz_US-Perf	R4	RP-230722	**Emil Olbrich, Anterix**
981040	**Maximum Power Reduction Requirements (MPR) for LTE intra-band Carrier Aggregation (CA) with a Component Carrier (CC) gap larger than 35 MHz**	**LTE_intra_CA_MPR_35MHz_gap**		RP-230705	**Mohammad Abdi Abyaneh, Huawei, HiSilicon**

981140	Core part: Maximum Power Reduction Requirements (MPR) for LTE intra-band Carrier Aggregation (CA) with a Component Carrier (CC) gap larger than 35 MHz	LTE_intra_CA_MPR_35MHz_gap-Core	R4	RP-230705	**Mohammad Abdi Abyaneh, Huawei, HiSilicon**
960099	**Rel-18 LTE-Advanced Carrier Aggregation for x bands (2<=x<= 6) DL with y bands (y=1, 2) UL**	**LTE_CA_R18_xBDL_yBUL**		RP-232368	**Mohammad Abdi Abyaneh, Huawei-HiSilicon**
960199	Core part: Rel-18 LTE-Advanced Carrier Aggregation for x bands (2<=x<= 6) DL with y bands (y=1, 2) UL	LTE_CA_R18_xBDL_yBUL-Core	R4	RP-232368	**Mohammad Abdi Abyaneh, Huawei-HiSilicon**
960299	Perf. part: Rel-18 LTE-Advanced Carrier Aggregation for x bands (2<=x<= 6) DL with y bands (y=1, 2) UL	LTE_CA_R18_xBDL_yBUL-Perf	R4	RP-232368	**Mohammad Abdi Abyaneh, Huawei-HiSilicon**
961000	**LTE intra-band contiguous Carrier Aggregation for band 8**	**LTE_CA_intra_B8**	**R4**	RP-221846	**China Mobile**
961100	Core part: LTE intra-band contiguous Carrier Aggregation for band 8	LTE_CA_intra_B8-Core	R4	RP-221846	**China Mobile**
991040	**Introduction of 600MHz US LTE band with 1.4 and 3MHz channel bandwidths**	**LTE600_US_lowCBW**	**R4**	RP-230745	**T-Mobile USA**
991140	Core part: Introduction of 600MHz US LTE band with 1.4 and 3MHz channel bandwidths	LTE600_US_lowCBW-Core	R4	RP-230745	**T-Mobile USA**
991240	Perf. part: Introduction of 600MHz US LTE band with 1.4 and 3MHz channel bandwidths	LTE600_US_lowCBW-Perf	R4	RP-230745	**T-Mobile USA**

25 NR and LTE items

25.1 4Rx handheld UE for low NR bands (<1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC

981041	**4Rx handheld UE for low NR bands (<1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC**	**4Rx_low_NR_band_handheld_3Tx_NR_CA_ENDC**		RP-231719	**Jinqiang Xing, OPPO**
981141	Core part: 4Rx handheld UE for low NR bands (<1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC	4Rx_low_NR_band_handheld_3Tx_NR_CA_ENDC-Core	R4	RP-231719	**Jinqiang Xing, OPPO**

Summary based on the input provided by OPPO in RP-240306.

This WI targets to introduce requirements for 4Rx antennas in low NR bands (<1GHz) with handheld UE types and requirements for 3Tx NR inter-band UL Carrier Aggregation (CA) and EN-DC with FWA (Fixed Wireless Access) UE types.

This WI introduce UE RF requirements for two features, one is introducing 4Rx antenna ports to low frequency bands below 1GHz with handheld UE type, and the other is introducing 3Tx chain UE RF architectures for FWA devices which usually have larger physical sizes comparing to handheld UE.

4Rx handheld UE for low NR bands (<1GHz)

The 4Rx antenna ports requirements was introduced in Rel-15 but only for some limited bands with frequencies above 1GHz, then in Rel-16 the requirements for 4Rx antenna ports in below 1GHz bands were introduced but only for FWA devices. In this Rel-18 WI, 4Rx for handheld UEs in bands below 1GHz (n28, n20, n8, n5, n26 and n71) was introduced.

Usually the antenna size will increase when the targeting frequency becomes lower. Therefore, implementing 4Rx antennas in low frequency bands is difficult especially in handheld UE types whose physical size usually is small. After

studies in this WI, the feasibility of supporting 4Rx antennas in handheld UE in low frequency bands (<1GHz) was confirmed at least for some UEs.

When defining requirements for 4Rx antennas in low frequency bands, the ΔRIB,4R (Reference sensitivity adjustment due to support for 4 antenna ports) requirement was discussed and specified as -2.4dB for the bands in this WI. Meanwhile, some clarifications were added saying that 4Rx operation is primarily for FWA form factor and can be applicable to handheld UE with relaxed requirements to reflect the difficulty of implementing 4Rx in low frequency bands for handheld UE. With that, the requirements are complete for 4Rx antennas in low frequency bands.

3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC

3Tx here means UE supports three transmit RF chains which makes it can transmit signals via three antennas simultaneously. In this WI, the 3Tx feature targeted inter-band UL CA and EN-DC cases with FWA UE type which has relatively larger physical size comparing to handheld UE.

In this WI, the following power scenarios were considered:

- CA power class or EN-DC power class is PC2 (power class 2 i.e. 26dBm):
  - PC3 (power class 3 i.e. 23dBm) FDD band 1Tx + PC2 TDD band 2Tx (UL MIMO and TxD (Tx Diversity))
  - PC3 FDD band 1Tx + PC3 TDD band 2Tx (UL MIMO)
  - PC3 TDD band 1Tx + PC2 TDD band 2Tx (UL MIMO)
- CA power class or EN-DC power class is PC1.5 (power class 1.5 i.e. 29dBm):
  - PC3 FDD band 1Tx + PC1.5 TDD band 2Tx (UL MIMO and TxD)

Both Tx and Rx requirements were specified for this feature in this WI.

Tx requirements:

For the band with 2Tx in a 3Tx combination, it can support UL MIMO and/or TxD, therefore, separate clauses were defined for the Tx requirements, i.e. inter-band UL CA/EN-DC with UL MIMO, and inter-band UL CA/EN-DC with TxD. The targeted power classes of the total transmit power from three transmit chains at antenna connector include PC3, PC2 and PC1.5 where PC3 is the default power class.

To allow UE report whether it supports TxD in inter-band UL CA and EN-DC, a new per feature set TxD capability was introduced in this WI and LS was sent to RAN2 [4, 5] and it is expected to be specified in TS38.306 and TS38.331 with early implementation from Rel-17.

Rx requirements:

When introducing 3Tx chain UE architecture, the impacted Rx requirements are mainly MSD (Maximum Sensitivity Degradation) requirements which defines how much receive sensitivity degradation a UE is allowed.

Harmonic interference, harmonic mixing interference, IMD (intermodulation) interference and cross-band leakage interference are the main causes of MSD in CA or EN-DC. Below is the status of the MSD discussions in this WI:

- Harmonic interference: It is not related in this WI considering typically the band with 2Tx is on high frequency band in this WI which makes there is no harmonic interference problem here.

- For harmonic mixing and cross-band leakage interference: It was concluded that the MSD for 3Tx band combination with PC2 or PC1.5 total power class can reuse the existing MSD requirements of corresponding 2Tx band combination as long as the aggressor band has same power class.

- For IMD interference: When 3Tx total power class is PC2, the MSD requirements specified for 2Tx band combination are applicable to the same band combination with 3Tx. When 3Tx total power class is PC1.5, considering there is no PC1.5 with 2Tx inter-band UL CA in the spec when this WI was introduced, the MSD for 3Tx needs to be calculated. Therefore, new power configuration was adopted, i.e. 23dBm+29.8dBm is used in IMD MSD calculation where the band with 1Tx is 23dBm and the band with 2Tx is 24.8dBm+24.8dBm. And the MSD results are calculated based on this new power configuration.

With all above, the big CAT-B CRs [2,3] were agreed and WI was closed.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=981041,981141

[1] RP-231719, WID revision for Core part 4Rx handheld UE for low NR bands (1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC, OPPO, RAN#101, Sep 2023.
[2] R4-2321763, R18 38101-1 CR for 3Tx inter-band CA, OPPO, Samsung, Apple, Huawei, LGE, ZTE, Xiaomi, vivo, CHTTL, RAN4#109, Nov 2023.
[3] R4-2321764, R18 38101-3 CR for 3Tx inter-band ENDC, OPPO, Samsung, Apple, Huawei, LGE, ZTE, Xiaomi, vivo, CHTTL, RAN4#109, Nov 2023.
[4] R4-2317762, LS on new per band per BC TxD capability, R4->R2, RAN4#108bis, Oct 2023.
[5] R4-2403857, draft LS on applicable release of per FS TxD capability, R4->R2, RAN4#110, Feb 2024.

25.2 Enhancement of UE TRP and TRS requirements and test methodologies for FR1 (NR SA and EN-DC)

970082	**Enhancement of UE TRP (Total Radiated Power) and TRS (Total Radiated Sensitivity) requirements and test methodologies for FR1 (NR SA and EN-DC)**	**NR_FR1_TRP_TRS_enh**		RP-233075	**Wang, Ruixin, vivo**
970182	Core part: Enhancement of UE TRP and TRS requirements and test methodologies for FR1 (NR SA and EN-DC)	NR_FR1_TRP_TRS_enh-Core	R4	RP-233075	**Wang, Ruixin, vivo**
970282	Perf. Part: Enhancement of UE TRP and TRS requirements and test methodologies for FR1 (NR SA and EN-DC)	NR_FR1_TRP_TRS_enh-Perf	R4	RP-233075	**Wang, Ruixin, vivo**

Summary based on the input provided by vivo in RP-240138.

This FR1 TRP TRS core part WI defines the enhanced Over-the-Air (OTA) test methods for NR FR1 Total Radiated Power (TRP) and Total Radiated Sensitivity (TRS), for NR standalone (SA) and NR non-standalone (NSA) operation mode. The outcome is captured in a new technical report TR 38.870 [2], and some update is also reflected in TS 38.161 [4].

The AC (Anechoic Chamber) was introduced in Rel-17 for 1Tx UE. This Rel-18 WI specified enhanced AC test methods to support verification of radiated performance for some advanced UE features, i.e., RedCap, 2Tx configuration (TxD and UL-MIMO) and NR CA. New usage scenario for RedCap wrist-worn devices is also defined. In addition, this Rel-18 WI also defined a new RC (Reverberation Chamber) test methodology for UE with 1Tx configuration. The defined AC and RC test methods are generic to cover all NR bands.

OTA (over the air) test methods and radiated performance verification (as considered in this WI) are important since if the above UE features for FR1 (frequency range 1) are verified by conducted methodology at temporary antenna ports (as done so far), it remains unknown what the actual performance of the UE would be in realistic network conditions with the UE antenna included. FR1 OTA test methods are always defined first before corresponding requirements are defined. The end-to-end radiated performance verification based on OTA methodology is one of the most important characteristics to present the entire UE performance under conditions more closely resembling the end user's interaction with the device.

The purpose of this WI is to develop test method for FR1 TRP TRS under SA and NSA mode, including Anechoic Chamber system and Reverberation Chamber system. Some key outcomes can be summarized as following:

- UE type: Smartphone, wearable Redcap UE, Tablet, Laptop embedded equipment (LEE) and Laptop mounted equipment (LME).
- Usage scenarios:
  - Talk mode using head & hand phantom for narrow and wide phones
  - Browsing mode using hand phantom for narrow and wide phones
  - Using forearm phantom for wrist-worn devices. For wrist-worn Redcap devices, forearm phantom is the first priority.
  - Free Space is used for devices not used in above-mentioned scenarios, other phantoms are not precluded for wearable devices
- Test parameters:
  - Test parameters for each NR band and RedCap band have been defined
- UE positioning guidelines:

- UE positioning guidelines for Free space, Hand phantom only (Browsing mode), Head and Hand phantom (Talk Mode), Head phantom only, and Forearm phantom.
- Coordination with CTIA on phantom related aspects, 3GPP and their Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC) get the permission.

· AC test method:
- Test setup: Single-antenna and multiple-antennas anechoic chambers
- TRP TRS calibration procedure
- Ripple test procedure for 30cm and 50cm, both theta-axis and phi-axis
- TRP test procedure and UE configurations for 1Tx, 2Tx, and DL CA configurations
- TRS test procedure and UE configurations for 1Tx, 2Tx, and DL CA configurations
- Minimum measurement distance of anechoic chambers

· RC test method:
- Test setup: Reverberation Chamber
- S-parameters and power transfer functions
- Chamber loading for coherence bandwidth
- Chamber spatial uniformity
- Calibration procedure for RC system
- TRP test procedure and UE configurations for SA and EN-DC
- TRS test procedure and UE configurations for SA and EN-DC
- Test Volume

· Testing time reduction methodologies:
- Measurement grids for Anechoic Chamber method

· Measurement uncertainty assessment:
- Measurement error uncertainty contribution descriptions
- AC preliminary example of uncertainty budget
  - Expanded uncertainty for TRP hand only (browsing mode): 1.73 dB
  - Expanded uncertainty for TRP Beside Head and Hand (Talk mode): 1.96 dB
  - Expanded uncertainty for TRP Wrist-Worn: 1.78 dB
  - Expanded uncertainty for TRS hand only (browsing mode): 2.13 dB
  - Expanded uncertainty for TRS Beside Head and Hand (Talk mode): 2.31 dB
  - Expanded uncertainty for TRS Wrist-Worn: 2.17 dB
- RC preliminary example of uncertainty budget
  - Expanded uncertainty for TRP hand only (browsing mode): 1.90 dB
  - Expanded uncertainty for TRP Beside Head and Hand (Talk mode): 2.08 dB
  - Expanded uncertainty for TRS hand only (browsing mode): 2.28 dB
  - Expanded uncertainty for TRS Beside Head and Hand (Talk mode): 2.43 dB

· Test phantom definition:
- PDA Grip Hand
- Wide Grip Hand
- Head Phantom
- Forearm Phantom

· Environmental requirements:
- Room temperature with the DUT operated in stand-alone battery powered mode.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970082,970182,970282

[2] RP-233136, TR 38.870, Enhanced Over-the-Air (OTA) test methods for NR FR1 Total Radiated Power (TRP) and Total Radiated Sensitivity (TRS), vivo, RAN#102.
[3] NR RF requirements enhancement for frequency range 2 (FR2), Phase 3

25.3 Other items

1010053	**Rel-18 basket WI 3Tx NR inter-band UL Carrier Aggregation (CA) and EN-DC**	**R18_3Tx_NR_CA_ENDC**	**R4**	RP-232674	**Oppo**

1011053	Core pat: Rel-18 basket WI 3Tx NR inter-band UL Carrier Aggregation (CA) and EN-DC	R18_3Tx_NR_CA_ENDC-Core	R4	RP-232674	**Oppo**
970088	**Rel-18 High power UE (power class m with 1<m<3) for a single FR1 band in UL of Dual Connectivity (DC) combinations of x bands (x=1,2,3, 4 for y=1 or x=1, 2 for y=2) LTE inter-band CA (xDL/1UL) and y bands NR inter-band CA (yDL/1UL)**	**HPUE_FR1_DC_LTE_NR_R18**		RP-231625	**Per Lindell, Ericsson**
970188	Core part: Rel-18 High power UE (power class m with 1<m<3) for a single FR1 band in UL of Dual Connectivity (DC) combinations of x bands (x=1,2,3, 4 for y=1 or x=1, 2 for y=2) LTE inter-band CA (xDL/1UL) and y bands NR inter-band CA (yDL/1UL)	HPUE_FR1_DC_LTE_NR_R18-Core	R4	RP-231625	**Per Lindell, Ericsson**
970288	Perf. part: Rel-18 High power UE (power class m with 1<m<3) for a single FR1 band in UL of Dual Connectivity (DC) combinations of x bands (x=1,2,3, 4 for y=1 or x=1, 2 for y=2) LTE inter-band CA (xDL/1UL) and y bands NR inter-band CA (yDL/1UL)	HPUE_FR1_DC_LTE_NR_R18-Perf	R4	RP-231625	**Per Lindell, Ericsson**
1000054	**UE Conformance - Rel-18 High Power UE for NR CA and DC; and NR and LTE DC Configurations;**	HPUE_NR_CADC_NR_LTE_DC_R18-UEConTest	R5	RP-231199	**Lei GAO, China Telecom**
961012	**High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands**	**LTE_NR_HPUE_FWVM_R18**		RP-231615	**Petri Vasenkari, Nokia**
961112	Core part: High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands	LTE_NR_HPUE_FWVM_R18-Core	R4	RP-231615	**Petri Vasenkari, Nokia**
1000059	UE Conformance - High-power UE operation for fixed-wireless/vehicle-mounted use cases in LTE bands and NR bands in Rel-18	LTE_NR_HPUE_FWVM_R18-UEConTest	R5	RP-231615	**Tuomo S yn j kangas, Nokia**
1000057	**UE Conformance - Rel-18 NR CA and DC; and NR and LTE DC Configurations**	NR_CADC_NR_LTE_DC_R18-UEConTest	R5	RP-231248	**Yuxin Hao, Huawei Technologies. Co., Ltd.**
970084	**Simultaneous Rx/Tx band combinations for NR CA/DC, NR SUL and LTE/NR DC in Rel-18**	**LTE_NR_Simult_RxTx_R18**		RP-223354	**Dan Hu, Huawei**
970184	Core part: Simultaneous Rx/Tx band combinations for NR CA/DC, NR SUL and LTE/NR DC in Rel-18	LTE_NR_Simult_RxTx_R18-Core	R4	RP-223354	**Dan Hu, Huawei**
970284	Perf. part: Simultaneous Rx/Tx band combinations for NR CA/DC, NR SUL and LTE/NR DC in Rel-18	LTE_NR_Simult_RxTx_R18-Perf	R4	RP-223354	**Dan Hu, Huawei**
961009	**Rel-18 single SUL band combinations for SA NR supplementary uplink (SUL), NSA NR SUL, NSA NR SUL with UL sharing from the UE perspective (ULSUP)**	**NR_SUL_combos_R18**		RP-232372	**Zhang, Peng, Huawei**
961109	Core part: Rel-18 single SUL band combinations for SA NR supplementary uplink (SUL), NSA NR SUL, NSA NR SUL with UL sharing from the UE perspective (ULSUP)	NR_SUL_combos_R18-Core	R4	RP-232372	**Zhang, Peng, Huawei**
961209	Perf. Part: Rel-18 single SUL band combinations for SA NR supplementary uplink (SUL), NSA NR SUL, NSA NR SUL with UL sharing from the UE perspective (ULSUP)	NR_SUL_combos_R18-Perf	R4	RP-232372	**Zhang, Peng, Huawei**
961001	**Rel-18 Dual Connectivity (DC) of 1 band LTE (1DL/1UL) and 1 NR band (1DL/1UL)**	**DC_R18_1BLTE_1BNR_2DL2UL**		RP-232302	**Bo-Han Hsieh (Tank), CHTTL**
961101	Core part: Rel-18 Dual Connectivity (DC) of 1 band LTE (1DL/1UL) and 1 NR band (1DL/1UL)	DC_R18_1BLTE_1BNR_2DL2UL-Core	R4	RP-232302	**Bo-Han Hsieh (Tank), CHTTL**
961201	Perf. part: Rel-18 Dual Connectivity (DC) of 1 band LTE (1DL/1UL) and 1 NR band (1DL/1UL)	DC_R18_1BLTE_1BNR_2DL2UL-Perf	R4	RP-232302	**Bo-Han Hsieh (Tank), CHTTL**

961002	**Rel-18 Dual Connectivity (DC) of x LTE bands and y NR bands with z bands DL and 3 bands UL (x=1, 2, 3, 4; y=1, 2; 3<=z<=6)**	**DC_R18_xBLTE_yBNR_zDL3UL**		RP-222237	**Yuanyuan Zhang, Samsung**
961102	Core part: Rel-18 Dual Connectivity (DC) of x LTE bands and y NR bands with z bands DL and 3 bands UL (x=1, 2, 3, 4; y=1, 2; 3<=z<=6)	DC_R18_xBLTE_yBNR_zDL3UL-Core	R4	RP-222237	**Yuanyuan Zhang, Samsung**
961202	Perf. part: Rel-18 Dual Connectivity (DC) of x LTE bands and y NR bands with z bands DL and 3 bands UL (x=1, 2, 3, 4; y=1, 2; 3<=z<=6)	DC_R18_xBLTE_yBNR_zDL3UL-Perf	R4	RP-222237	**Yuanyuan Zhang, Samsung**
961003	**Rel-18 Dual Connectivity (DC) of x bands (x=1,2,3,4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)**	**DC_R18_xBLTE_2BNR_yDL2UL**		RP-231723	**Sang-Wook Lee, LG Electronics**
961103	Core part: Rel-18 Dual Connectivity (DC) of x bands (x=1,2,3,4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)	DC_R18_xBLTE_2BNR_yDL2UL-Core	R4	RP-231723	**Sang-Wook Lee, LG Electronics**
961203	Perf. part: Rel-18 Dual Connectivity (DC) of x bands (x=1,2,3,4) LTE inter-band CA (xDL/1UL) and 2 bands NR inter-band CA (2DL/1UL)	DC_R18_xBLTE_2BNR_yDL2UL-Perf	R4	RP-231723	**Sang-Wook Lee, LG Electronics**
961004	**Rel-18 Dual Connectivity (DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)**	**DC_R18_2BLTE_1BNR_3DL2UL**		RP-232370	**Liehai Liu, Huawei**
961104	Core part: Rel-18 Dual Connectivity (DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)	DC_R18_2BLTE_1BNR_3DL2UL-Core	R4	RP-232370	**Liehai Liu, Huawei**
961204	Perf. part: Rel-18 Dual Connectivity (DC) of 2 bands LTE inter-band CA (2DL/1UL) and 1 NR band (1DL/1UL)	DC_R18_2BLTE_1BNR_3DL2UL-Perf	R4	RP-232370	**Liehai Liu, Huawei**
961005	**Rel-18 Dual Connectivity (DC) of x bands (x=3,4,5) LTE inter-band CA (xDL/1UL) and 1 NR band (1DL/1UL)**	**DC_R18_xBLTE_1BNR_yDL2UL**		RP-232248	**Johannes Hejselbaek, Nokia**
961105	Core part: Rel-18 Dual Connectivity (DC) of x bands (x=3,4,5) LTE inter-band CA (xDL/1UL) and 1 NR band (1DL/1UL)	DC_R18_xBLTE_1BNR_yDL2UL-Core	R4	RP-232248	**Johannes Hejselbaek, Nokia**
961205	Perf. part: Rel-18 Dual Connectivity (DC) of x bands (x=3,4,5) LTE inter-band CA (xDL/1UL) and 1 NR band (1DL/1UL)	DC_R18_xBLTE_1BNR_yDL2UL-Perf	R4	RP-232248	**Johannes Hejselbaek, Nokia**
961006	**Rel-18 Dual Connectivity (DC) of x bands (x=1,2,3) LTE inter-band CA (xDL/1UL) and y bands (3<=y<=5 and x+y <= 6) NR inter-band CA (yDL/1UL)**	**DC_R18_xBLTE_yBNR_zDL2UL**		RP-231842	**Wubin Zhou, ZTE**
961106	Core part: Rel-18 Dual Connectivity (DC) of x bands (x=1,2,3) LTE inter-band CA (xDL/1UL) and y bands (3<=y<=5 and x+y <= 6) NR inter-band CA (yDL/1UL)	DC_R18_xBLTE_yBNR_zDL2UL-Core	R4	RP-231842	**Wubin Zhou, ZTE**
961206	Perf. part: Rel-18 Dual Connectivity (DC) of x bands (x=1,2,3) LTE inter-band CA (xDL/1UL) and y bands (3<=y<=5 and x+y <= 6) NR inter-band CA (yDL/1UL)	DC_R18_xBLTE_yBNR_zDL2UL-Perf	R4	RP-231842	**Wubin Zhou, ZTE**
960096	**Rel-18 band combinations for concurrent operation of NR/LTE Uu bands/band combinations and one NR/LTE V2X PC5 band**	**NR_LTE_V2X_PC5_combos_R18**		RP-230390	**Qiuge Guo, CATT**
960196	Core part: Rel-18 band combinations for concurrent operation of NR/LTE Uu bands/band combinations and one NR/LTE V2X PC5 band	NR_LTE_V2X_PC5_combos_R18-Core	R4	RP-230390	**Qiuge Guo, CATT**
960296	Perf. part: Rel-18 band combinations for concurrent operation of NR/LTE Uu bands/band combinations and one NR/LTE V2X PC5 band	NR_LTE_V2X_PC5_combos_R18-Perf	R4	RP-230390	**Qiuge Guo, CATT**
960094	**Rel-18 downlink interruption for NR and EN-DC band combinations at dynamic Tx Switching in Uplink**	**DL_intrpt_combos_TxSW_R18**		RP-222288	**Liu, Bo, China Telecom**

960194	Core part: Rel-18 downlink interruption for NR and EN-DC band combinations at dynamic Tx Switching in Uplink	DL_intrpt_combos_TxSW_R18-Core	R4	RP-231194	**Liu, Bo, China Telecom**
960294	Perf. part: Rel-18 downlink interruption for NR and EN-DC band combinations at dynamic Tx Switching in Uplink	DL_intrpt_combos_TxSW_R18-Perf	R4	RP-231194	**Liu, Bo, China Telecom**

26 Network automation

26.1 Enablers for Network Automation for 5G phase 3

990118	**Enablers for Network Automation for 5G phase 3**	**eNA_Ph3**		SP-221345	**Aihua Li, China Mobile**
940073	*Study on Enablers for Network Automation for 5G - phase 3*	FS_eNA_Ph3	S2	SP-220678	**Aihua Li, China Mobile**
950021	*Study on security aspects of enablers for Network Automation for 5G - phase 3*	FS_eNA_SEC_Ph3	S3	SP-220199	**Chang Liu, China Mobile**
990042	Security aspects of enablers for Network Automation for 5G - phase 3	eNA_Ph3_SEC	S3	SP-230155	**Chang Liu, China Mobile**
980020	**(stage 2 of eNA_Ph3) Enablers for Network Automation for 5G phase 3**	eNA_Ph3	S2	SP-230110	**Aihua Li, China Mobile**
990010	CT3 aspects of eNA_Ph3	eNA_Ph3	C3	CP-230119	**Zhennning Huang, China Mobile**
990104	CT4 aspects of eNA_Ph3	eNA_Ph3	C4	CP-230119	**Zhennning Huang, China Mobile**

No summary provided.

26.2 Enhancement of Network Automation Enablers

980039	**Enhancement of Network Automation Enablers**	eNetAE	C3	CP-231191	**Xuefei Zhang, Huawei**

Summary based on the input provided by Huawei in CP-241259.

The network data analytics related services (e.g. Nnwdaf services defined in TS 29.520, Ndccf services defined in TS 29.574, Nadrf services defined in TS 29.575, Nmfaf services defined in TS 29.576, etc.) are specified in Rel-15, Rel-16 and Rel-17 in order to efficiently collect the data, store the data and analytics, and provide the analytics to the consumer.

There is a need to apply the technical improvements and enhancements in Release 18 (e.g. complete the missing non-critical stage-2 requirements, enhancements on the definition of the API in stage-3 level, etc.) to these network data analytics related services, as such enhancements may not be covered by the other dedicated Rel-18 work items.

eNetAE specifies the technical improvements and enhancements to the network data analytics related services in Rel-18 stage-3 level not covered by other work items and including the implementation of the missing critical requirements in previous releases. This includes the following (the below list is not exhaustive):

1. Specification of the impact of user consent in data collection and data storage.
   a. Error handling on Nnwdaf, Ndccf and Nnef services for the scenario in which the user consent is not granted during the data collection procedures.
   b. Enhancements of data collection and storage via DCCF and MFAF involves user consent change and consumer providing user consent in the request.
   c. Improvements for the scenario in which the consumer requests analytics or ML model for Internal Group Id, External Group Id or "any UE" including those users for which the user consent is not granted or is revoked.

2. Support of multiple notification endpoints for Nnwdaf, Ndccf and Nmfaf services.

3. Enhancements of the Nnwdaf_EventsSubscription, Nnwdaf_AnalyticsInfo and/or Nnwdaf_DataManagement services:

   - Support of the acceptable deviation from the threshold level

- Enhancements of the expected UE Behaviour parameters provided by the AF for UE communication
- Enhancements of the amount information included in Abnormal behaviour analytics
- Support of the preferred level of accuracy "Medium" and "Highest"
- Support of the ordering criterion provided by the consumer for some analytics IDs
- Support of Termination Request included in the Nnwdaf_EventsSubscription_Notify request
- Support of temporal aggregation and anonymization rules for processing instructions
- The enhancements of analytics exposure
- Enhancements of the Event Filters for AF Event Exposure
- Support of immediate reports on NWDAF and DCCF
- Support of providing the number of impacted UE for Abnormal Behaviour analytics
- Support of providing the time stamp for the data volume dispersion information
- Support of preferred granularity of location for some analytics IDs

4. Support of analytics and data storage without providing ADRF information by the consumer.

5. Clarification of the attributes which are not applicable or should be ignored in the data types reused by DCCF during data collection and analytics exposure procedures.
   a. Some attributes within the data types reused by DCCF were clarified, e.g., attributes "altNotifIpv4Addrs", "altNotifIpv6Addrs" and "altNotifFqdns" in NsmfEventExposure data type, attribute "supportedFeatures" in NnwdafEventsSubscription data type, etc.
   6. Corrections and/or updates to network data analytics related services missed in the previous 3GPP Releases, which are not covered by the other dedicated Rel-18 work items.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980110,840085,960030,970010,980083,980084,980085,90035,1010016

[1] TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".
[2] TS 29.520: "5G System; Network Data Analytics Services; Stage 3".
[3] TS 29.574: "5G System; Data Collection Coordination Services; Stage 3".
[4] TS 29.575: "5G System; Analytics Data Repository Services; Stage 3".
[5] TS 29.576: "5G System; Messaging Framework Adaptor Services; Stage 3".

27 Other aspects

27.1 Support for Wireless and Wireline Convergence Phase 2

980110	**Support for Wireless and Wireline Convergence Phase 2**	**5WWC_Ph2**		SP-220904	**Laurent Thiebaut, Nokia**
840085	*Study on the support for 5WWC Phase 2*	FS_5WWC_Ph2	S2	SP-220419	**Laurent Thiebaut, Nokia**
960030	*Study on Security aspects for 5WWC Phase 2*	FS_5WWC_Ph2_Sec	S3	SP-221144	**Saurabh Khare, Nokia**
970010	**Stage 2 of 5WWC_Ph2**	5WWC_Ph2	S2	SP-230367	**Laurent Thiebaut, Nokia**
980083	CT1 aspects of 5WWC_Ph2	5WWC_Ph2	C1	CP-232171	**Nassar, Mohamed A.(Nokia)**
980084	CT3 aspects of 5WWC_Ph2	5WWC_Ph2	C3	CP-232171	**Nassar, Mohamed A.(Nokia)**
980085	CT4 aspects of 5WWC_Ph2	5WWC_Ph2	C4	CP-232171	**Nassar, Mohamed A.(Nokia)**
990035	Security aspects for 5WWC Phase 2	5WWC_Ph2_Sec	S3	SP-230148	**Khare, Saurabh, Nokia**
1010016	Charging Aspects of 5WWC phase 2	5WWC_Ph2	S5	SP-231154	**Sun Mingrui, China Unicom**

Summary based on the input provided by Nokia in SP-240382.

Support of Untrusted Non 3GPP access to 5GC / Trusted Non 3GPP access to 5GC / Wireline access to 5GC had been specified as part of 3GPP R15 (5GS_Ph1) and 3GPP R16 (5WWC). As part of R18 5WWC_Ph2 following enhancements have been specified:

- Feature 1: How to select a N3IWF or a TNGF that supports the S-NSSAI(s) needed by the UE
- Feature 2:

- Differentiated Support for UE(s) behind an RG,
- Differentiated Support for NAUN3 devices (devices that the 5GC cannot authenticate) behind a 5G RG,
- Differentiated Support for AUN3 devices (devices that the 5GC can authenticate) behind a 5G RG

To support the selection of a N3IWF that supports the S-NSSAI(s) needed by the UE:

- Access Network Discovery & Selection policies (ANDSP) sent by the PCF to the UE [3] have been enhanced with information about supported S-NSSAI(s) per N3IWF to allow the UE to determine an appropriate N3IWF that supports the S-NSSAI(s) needed by the UE.
- if the N3IWF selected by the UE does not support the slices requested by UE, the AMF may trigger the PCF to provide the UE with updated ANDSP and/or may provide target N3IWF information to the UE via a Registration Reject so that UE can use the target N3IWF information to connect via the target N3IWF [2].

To support the selection of a TNGF that supports the S-NSSAI(s) needed by the UE:

- Access Network Discovery & Selection policy (ANDSP) [3] has been extended with information about which TNGF ID to use for which slices and which SSID to use to reach this TNGF. When initiating registration over Trusted non 3GPP access, the UE may indicate that a specific TNGF is to be used by including a TNGF ID in its NAI's realm.
- if the TNGF selected by the UE does not support the slices requested by UE, the AMF may trigger the PCF to provide the UE with updated ANDSP and/or may provide target TNAN information (SSIDs, TNGF ID) to the UE via a Registration Reject so that UE can use this information to connect via the target TNGF [2].

Differentiated Support for NAUN3 devices (devices that the 5GC cannot authenticate) behind a 5G RG, is supported as specified in [1]:

- The 5G RG is configured by means out of scope of 3GPP with the mapping between SSID, 5G RG physical ports, etc. and Connectivity Group ID whose values is defined by the operator.
- Policies configured by the PCF for the 5G RG [3] are used to map from Connectivity Group ID to parameters of the PDU session (DNN, S-NSSAI, PDU Session Type, SSC mode) to use for the traffic of NAUN3 devices associated with a given Connection Capability.

Differentiated Support for AUN3 devices (devices that the 5GC can authenticate) behind a 5G-RG is supported as specified in [1]:

- Each AUN3 device has its own UDM/UDR subscription data including its own SUPI and policy control subscription data.
- In order to serve the AUN3 device in 5GC, a 5G-RG issues a NAS register and handles RM and CM related signalling on behalf of an AUN3 device.
- The AMF and the 5G-RG maintain a separate NAS connection per AUN3 device. This includes maintaining a GUTI and NAS (RM, CM, etc.) context per AUN3 device. As defined in TS 33.501 NAS security does not apply to AUN3 devices.
- A 5G-RG serving an AUN3 device establishes a single PDU Session on behalf on this AUN3 device.
- There shall be a separate N2 connection per AUN3 device that is in state CM-CONNECTED. .
- The AUN3 devices and the 5G-RG belong to the same PLMN.

Differentiated Support for UE(s) behind an RG is supported as specified in [1]:

- The RG's PCF is preconfigured with IP address ranges corresponding to TNGF/N3IWF(s) and with DSCP used over NWu and NWt, (this corresponds to the DSCP values used below the IPsec tunnel between the UE and the TNGF/N3IWF). This PCF can thus apply specific QoS policies for the traffic of UE(s) served by RG(s)
- A 5G-RG acting as a TNAP shall provide its TNAP ID to the TNGF and the TNGF provides this TNAP ID as part of ULI (User Location Information) sent to the 5GC; this information is propagated to the PCF that may use it to determine PCC rules depending on whether an UE is using a 5G-RG as a host or as a guest.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980110,840085,960030,970010,980083,980084,980085,90035,1010016

[1] TS 23.316: "Wireless and wireline convergence access support for the 5G System (5GS)".
[2] TS 23.502: "Procedures for the 5G system, Stage 2".
[3] TS 23.503: "Policy and Charging Control Framework for the 5G System".

27.2 Secondary DN Authentication and authorization in EPC IWK cases

980118	**Secondary DN Authentication and authorization in EPC IWK cases**	**TEI18_SDNAEPC**		SP-220798	**Laurent Thiebaut, Nokia**
970008	**Stage 2 of Secondary DN Authentication and authorization in EPC IWK cases**	**TEI18_SDNAEPC**	**S2**	SP-220798	**Laurent Thiebaut, Nokia**
980099	CT1 aspects of TEI18_SDNAEPC	TEI18_SDNAEPC	C1	CP-230188	**Nassar, Mohamed A.(Nokia)**
980100	CT3 aspects of TEI18_SDNAEPC	TEI18_SDNAEPC	C3	CP-230188	**Nassar, Mohamed A.(Nokia)**
980101	CT4 aspects of TEI18_SDNAEPC	TEI18_SDNAEPC	C4	CP-230188	**Nassar, Mohamed A.(Nokia)**

Summary based on the input provided by Nokia in SP-240383.

Before 3GPP R18, EAP based secondary authentication (to use a PDU Session) had only been defined for 5GS and was thus not applicable to EPS. This prevented usage of this feature for UE(s) who would need to access to the same DNN/APN over 3GPP access to EPC.

The support of secondary DN Authentication and authorization in EPC (interworking) cases has been specified (in [1]) as follows:

- A combo SMF+PGW-C is used to serve DNN(s) requiring Secondary authentication/authorization by a DN-AAA server.
- For Secondary authentication/authorization by a DN-AAA server, the SMF+PGW-C uses the same procedures with PCF, UDM and DN-AAA and uses the same corresponding interfaces regardless of whether the UE is served by EPC or 5GC.
- Only the interface towards the UE is different (usage of 4G NAS instead of 5G NAS) between the EPC and 5GC cases.
- The MME and SGW are not impacted by the procedure for Secondary authentication/authorization by a DN-AAA server. Specific exchanges between the UE and the SMF+PGW-C for Secondary authentication/authorization by a DN-AAA server are carried via PCO (Protocol configuration Options) which is transparent to the MME/SGW.
- As it is not possible to exchange PCO in multiple round-trips between the UE and the PGW-C without first establishing the PDN Connection, the PDN Connection is established before Secondary authentication/authorization by a DN-AAA server has taken place.
- When Secondary authentication/authorization by a DN-AAA server has successfully taken place, the SMF+PGW-C allows traffic exchange at the UPF and indicates to the UE that User plane traffic is now possible.
- Only 3GPP access to EPC is supported.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980118,970008,980099,,980100,980101

[1] TS 23.502: "Procedures for the 5G system, Stage 2".

27.3 Mobile IAB (Integrated Access and Backhaul) for NR

941009	**Mobile IAB (Integrated Access and Backhaul) for NR**	**NR_mobile_IAB**		RP-232643	**Georg Hampel, Qualcomm**
941109	Core part: Mobile IAB (Integrated Access and Backhaul) for NR	NR_mobile_IAB-Core	R3	RP-232643	**Georg Hampel, Qualcomm**
941209	Perf. part: Mobile IAB (Integrated Access and Backhaul) for NR	NR_mobile_IAB-Perf	R3	RP-232643	**Georg Hampel, Qualcomm**

Summary based on the input provided by Qualcomm inc. in RP-233321.

The Rel-18 WI on Mobile Integrated Access and Backhaul (IAB) for NR [1] [2] builds on the architecture and protocols derived in the Rel-17 WI NR_IAB_enh. The work on Mobile IAB in Rel-18 focused on the scenario of mobile-IAB-nodes mounted on vehicles providing 5G coverage/capacity enhancement to onboard and/or surrounding UEs.

The Rel-18 WI on Mobile Integrated Access and Backhaul (IAB) for NR introduces the mobile IAB-node, which is a RAN-node that supports NR access links to UEs and an NR backhaul link to a parent node, and which can conduct physical mobility across the RAN area. Mobile IAB supports the following functionality.

- Support for mobility of the mobile IAB-node. This includes:
  - Network integration procedure for the mobile IAB-node.
  - Support for a sequence of inter-donor migrations of the mobile IAB-MT.
  - Support for inter-donor mobile IAB-DU migration.
  - A mobile-IAB-specific authorization framework.
  - Mobile-IAB-aware UE location updates.
  - UE positioning using a mobile TRP hosted by a mobile IAB-node.
- Enhancements for Rel-18 UEs onboard of a vehicle hosting a mobile IAB-node:
  - Support of RACH-less handover between logical mobile IAB-cells for UEs that are connected via the mobile IAB-node during mobile IAB-DU migration.
  - Prioritization of mobile IAB cells for inter-frequency cell reselection.

Mobile IAB-nodes can support legacy UEs. Mobile IAB are applicable to FR1 and FR2. Mobile IAB further supports in-band and out-of-band backhauling. The mobile IAB-node does not support descendent nodes. The mobile IAB-MT can only be single connected. It is further assumed that inter-IAB-donor IP connectivity and Xn connectivity is provided.

The Mobile IAB for NR WI was conducted in collaboration with SA2's SI/WI on VMR. The term mobile IAB-node used in the 38-series of 3GPP Specifications corresponds to the term MBSR defined in TS 23.501.

2.1 Support for mobility of the mobile IAB-node

2.1.1 Network integration procedure for the mobile IAB-node

The network integration of the mobile IAB-node follows a similar procedure as the network integration of the Rel-16/17 IAB-node. The mobile IAB-MT selects the parent node based on a mobile-IAB-specific broadcast indicator in SIB1. It ignores the parent node broadcast indicator for Rel-16/17 IAB. This allows the RAN to provide support for mobile IAB-nodes independently from Rel-16/17 IAB-nodes. After mobile IAB-MT integration, the IAB-donor may configure backhaul connectivity. With backhaul connectivity established, the mobile IAB-DU can set up F1 connectivity with the IAB-donor, and then start to serve UEs.

Opposed to Rel-16/17 IAB, the mobile IAB-DU may integrate with a different IAB-donor than the mobile IAB-MT. The mobile IAB-DU's IAB-donor, referred to as F1-terminating IAB-donor, is selected by the IAB-node's OAM. The mobile IAB-MT's IAB-donor is referred to as RRC-terminating IAB-donor. In case the F1-terminating is different from the RRC-terminating IAB-donor, it can use the legacy XnAP Transport Migration Management procedure toward the RRC-terminating IAB-donor to offload F1- and non-F1 traffic to the mobile IAB-MT's backhaul path.

In case the F1-terminating IAB-donor identifies collision of a mobile-IAB-cell's NCI with an NCI used by another cell of this IAB-donor during the mobile IAB-DU's F1 Setup procedure, it may reconfigure the NCI of the mobile IAB-cell. In this case, the IAB-node reports the cell's new NCI to its OAM.

2.1.2 Sequence of inter-donor migrations of the mobile IAB-MT

For the support of mobility of the mobile IAB-node, the mobile IAB-MT can be migrated from a source to a target IAB-donor using Xn-based or NG-based handover. During the mobile IAB-MT migration, the F1-terminating IAB-donor can be the same as the source or target RRC-terminating IAB-donors, or it can be different than both of these RRC-terminating IAB-donors. After mobile IAB-MT handover, the F1- and non-F1 traffic is migrated from the mobile IAB-MT's source backhaul path to the mobile IAB-MT's target backhaul path. This traffic migration is initiated by the F1-terminating IAB-donor using the legacy XnAP Transport Migration Management procedure. The mobile IAB-node forwards information on the RRC-terminating IAB-donor to the F1-terminating IAB-donor.

Multiple mobile IAB-MT migration procedures can be conducted in a sequence. During such a sequence, the F1-terminating IAB-donor may remain the same.

To mitigate PCI collisions between mobile-IAB cells and the stationary network, legacy mechanisms can be used such as PCI space partitioning or PCI reconfiguration. Further, PCI confusion can be detected using existing mechanisms (e.g., via measurement reports). To mitigate RACH configuration collision between mobile-IAB cells and cells of the stationary network, legacy mechanism can be used, e.g., exchange of cell RACH configurations between IAB-donors via Xn. Further, a mobile-IAB-cell identifier is included in the served cell information exchanged between IAB-donors.

While the mobile IAB-node moves across the RAN area, the TAC and RANAC broadcasted by the mobile IAB-DU can be reconfigured via OAM. These TAC/ RANAC values do not need to be the same as those of the mobile IAB-MT's cell.

2.1.3 Inter-donor mobile IAB-DU migration

The mobile IAB-DU migration procedure allows changing the F1-terminating IAB-donor of the mobile IAB-node. The mobile IAB-DU migration procedure can be conducted independently of the mobile IAB-MT migration procedure. During the mobile IAB-DU migration procedure, the mobile IAB-node concurrently supports two logical mobile IAB-DUs, referred to as source and target logical mobile IAB-DUs, which connect to the respective source and target F1-terminating IAB-donors. During this procedure, the UEs, which are initially connected to the source logical mobile IAB-DU/IAB-donor, are handed over to the target logical IAB-DU/IAB-donor.

To assist the source F1-terminating IAB-donor with handover of UEs, the source logical mobile IAB-DU can provide information about the cells activated by the target F1-terminating IAB-donor, and potentially with a mapping of these cells to cells activated on the source mobile IAB-DU.

During DU migration, the source or the target F1-terminating IAB-donor may be the same or different than the RRC-terminating IAB-donor. In case the target F1-terminating IAB-donor is different from the RRC-terminating IAB-donor, it may use the legacy XnAP Transport Migration Management procedure toward the RRC-terminating IAB-donor to offload its F1-traffic to the mobile IAB-MT's backhaul for UEs handed over. Equivalently, in case the source F1-terminating IAB-donor is different from the RRC-terminating IAB-donor, it may use the legacy XnAP Transport Migration Management procedure toward the RRC-terminating IAB-donor to request release of F1-traffic from the mobile IAB-MT's backhaul for UEs handed over.

During concurrent operation of two logical mobile IAB-DUs, the BAP sublayer may obtain mapping configurations from both F1-terminating IAB-donors. For an F1 packet, the mobile IAB-node selects a mapping configuration associated with the F1 packet's logical mobile IAB-DU. For non-F1 packets, the mobile IAB-node can select between configurations received from both IAB-donors based on implementation.

The mobile IAB-DU migration procedure may be triggered by the mobile IAB-node's OAM or by the source F1-terminating IAB-donor. The entity triggering the mobile IAB-DU migration also provides the information of the target F1-terminaing IAB-donor. During the target logical mIAB-DU's F1 Setup procedure, the NCI of the target logical mIAB-DU's served cell may be reconfigured by the F1-terminating IAB-donor-CU as described for network integration above.

2.1.4 Mobile-IAB-specific authorization

The mobile IAB-specific authorization procedure was defined jointly with SA2.

The core network supports a separate authorization procedure for mobile IAB-nodes. The mobile IAB-MT includes its intention to operate as mobile IAB-node in the RRCSetupComplete message. Based on this indictor, the RRC-terminating IAB-donor selects a mobile-IAB-specific AMF and forwards the mobile-IAB-specific indicator to the AMF, which then indicates the mobile-IAB authorization status to the RRC-terminating IAB-donor. The mobile-IAB authorization status may be "authorized" or "not authorized", and it may be changed by the AMF over time.

In case the mobile IAB-node is authorized for mobile-IAB operation, the RRC-terminating IAB-donor establishes the backhaul for the mobile IAB-MT, and the mobile IAB-DU connects to the F1-terminating IAB-donor. These steps follow the mobile IAB network integration procedure above.

In case the mobile IAB-node is not authorized for mobile-IAB operation, the RRC-terminating IAB-donor omits the establishment of the backhaul for the mobile IAB-MT, and F1 is not established either.

In case the mobile IAB-node's authorization status is changed from "authorized" to "not authorized", the F1-terminating IAB-donor performs an orderly release of F1 (including handover of UEs to other cells). After that, the RRC-terminating IAB-donor releases the mobile IAB-MT's backhaul, and subsequently informs the AMF about the completion of all steps for mobile IAB-node deauthorization.

The AMF also sends information on the mobile IAB's authorization status to the mobile IAB-MT via NAS.

2.1.5 Mobile-IAB-aware UE location update

These enhancements were defined jointly with SA2.

To allow the AMF to identify the location of a UE connected to a mobile IAB-node, the mobile IAB-MT's ULI is included in the UE's ULI update in the AMF. In case RRC-terminating and F1-terminating IAB-donors are different, the mobile IAB-MT's ULI information is passed from the RRC-terminating IAB-donor to the F1-terminating IAB-donor.

2.1.6 UE positioning using a mobile TRP hosted by a mobile IAB-node

These enhancements were defined jointly with SA2.

Mobile IAB supports UE positioning with a mobile TRP, which belongs to a mobile IAB-DU. The LMF can request information on mobile TRPs from the IAB-donor via NRPPa. This information includes the location of the mobile TRPs. The location of a mobility TRP is further included in UE positioning reports to the LMF.

2.2 Enhancements for Rel-18 UEs onboard of a vehicle hosting a mobile IAB-node

2.2.1 RACH-less handover

During mobile-IAB-DU migration, the UE can perform RACH-less handover between source and target logical mobile IAB-DU. For RACH-less handover, the timing advance at the target and the source cells is assumed to be the same. The indication for RACH-less handover and the beam to be used at the target cell is provided to the UE in the handover command. At the target cell, UL grant can be configured or dynamically allocated.

2.2.2 Inter-frequency cell-reselection prioritization of mobile IAB cells

Rel-18 UEs can identify a mobile-IAB cell based on the mobile-IAB cell indicator broadcast by this cell in SIB1. A UE that is onboard of a vehicle may further prioritize mobile-IAB cells for inter-frequency cell-reselection. For this purpose, the network can provide assistance information in SIB4 on frequencies and PCI values used by mobile-IAB cells. It is up to implementation how the UE identifies whether it is onboard of a vehicle.

2.3 RF and RRM requirements

RAN4 objectives as captured in [1] aim at studying impacts on RF and RRM requirements, and to conduct co-existence study to assess the impact of moving cells. Based on the study outcome, RAN4 was expected to specify RF and RRM requirements and mechanisms for the mIAB-node to enable co-existence, if needed as well as specify RRM requirements for the mIAB-node to enable IAB-node mobility, if needed. For both RF and RRM requirements, RAN4 has agreed to add a new section in TS 38.174 to capture mobile-IAB nodes new requirements.

From RF perspective, RAN4 has conducted adjacent channel co-existence study, taking into consideration the mobility of the mobile-IAB nodes and has concluded that legacy ACLR/ACS requirements from Rel-16 IAB nodes can be reused for mobile IAB nodes. Additionally, to account for the possible close proximity of mobile-IAB-MTs within the network, RAN4 agreed to specify the mobile-IAB-MT output power equal to the legacy Local-area IAB output power and to employ a UE-like dynamic range for the mobile-IAB-MT nodes.

From RRM perspective, RRM requirements for mobile-IAB-MT have been agreed in RAN4 and added to TS 38.174 as highlighted in [2]. Generally, mobile-IAB-MT has been perceived from RRM point of view similar to a legacy UE interacting within the network. Accordingly, UE RRM requirements, such as signalling characteristics and general measurement requirements have been reused for mobile-IAB-MT.

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941009,941109,941209

27.4 Further NR coverage enhancements

940095	**Further NR coverage enhancements**	**NR_cov_enh2**		RP-221858	**Nanxi LI, China Telecom**
940195	Core part: Further NR coverage enhancements	NR_cov_enh2-Core	R1	RP-221858	**Nanxi LI, China Telecom**
940295	Perf. part: Further NR coverage enhancements	NR_cov_enh2-Perf	R1	RP-221858	**Nanxi LI, China Telecom**

Summary based on the input provided by CMCC in RP-233439.

Coverage is one of the key factors that an operator considers when commercializing cellular communication networks due to its direct impact on service quality as well as CAPEX and OPEX. In Rel-17 work item 900061 "NR Coverage Enhancements" [1], NR coverage has been extended for some of the bottleneck channels identified in the Rel-17 study

item 860036 “Study on NR coverage enhancements” [2], in particular for PUSCH, PUCCH and Msg3. However, not all needs for coverage enhancement have been addressed by the Rel-17 WID, due to its limited scope. This work item [3] specifies PRACH coverage enhancement, power domain enhancement and enhancement to support dynamic waveform switching.

The following key functionalities are introduced as part of the Work Item:

- **PRACH coverage enhancement**

PRACH repetitions with the same Tx beam is introduced for 4-step RACH procedure. When one or multiple values of {2,4,8} are configured by the gNB for the number of PRACH repetitions, UE determines the number of repetitions based on SSB-RSRP threshold(s) for the first RACH attempt. If the number of PRACH repetitions is determined as 1 (i.e., single PRACH transmission) for the first RACH attempt, when the RACH attempt fails, UE can only perform single PRACH transmissions in re-attempts. If the number of PRACH repetitions is determined as larger than 1 for the first RACH attempt, when the RACH attempt fails, UE can increase the number of PRACH repetitions in re-attempts when certain condition is satisfied. For *N* PRACH repetitions, UE selects a set of *N* valid PRACH occasions (ROs) to transmit the PRACH with a same preamble, where the *N* valid ROs are consecutive in time, with the same frequency resources, and are associated with a same SSB. The whole *N* PRACH repetitions are deemed as one RACH attempt.
A time period, starting from frame 0, is introduced to determine the set(s) of ROs for PRACH repetitions. A time period is the smallest integer number of association pattern periods such that at least one set of valid ROs for each of the transmitted SSB indexes can be determined within the time period for all configured number of PRACH repetitions. The set(s) of valid ROs for each configured number of PRACH repetitions then repeats every time period.
Within a time period, for set(s) of *N* valid ROs associated with the same SSB for PRACH repetitions, and for each frequency resource index for frequency multiplexed PRACH occasions, the first valid RO of the first set is the first valid RO; if a RRC configured parameter *TimeOffsetBetweenStartingRO* is provided, the first valid PRACH occasion of subsequent sets, if any, is after *TimeOffsetBetweenStartingRO* consecutive valid ROs associated with the same SSB in time from the first valid RO of the previous set; if *TimeOffsetBetweenStartingRO* is not provided, the first valid PRACH occasion of subsequent sets, if any, is after the ROs of the previous set.
The feature of PRACH repetitions is supported for CBRA and *ReconfigurationWithSync* case for CFRA.

- **Enhancements to realize increasing UE power high limit for CA and DC**

Reporting the parameter $\Delta P_{\mathrm{PowerClass}}$ is introduced for FR1 deployments, on a per cell basis. Such reporting occurs whenever duty cycle is exceeded or advertised power capabilities are restored at the UE and may allow network to adjust attainable output power calculation for a given power class. A legacy PHR format carries the reporting, by reusing the 2 bits used for MPE reporting. $\Delta P_{\mathrm{PowerClass}}$ (valid and applicable for single band with single CC operation) or its variations, e.g., $\Delta P_{\mathrm{PowerClass,CA}}$ (for NR CA), is indeed used to cap lower and higher limit of configured transmitted power of P_{CMAX} (per serving cell) or those of P_{CMAX} (per aggregated cells), respectively. Specifically for the higher limit of the configured transmitted power, $\Delta P_{\mathrm{PowerClass}}$ et al. are the only parameters which are not configurable by network and must be known to calculate the corresponding higher limit of the configured transmitted power. For instance, for single band with single CC operation case,

$$P_{\mathrm{CMAX\_H,f,c}} = min\{P_{\mathrm{EMAX,c}}, P_{\mathrm{PowerClass}} - \Delta P_{\mathrm{PowerClass}}\}$$

where $P_{\mathrm{EMAX,c}}$ is configurable by network and $P_{\mathrm{PowerClass}}$ can be known by network since it is reported as UE capability of *ue-PowerClass* or its extension. Here, reporting $\Delta P_{\mathrm{PowerClass}}$, whose value can be 0, 3 or 6 dB, allows the network to have more precise information about the higher limit of the configured transmitted power at the UE.
For example, assume a PC 1.5 device, for which $P_{\mathrm{PowerClass}} = 29$ dBm, being configured with $P_{\mathrm{EMAX,c}} = 29$ dBm. Since $\Delta P_{\mathrm{PowerClass}}$ may be as high as 6 dB, e.g., due to satisfying regulation like SAR when scheduled uplink symbols % is too high, the $P_{\mathrm{CMAX\_H,f,c}}$ can be as low as 23 dBm. It is, however, not possible for the network to be aware of when the UE sets $\Delta P_{\mathrm{PowerClass}}$ from 0 dB to 6 dB since the evaluation period, start and end timing of the evaluation is up to UE implementation. Given that the attainable power is one of the most important information for the network, the introduction of a scheme to allow UE to inform network of the value is beneficial at least when the scheme is configured and triggered by the network.

- **Enhancements to reduce MPR/PAR, including frequency domain spectrum shaping**

MPR reduction is introduced by allowing 1dB power boosting with and without frequency domain spectrum shaping for both pi/2 BPSK and QPSK with PC3 as well as PC2. Specifically, the reference power at the UE is increased equivalent to the power boost while the allowed MPR values are maintained. Such MPR reduction is currently available for the inner allocations with frequency domain spectrum shaping and accompanying spectrum flatness requirement relaxation as well as for a subset of the inner allocations with no frequency domain spectrum shaping and spectrum flatness requirement relaxation.

- **Dynamic waveform switching between DFT-S-OFDM and CP-OFDM**

Dynamic waveform indication is introduced to allow the network to set the most beneficial waveform (e.g., DFT-S-OFDM waveform is beneficial for coverage, while CP-OFDM waveform is beneficial for capacity) considering the UE

coverage situation without requiring RRC reconfiguration. The indication is applicable to PUSCH dynamically scheduled by DCI format 0_1 or 0_2 and is realized by introducing a transform precoder indicator field in these DCI formats, where transform precoder enabled or disabled corresponds to DFT-S-OFDM or CP-OFDM waveform, respectively.
In addition, reporting of configured maximum power for assumed PUSCH is introduced to assist the network in determining whether to change the waveform. The assumed PUSCH is with CP-OFDM waveform if the actual PUSCH is with DFT-S-OFDM waveform, and vice-versa. Two new MAC CEs are introduced for reporting this information together with legacy power headroom information of the actual PUSCH within a single entry PHR format or a multiple-entry PHR format.

References

List of related CRs: select "TSG Status = Approved" in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940095,940195,940295

27.5 NR demodulation performance evolution

950073	**NR demodulation performance evolution**	**NR_demod_enh3**		RP-232685	**Jingzhou Wu, China Telecom**
1001061	Core part: NR demodulation performance evolution	NR_demod_enh3-Core	R4	RP-232685	**Jingzhou Wu, China Telecom**
950273	Perf. part: NR demodulation performance evolution	NR_demod_enh3-Perf	R4	RP-232685	**Jingzhou Wu, China Telecom**

Summary based on the input provided by China Telecom in RP-233585.

This work item introduced new UE demodulation requirements, and the corresponding new features and network assistant signalling for UE side are introduced in the WI.

This section provides a summary of the requirements introduced in Rel-18 NR demodulation performance evolution WI.

Objective #1: Advanced receiver to cancel inter-user interference for MU-MIMO.

o Within the phase I study [2], MU-MIMO scenario with gNB transmits PDSCH to the paired UEs through the same time-frequency resources is evaluated and both E-MMSE-IRC and R-ML are evaluated as candidate advanced receivers [3]. The required information for both E-IRC and R-ML receiver is also studied in the phase I. RAN4 has agreed the network default configuration assumptions. Therefore, the advanced receiving algorithm can be performed under these default assumptions. For some of the default assumptions, it is required for the network to indicate the UE whether the default assumption is valid or not by RRC signalling. For UE with R-ML receiver, DCI based network assistant signalling is required. Link level simulation evaluation verifies the performance gain of R-ML receiver over the baseline MMSE-IRC receiver.

o Based on the phase I study outcome, the phase II work is conducted to introduce the network assistant signalling for the selected R-ML based advanced receiver for MU-MIMO. The network assistant signalling design is captured in [4, 7-8]. As an outcome, the network assistant signalling the new DCI and RRC based network assistant signalling is introduced in [9-10] and the corresponding basic UE feature design is captured in an LS [11].

Objective #2: The absolute physical layer throughput requirements with link adaptation is introduced in [12]. 2T2R and 2T4R is covered in the requirement definition and HARQ re-transmission is enabled in the test. Outer loop link adaptation (OLLA) at the BS side is not considered in the test [13].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940095,940195,940295

[1] RP-232685 Revised WID: NR demodulation performance evolution China Telecom
[2] TR 38.878 NR demodulation performance evolution
[3] R4-2302929, WF on advanced receiver for MU-MIMO scenario, China Telecom
[4] R4-2309892, WF on advanced receiver for MU-MIMO scenario, China Telecom
[5] R4-2309895, LS on required DCI signalling for advanced receiver on MU-MIMO scenario, Huawei, China Telecom, Qualcomm
[6] R4-2311098 Simulation result collection for advanced receiver for MU-MIMO China Telecom

[7] R4-2315980 Reply LS on required DCI signalling for advanced receiver on MU-MIMO scenario Huawei, China Telecom, Apple
[8] R4-2316980 LS on network assistant signalling for advanced receivers Nokia
[9] R1-2312775, Introduction of Rel-18 NR demodulation performance evaluation, Huawei
[10] R2-2313704, Introduction of network RRC signalling for advanced receiver CATT, China Telecom
[11] R4-2321823 LS on RAN4 UE feature list for Rel-18 (version 2) CMCC
[12] R4-2307627 Big CR on ATP requirements China Telecom
[13] R4-2302930 WF on absolute physical layer throughput requirement, Intel Corporation

27.6 NR channel raster enhancement

991045	**NR channel raster enhancement**	**NR_channel_raster_enh**	**R4**	RP-230813	**Christian Bergljung, Ericsson**
991145	Core part: NR channel raster enhancement	NR_channel_raster_enh-Core	R4	RP-231469	**Christian Bergljung, Ericsson**

Summary based on the input provided by Ericsson in RP-234071.

A UE-specific channel bandwidth and location can be configured within a gNB channel bandwidth by the serving cell configuration of the RRC. However, this is not always possible in operating bands with 100 kHz channel raster granularity with gNB and UE channel bandwidth locations restricted to this channel raster.

In this WI an enhanced channel raster with a finer 10 kHz granularity was specified for the gNB and UE in operating bands with a 100 kHz channel raster such that requirements are specified for all possible UE-specific bandwidths and locations within a wider gNB channel bandwidth for both TN and NTN. Then configuration of a narrower UE channel bandwidth inside a wider gNB channel bandwidth is always possible for UEs supporting the enhanced channel raster.

The objective of the WI was to specify necessary changes to the channel raster such that configuring a narrower UE channel bandwidth inside a wider gNB channel bandwidth is always possible [1].

A UE-specific channel bandwidth and location can be configured within a gNB/SAN channel bandwidth with physical resource block (PRB) granularity by the serving cell configuration of the RRC. Requirements for these channel bandwidths are specified for bandwidths centred on the channel raster for NR as per the 38.101-1, 38.101-2, 38.101-5, 38.104 and 38.108 for TN and NTN.

The above implies that gNB/SAN and UE-specific channel bandwidth locations must be both PRB aligned and with centre frequencies separated by a multiple of the channel raster granularity for requirements to apply. This is not always possible for operating bands with 100 kHz channel raster granularity (bands below 3 GHz). If the gNB/SAN carrier bandwidth (in MHz) has an even/odd transmission bandwidth configuration (maximum number of PRBs within the channel bandwidth) and the narrower UE specific channel bandwidth (MHz) has an odd/even maximum transmission bandwidth configuration (TS 38.101-1 subclause 5.3.2), the UE specific bandwidth cannot be configured as shown in Figure 1 for 15 kHz numerology, the gNB/SAN and UE channel bandwidths cannot both be PRB aligned and separated by a multiple of 100 kHz. BWPS denotes an active bandwidth part to be contained within the UE-specific channel bandwidth.

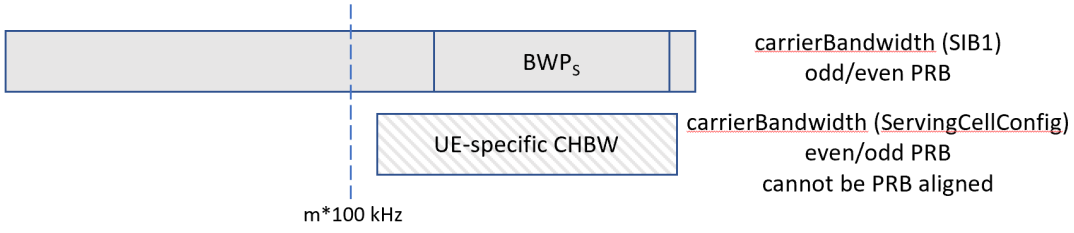


Figure 1: a narrower UE-specific channel bandwidth within a wider gNB/SAN bandwidth.

The problem was solved by introducing in the UE specifications [2,3] an enhanced channel raster with a finer 10 kHz granularity, then gNB/SAN and UE channel bandwidths can be both PRB aligned and separated by a multiple of 10 kHz for all channel bandwidths. An enhanced channel raster with a 10 kHz granularity was also introduced for the gNB/SAN in [4,5]. Then configuration of a narrower UE channel bandwidth inside a wider gNB/SAN channel bandwidth is always possible and without restrictions.

Support of the enhanced channel raster is subject to per-band UE capability applicable for bands with a 100 kHz channel raster.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940095,940195,940295

[1] RP-234025, Revised WID: Channel raster enhancement, Ericsson
[2] R4-2321749, Introduction of an enhanced channel raster, Nokia, Nokia Shanghai Bell
[3] R4-2318412, Enhanced channel raster for NTN bands, Apple, Ligado Networks, Inmarsat, Viasat, Globalstar, Thales, Hughes/Echostar
[4] R4-2321750, CR to TS38.104: Introduction of an enhanced channel raster, ZTE Corporation
[5] R4-2321751, CR to TS 38.108: Introduction of an enhanced channel raster, Huawei, HiSilicon

27.7 BS/UE EMC enhancements for NR and LTE

950072	**BS/UE EMC enhancements for NR and LTE**	**NR_LTE_EMC_enh**		RP-220916	**Aurelian Bria, Ericsson**
950172	Core part: BS/UE EMC enhancements for NR and LTE	NR_LTE_EMC_enh-Core	R4	RP-220916	**Aurelian Bria, Ericsson**
950272	Perf. part: BS/UE EMC enhancements for NR and LTE	NR_LTE_EMC_enh-Perf	R4	RP-220916	**Aurelian Bria, Ericsson**

Summary based on the input provided by Ericsson in RP-233684.

The current RAN4 UE EMC specifications TS 38.124 (NR) and TS 36.124 (E-UTRA) only specify general requirements as single carrier cases. The requirements for a user terminal (UE) supporting different features are not considered. The objective of this WI was to enhance the EMC test specifications with support for such features.

On the Base station side, current testing of EMC requirements as specified in TS 37.113 (MSR BS) or TS 37.114 (AAS BS) is increasingly complex and considers many test configurations, due to various possible radio access technologies (RAT) combinations. For example, the TCs for MSR BS are defined in TS 37.141 and include 19 different capability sets (including 3 of single mode condition: WCDMA, LTE and NB-IoT standalone), which cover the possible RAT combinations available in an MSR BS. The objective of the WI was to find ways to reduce the number of tested CS for an MSR BS and AAS BS without compromising on the compliance requirements.

UE EMC

Only CA and DC for E-UTRA UE and NR UE were considered to be in the scope of the work.

The outcome of this WI was an optimization of the DC and CA test cases, in case when multiple band combinations are supported:

- For UE supporting E-UTRA and multiple CA or DC band combinations, only one band combination with the largest frequency span (i.e. lowest frequency to highest frequency for the supported band combination) is selected for testing for emission tests, besides radiated emissions [1].

- For UE supporting NR one band combination with the largest frequency span (i.e. lowest frequency to highest frequency for the supported BC) is selected for each supported frequency range (i.e. FR1 only, FR1+FR2, FR2 only) for conducted immunity tests and conducted emission tests [2].

BS EMC

The outcome of the WI was the reduction in number of RATs considered for immunity testing, for MSR BS and AAS BS, given that signals belonging to the supported RATs are processed in common active components, especially in the digital unit of the BS.

Currently, the tests performed on a Base Station according to a declared Capability Set shall cover all single RAT and multi-RAT configurations included in the declared Capability Set. We agreed that an exception can be made only for immunity testing, based on a number of additional manufacturer declarations, which identifies the cases when common active components are utilized for processing signals belonging to several RATs. In such cases it is sufficient to consider a reduced set of RATs for immunity testing, as described in a new normative annex [3][4].

The set of RATs which are considered sufficient for the immunity testing purposes depends on the BS hardware capabilities declared by the manufacturer, as mentioned above. The following RAT combinations were identified as candidates for the immunity testing simplification:

- For MSR/AAS BS declared to support E-UTRA and UTRA, UTRA does not have to be configured.
- For MSR/AAS BS declared to support NR and UTRA, UTRA does not have to be configured.
- For MSR BS declared to support NB-IoT and GSM, GSM needs not to be configured.

By eliminating GSM and UTRA from the set of RATs we minimize the number of CSs that are sufficient to be tested for demonstrating compliance.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950072,950172,950272

[1] R4-2320381 CR to 36.124: CR to 36.124: EMC requirements simplifications for CA and DC combinations, Rel-18, Huawei (RAN4#109)
[2] R4-2321069 CR to 38.124 on R18 UE EMC requirements for CA and DC combinations, Xiaomi (RAN4#109)
[3] R4-2321067 CR to TS 37.113: Implementation of EMC enhancement, Ericsson, Nokia, ZTE Corporation, Huawei (RAN4#109)
[4] R4-2321068 CR to TS 37.114: Implementation of AAS BS testing simplifications, Huawei, Ericsson, Nokia, ZTE Corporation (RAN4#109)
[5] RP-233683 Status report for WI on BS/UE EMC Enhancements for NR and LTE (RAN#102)
[6] RP-233689 Revised WID on BS/UE EMC Enhancements for NR and LTE (RAN#102)

27.8 Enhancement on NR QoE management and optimizations for diverse services

941008	**Enhancement on NR QoE management and optimizations for diverse services**	**NR_QoE_enh**		RP-223488	**Pei Li, China Unicom**
941108	Core part: Enhancement on NR QoE management and optimizations for diverse services	NR_QoE_enh-Core	R3	RP-223488	**Pei Li, China Unicom**
940032	*Study on Key Quality Indicators (KQIs) for 5G service experience*	FS_KQI_5G	S5	SP-211433	**Man WANG, Huawei**

Summary based on the input provided by China Unicom in RP-233604.

This WI specifies the enhancements of NR QoE functionalities, including supporting for new communication service type for MBS, and enabling the QoE measurement collection function in RRC_INACTIVE and RRC_IDLE state. QoE in NR-DC scenario and the continuity of legacy QoE measurement job for streaming and MTSI service for intra-5GC inter-RAT handover procedure is also supported. Furthermore, the Rel-17 left-over features and enhancements, e.g. RAN visible QoE Report deactivation over F1, are also supported in this release.

In the WI, the QoE Measurement Collection function supports collection of QoE measurements for MBS communication service. The measurement collection is designed to support for the two communication service types, MBS broadcast and MBS multicast.

QoE measurement collection for application sessions delivered via MBS broadcast communication service is supported in RRC_CONNECTED, RRC_INACTIVE, and RRC_IDLE states, which enables MBS broadcast QoE measurements to be proceeded when the UE moves from RRC_IDLE/RRC_INACTIVE to RRC_CONNECTED states. QoE measurement collection for the application sessions delivered via MBS multicast communication service is supported for RRC_CONNECTED state. When the UE camps on RRC_IDLE state, the UE keeps the QoE configurations which is received in RRC_CONNECTED state or which is stored in RRC_INACTIVE state in the AS layer. The UE is responsible to store the network instance of QoE configuration when UE stay in the RRC_IDLE state, then when UE moves to RRC_CONNECTED state, the UE will send the QoE report via the re-connecting NG-RAN node.

QoE measurement collection for high mobility scenario is also discussed and supported in a flexible solution, e.g. OAM collects QoE report in high mobility scenario. The QoE measurement procedure can be confined to high mobility state of UE and HSDN cells.

The QoE configuration, and measurement reporting via MN or SN for NR-DC architecture is supported in R18 QoE as well as the RAN visible QoE collection. The reporting leg (MN or SN) can dynamically switch according to the RAN

side indication in the RAN overload scenario. The RAN optimization for MN/SN node is supported by RVQoE collection in MN/SN accordingly. The continuity of QoE measurement configuration and reporting in NR-DC scenario is supported when the MN/SN changes.

QoE measurement collection continuity for intra-system inter-RAT handover is supported. For the handover from NR to LTE, one QoE measurement can be continuous during the handover procedure. The source gNB can decide to select one QoE measurement configuration, and then sends this QoE measurement configuration to target ng-eNB.

For the R17 leftover issues, the enhancements of RVQoE report impacts on Uu and F1 interface. The QoS flow ID and the PDU session ID shall be transferred over the Uu interface for RAN side optimization. The RVQoE deactivation procedure in F1 interface is also supported for QoE information transfer control procedure from gNB-CU to gNB-DU. For the assistance information from OAM, gNB may utilized this information to decide whether pause/resume the measurement reporting of certain QoE measurement configurations in case of RAN overload.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941008,941108

27.9 Additional NRM features phase 2

950031	**Additional NRM features phase 2**	AdNRM_ph2	S5	SP-220351	**Sean Sun, Nokia**

Summary based on the input provided by Nokia, Nokia Shanghai Bell in SP-240071.

This WID was the continuation of Additional NRM features work item from Release 17. It focused on following main topics:

- Enhance NRM to support features, including architecture enhancements for the support of 5G core System Enhancement, fill the gap of 5GC NRM, enhancement for NR and slice NRM related to misalignment with GSMA NG.116 and inconsistencies in Network slice NRM.

- Migrate normative YANG and YAML code to Forge.

More precisely, it extends the 5G Network Resource Model to support several new features of 5G Core (5GC), NG Radio Access Network (NG-RAN) and Network Slice, together with enhancements of the stage 3 Solution Set (SS):

- Support of 5GC features. 5GC NRM is extended to support the configuration of 5G Core Function according to TS 29.510 [1], e.g 5G Core managed NFs Profile, UDR Function, UDM Function, PCF Function, NSSF Function, UPF Function, NSSAAF Function, EASDF Function, AF Function, LMF Function, SMSF Function, UDSF Function, SEPP Function, SCP Function, NWDAF Function, NSACF Function, NEF Function, AUSF Function, DCC Function, MFAF Function, CHF Function, GMLC Function, TSCTSF Function, AANF Function, BSF Function, MBSMF Function, MBUPF Function, NRF Function, MNPF Function, enhanced data model for UpfInfo, NetInfo, AmfInfo, SmfInfo and related class diagram in TS 28.541 [2].

- Support of NG-RAN. The NG-RAN NRM is extended to support new or enhance existing features or functionalities. To support defining and associating sets of BWPs, a "BWPSet" IOC is added and existing "NRCellDU" NRM is enhanced. To support separation of 5QI definitions for deployments such as MOCN RAN Sharing, QoS NRM is enhanced by adding additional option to contain "Configurable5QISet". Refer to TS 28.541 [2].

- Support of Network Slice NRM.

  1) Added support for configuration of GSMA attributes related to data networks and non-IP sessions.

  2) Improved "EP_Transport" model to clarify connection point information. And improved LogicalInterfaceInfo model to add support of static route.

  3) Fixed inconsistencies related to network slice SLA attributes kPIMonitoring, availability, maxDLDataVolume and maxULDataVolume.

  4) Added support to Access network specific GST configuration.

  5) Added slice validity related attributed to support configuration of temporarily available network slices.

6) Added inter-packet delay variation related SLA attributes dLPktDelayVariation and uLPktDelayVariation. These attributes replaced jitter attribute.

Refer to TS 28.541 [2].

- To support scheduling tasks based on conditions, new NRM fragment for scheduler and condition monitor, e.g, two IOCs, "ConditionMonitor" and "Scheduler", and one "TimeInterval" DataType are added, refer to TS 28.622 [3] and TS 28.623 [4].

- YANG solution set is enhanced to support Files and File IOC, and OpenAPI Solution Set is enhanced to support "QMCJob" in TS 28.623 [4] and TS 28.541 [2].

- Following the revised stage 3 working procedure, normative stage 3 code for generic NRM and NR, 5GC, Slice NRM stage 3 are moved to 3GPP Forge. Refer to TS 28.623 [4], TS 28.541 [2] and TR 21.900 [5]. Please refer the below link for the SA5 Forge repository: https://forge.3gpp.org/rep/sa5/MnS .

References

[1] TS 29.510: "Network Function Repository Services Stage 3".
[2] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3"
[3] TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
[4] TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".
[5] TR 21.900: "Technical Specification Group working methods".
[6] List of related CRs: select "TSG Status = Approved" in: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950031

27.10 Further enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR and EN-DC

941007	**Further enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR and EN-DC**	**NR_ENDC_SON_MDT_enh2**		RP-221825	**Liang LIU, CMCC**
941107	Core part: Further enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR and EN-DC	NR_ENDC_SON_MDT_enh2-Core	R3	RP-231157	**Liang LIU, CMCC**
950064	UE Conformance - Enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR standalone and MR-DC (Multi-Radio Dual Connectivity)	NR_ENDC_SON_MDT_enh-UEConTest	R5	RP-232426	**Danni Song, CMCC**

Summary based on the input provided by CMCC in RP-233439.

This work item introduces data collection further enhancement in NR standalone and MR-DC for SON/MDT purpose, including SON/MDT enhancements for inter-RAT Successful Handover Report (inter-RAT SHR) and Successful PScell Change Report (SPR), MRO for MR-DC Conditional PSCell Change (CPC) and Conditional PSCell Addition (CPA), Fast MCG recovery, Inter-system handover voice fallback and MR-DC SCG failure, RACH Enhancements, SON/MDT Enhancements for Non-Public Networks (NPN), SON for NR-U and MDT Enhancements.

The key functionalities of this WI are described as below.

Inter-RAT SHR

Successful Handovers Reports (SHR) is reported by the UE to detect near-failure events happened during successful handovers. Intra-NR SHR is introduced in Rel-17, and SHR for intra-system inter-RAT is introduced in Rel-18.

Inter-RAT SHR from NR to LTE is treated first in Rel-18 and it can be triggered by T310/T312 thresholds provided by the source node. If a UE successfully handover from NR to LTE but the elapsed T310/T312 exceeds SHR trigger, it is considered to have a high risk of failure. UE generates Inter-RAT SHR including the parameters, e.g. Source NR cell informatio, Target LTE cell information, Measurement results for source, target and neighbours, Cause to indicate which inter-RAT SHR triggering condition was met, UE location Information, which are useful for network to optimize inter-RAT successful handover from NR to LTE. For handover from NR to LTE, cross-RAT reporting is not supported, that means UE can only report the SHR report (if available) to the network when it comes back to NR. Then the receiving node forwards the inter-RAT SHR to corresponding node which generates the SHR trigger condition that triggers the inter-RAT SHR.

Successful PScell Change Report (SPR)

The objective of Successful PSCell change Report (SPR) is to detect sub-optimal successful PSCell change/CPC or successful PSCell addition/CPA. For analysis of such sub-optimal successful PSCell change/CPC and successful PSCell addition/CPA, the UE generates SPR based on the SPR triggers configured by the network. SPR triggers could be T310/T312/T304 trigger and Successful PSCell change Report includes the information e.g. Source PSCell information, Target PSCell information, SPR cause value, Latest measurement results, Location information of the UE, Time elapsed between the CPAC execution and reception of CPAC configuration, etc. In case the SPR is retrieved in a “new node” (different from the node that sent the SPR configuration to the UE i.e., “old MN”), the SPR is always sent from the “new node” to the “old MN” which then forwards to the respective node(s) which should perform SPR related optimizations.

- For SN-initiated PSCell change/CPC, the source SN decides the T310/T312 triggers for SPR and is responsible for SPR related optimizations e.g., to optimize PSCell change/CPC configuration or associated mobility thresholds or adjust T310/T312 timer values.

- For MN-initiated PSCell change/CPC, the MN decides the T310/T312 triggers for SPR. MN may optimize PSCell change/CPC configuration or associated mobility thresholds or both. Source SN may optimize lower layer issues e.g., adjust T310/T312 timer values.

- For PSCell addition/CPA and PSCell change/CPC (MN or SN initiated), the target SN always decides the T304 trigger for SPR and performs root cause analysis. The objective of T304 SPR trigger is to optimize RACH access issues in target SN.

MRO for CPC and CPA(CPAC)

MRO for CPC and CPA is to detect CPAC failures that occur due to Too late CPC execution or Too early CPC/CPA execution, or CPC/CPA execution to wrong PSCell and to help network identify the problem node(e.g. MN, source SN or (candidate) target SN) in the procedure of CPAC.

When CPAC failure occurs, UE reports SCGFailureInformation message to MN, including Source PSCell info, Target PScell info, Latest radio measurements of neighbour cell(s), the type of the first triggered CPAC event and the time duration between the two triggered CPAC events if multiple events are configured. And then the MN performs the initial analysis when SCGFailureInformation is received from the UE e.g. whether it is CPA or CPC, if CPC whether it is MN initiated or SN initiated. For CPA or MN initiated CPC, the procedure is initiated by MN, and the possible problem node is MN or the (candidate) target SN. For SN initiated CPC, the procedure is initiated by source SN and the possible problem node is the source SN or the (candidate) target SN. After the root cause analysis, network identify the problem node and the relevant node should to make the optimization.

MRO for the fast MCG recovery

The fast MCG recovery feature introduced in Rel-16 aims to decrease the connection interruption time during radio link failure (RLF). For the successful Fast MCG recovery, UE in MR-DC does not trigger RRC re-establishment upon detecting an RLF. Instead, it suspends the MCG transmissions of all bearers and prepares an MCGFailureInformation message, containing the reason for failure and any available measurements at the time of failure. Then the UE sends the message to the network via the SCG. Upon receiving the MCGFailureInformation message from the UE, the MN determines the best action to address the MCG failure, for example, sends a reconfiguration to change the Primary Cell of the UE to a better cell to restore the MCG connectivity or an RRC release message to the UE to release the connection if no suitable target cell is determined.

MRO enhancement for fast MCG recovery is not to optimize the procedure defined in Rel-16, the intention is to avoid the failure of fast MCG recovery or near failure fast MCG recovery based on the information reported by the UE and exchanged among network interface. And the following scenarios are included in MRO enhancement for fast MCG recovery in Rel-18:

- Fast MCG recovery failure cases, i.e. SCG fails when the UE is undergoing fast MCG recovery (i.e. SCG failure happens while T316 is running), or the signalling delay is longer than the time the UE waits for the response (T316 expired), or the SCG fails or is deactivated yet before the UE sends the MCGFailureInformation.

- Fast MCG recovery near failure case, i.e. UE receives the response message from MN via SN while T316 is running which almost expires but not yet.

RLF report is enhanced to support MRO for fast MCG recovery. For fast MCG recovery failure cases, it is beneficial for the UE to report PSCell where SCG failure happened, the cause of the fast MCG recovery failure and also if the problem is SCG failure, the SCG failure type. For near failure case, UE reports the elapsed T316 between the transmission of MCGFailureInformation and receiving RRC reconfiguration or RRC release message and this PSCell identity in RLF report.

MRO for inter-system handover for voice fallback

Besides Inter-system handover from 5GS to EPS due to coverage, voice over NR with EPS Fallback includes an additional mobility trigger by which the UE falls back from NR to LTE during call establishment, in case not all feature for voice over NR are implemented in the UE or in case of temporary lack of radio resources in NR. In the previous releases, it has been specified SON solutions for MRO based on coverage, but failure of voice fallback is not involved. Therefore, the definition of Inter-system Mobility Failure for Voice Fallback, UE reporting and inter-node information exchange are specified in MRO for inter-system handover for voice fallback.

Inter-system Mobility Failure for Voice Fallback is that an RLF occurs shortly after a successful handover triggered due to Voice Fallback, or a failure occurs during an handover triggered due to Voice Fallback, from a cell belonging to an NG-RAN node to a cell belonging to an E-UTRAN node; the UE attempts to re-connect to a cell belonging to an E-UTRAN node, or an NG-RAN node. Source Cell ID , Failure Cell ID , Suitable Cell ID and UE RLF Report Container are included in inter-node information exchange in case Handover Report Type is Inter-system Mobility Failure during Voice Fallback, it is beneficial for NR node to optimize the configuration of handover for voice fallback.

MRO for MR-DC SCG failure

MRO for MR-DC SCG failure is to detect PSCell change failures that occur due to Too late PSCell change or Too early PSCell change, or Triggering PSCell change to wrong PSCell. SCG Failure Information Report message from UE is used for MR-DC SCG failure MRO. MN performs initial analysis to identify the node that caused the failure. The node responsible for the last PSCell change (the source SN, the last serving SN or the MN) performs the final root cause analysis, and may optimize PSCell change configuration or associated mobility thresholds.

RACH Enhancements

The revealed scenarios for RACH report optimization in Rel-18 includes the following,

- SN RACH report in MR-DC

- RACH report retrieval for CU-DU architecture

- RACH report Enhancement for RACH partitioning

For SN RACH report in MR-DC, UE reports the SN RACH report to the MN, and then MN sends the SN RACH report to SN. UE could report the recorded SgNB related RACH information to the current MN node for NR-DC case. And the node which received the information could send the SN related RACH report information to the SgNB(s). In order to help the network forward the report to the correct nodet, UE should report the PScell identity outside the RACH report. For (NG)EN-DC case, the UE can report NR RACH report (if available) and the NR cell identity list to the MN based on the network's request, and then the MN can forward the report to the corresponding NR cells.

For RACH report retrieval for CU-DU architecture, Rel-18 supports a network-based solution for RACH report retrieval over F1AP based on an indication from the gNB-DU to the gNB-CU of successful RACH procedures which are not known to the gNB-CU and defines a new class-2 F1AP message to indicate certain RACH occurrence(s) from gNB-DU to gNB-CU.

For RA Report Enhancements for RACH partitioning, RA report is enhanced to include feature combination related information and the addition of RACH partition configuration information. This information consists of the start preamble index and the number of preambles in the partition for which the RA Report was generated. This enables the NG-RAN to determine the RACH partition in use.

SON/MDT Enhancements for Non-Public Networks

A Non-Public Network (NPN) is a 5GS deployed for non-public use, including the following two types:

- a Stand-alone Non-Public Network (SNPN), i.e. operated by an NPN operator and not relying on network functions provided by a PLMN

- a Public Network Integrated NPN (PNI-NPN), i.e. a non-public network deployed with the support of a PLMN.

To enable the NPN feature supported in SON/MDT, the network configures a list of SNPN ID/CAG ID in MDT configuration to specify the area scope of MDT task, which may restrict MDT data collection only for some specific NPNs within the area scope. For the SON/MDT report retrieval mechanism, UE performs SNPN ID checking before sending the availability indication and transmitting the information for corresponding SON and MDT reports, upon the network requests for it.

SON for NR-U

NR-based access to unlicensed spectrum (NR-U) uses the NR protocol to provide access services in unlicensed spectrum as an extension and supplement to 5G NR. In the unlicensed spectrum, the gNB and the UE may apply Listen-Before-Talk (LBT) before performing a transmission on a cell, and when LBT is applied, the transmitter listens to/senses the channel to determine whether the channel is free or busy and performs transmission only if the channel is sensed free.

For Mobility Robustness Optimization, the network should separate the mobility related error from LBT-related ones to enable the gNB aware whether certain SON/MDT reports should be considered for optimization of mobility setting, while LBT failures may not related to mobility. A gNB may take into account the information regarding the LBT failures occurred during the handover execution for a specific UE, as detected by the UE for UL, and by the target gNB for DL. In the Handover Preparation procedure, the source gNB can request the target gNB to provide information on DL LBT failures at the target gNB during handover execution.

For Mobility Load Balancing, to enable the gNB aware the traffic load information of the UE in NR-U channel and allocate proper resource for the UE, NR-U channel load is taken into account, including DL/UL channel occupancy time percentage, DL/UL energy detection threshold, radio resource usage.

MDT Enhancements

Cross-RAT logged MDT reporting for signaling based logged MDT override protection is introduced in Rel-18 MDT Enhancements. Signaling based logged MDT override protection is to address the scenario where the signaling based MDT is configured in E-UTRAN when UE reselects to NR while logged measurements are collected or UE reselects to NR after logged measurements are collected and before uploading the logged MDT report. R17 NR signaling by the UE is reused to inform gNB whether signaling based MDT is configured even when it is configured by E-UTRA.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=941007,941107,950064

27.11 Self-Configuration of RAN Network Entities

940030	**Self-Configuration of RAN Network Entities**	RANSC	S5	SP-211431	**Hu, Yaxi, China Mobile**

Summary based on the input provided by China Mobile and Huawei in SP-240069.

This work item (RANSC) specifies the functionality for RAN NE self-configuration management and network configuration data handling to enable RAN NE self-establishment, as well as requirements need to be met to support this functionality.

Establishment of a new RAN NE in network by an autonomous way can greatly improve the efficiency of RAN deployment. It refers to the procedure of a new RAN NE automatically establishing when it is powered up and connects to the IP network, which includes:

- Network configuration data handling. It refers to the procedures to make the network configuration data (i.e. additional data used to generate the complete RAN NE configuration data) available to the RANSC MnS producer.

- Plug and connect to management system. It has been specified in Rel-17 PACMAN work item.

- Self-Configuration. RAN NE can be taken to a state ready to carry traffic using configuration in an automated manner.

The work item mainly focuses on concept, use cases, requirements and solutions for network configuration data handling and self-configuration management. There is one new specification (TS 28317 [1]) for RANSC is created correspond to this work item, covering stage 1, stage2 and stage3. This work item also removes network configuration data handling and self-configuration clauses for 5G from TS 28.313 and in which they are referred to the new specification TS 28.317.

Following content is specified in TS 28.317 [1].

1. The concept for Network configuration data handling and self-configuration management in the context of Service based management architecture (SBMA). Self-configuration management capability is needed to monitor the self-configuration process and provide the operator with this information (e.g. progress information). In addition, it allows the operator to control the execution of the self-configuration process.

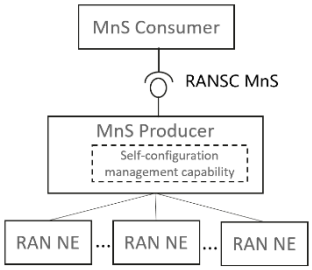


Figure 1 Example of deployment scenario for Self-configuration management

2. Use case and requirements for network configuration data handling and self-configuration management.

3. Stage2 solution for RANSC management service, including:

   - Management operations for self-configuration management

   - Information model definition for self-configuration management

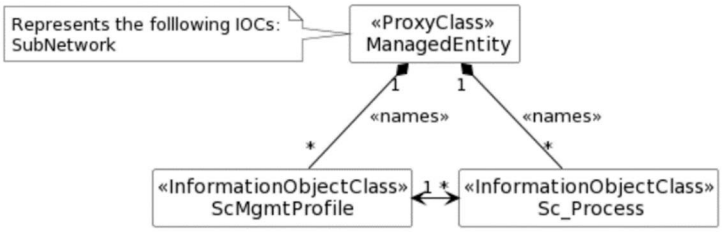


Figure 2: RANSC management information model

4. Stage 3 OpenAPI solution set for RANSC management service.

5. Procedure of Self-establishment is also provided for easy understanding and application of RANSC management service.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940030

[1] TS 28.317: "Management and orchestration; Self-configuration of Radio Access Network Entities (RAN NEs) v1.0.0"
[2] TS 28.313:"Management and orchestration; Self-Organizing Networks (SON) for 5G networks"

27.12 Enhancement of Shared Data ID and Handling

990004	**Enhancement of Shared Data ID and Handling**	ShDatID_H	CT4	CP-232030	JING, Hao, Huawei

Summary based on the input provided by Huawei in CP-240304.

Shared data is the subscription data shared among multiple subscirbers. The shared data mechanism is used to save the storage in the database and to reduce the signaling.

This work item introduce the enhancements of shared data, it is concluded to optimize the shared data retrieval procedure on Nudm_SDM Service operation for shared data identified by shared data IDs conveyed within AccessAndMobilitySubscriptionData

CT4 has introduced shared data concept since Release 15, by including Shared Data IDs as reference of individual subscription data type, for example, sharedAmData and sharedSmsMngSubsData. When the consumer of the Nudm_SDM service (e.g. AMF) retrieves AccessAndMobilitySubscriptionData from the UDM, it may detect that the retrieved data contains a shared data ID pointing to shared AccessAndMobilitySubscriptionData. If these shared AccessAndMobilitySubscriptionData are not yet available (i.e. cached) at the NF consumer, a second GET message to retrieve the shared AccessAndMobilitySubscriptionData from the UDM is required.

The second GET message can be avoided by retrieving both the AccessAndMobilitySubscriptionData and the shared AccessAndMobilitySubscriptionData with a single GET request by adding shared data IDs as a query parameter to the GET request.

In summary, it is concluded that the extra signalling to retrieve shared AccessAndMobilitySubscriptionData is optimized as defined in TS 29.503 [1].

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990004

[1] TS 29.503: "Unified Data Management Services".

27.13 Message Service within the 5G system Phase 2

990116	**Message Service within the 5G system (MSGin5G) Phase 2**	**5GMARCH_Ph2**		SP-220330	**Liu, Yue, China Mobile**
950026	**Stage 2 of 5GMARCH_Ph2**	5GMARCH_Ph2	S6	SP-220330	**Liu, Yue, China Mobile**
990019	CT1 aspects of 5GMARCH_Ph2	5GMARCH_Ph2	C1	CP-230198	**Liu, Yue, China Mobile**
990099	CT3 aspects of 5GMARCH_Ph2	5GMARCH_Ph2	C3	CP-230198	**Liu, Yue, China Mobile**
990041	**Security aspects of MSGin5G Ph2**	5GMARCH_Ph2_SEC	S3	SP-230154	**Huang Xiaoting, China Mobile**

Summary based on the input provided by China Mobile in SP-240798.

The WI "Application Architecture for MSGin5G Service Phase 2 (5GMARCH_Ph2)" is specified in TS 23.554 [1] in order to enhance the MSGin5G service, i.e. messaging communication in 5GS especially for Massive Internet of Things (MIoT), introduced in Rel-17 5GMARCH WI. The related stage 1 service level requirements are specified by Rel.16 WI 5GMSG in TS 22.262 [2].

The following aspects are specified in Rel.17 for the support of MSGin5G service:

- functional architecture, procedures, information flows and APIs for MSGin5G Service are specified in TS 23.554 [1];
- security aspects of MSGin5G Service are specified in Annex Y of TS 33.501 [3];
- the related detailed procedures over CoAP protocol between MSGin5G Client and MSGin5G Server are specified in TS 24.538 [4];and
- the RESTful APIs provided by MSGin5G Server towards the Application Server and Message Gateway is specified in TS 29.538 [5].

Figure 1 shows the application architecture of the MSGin5G service.

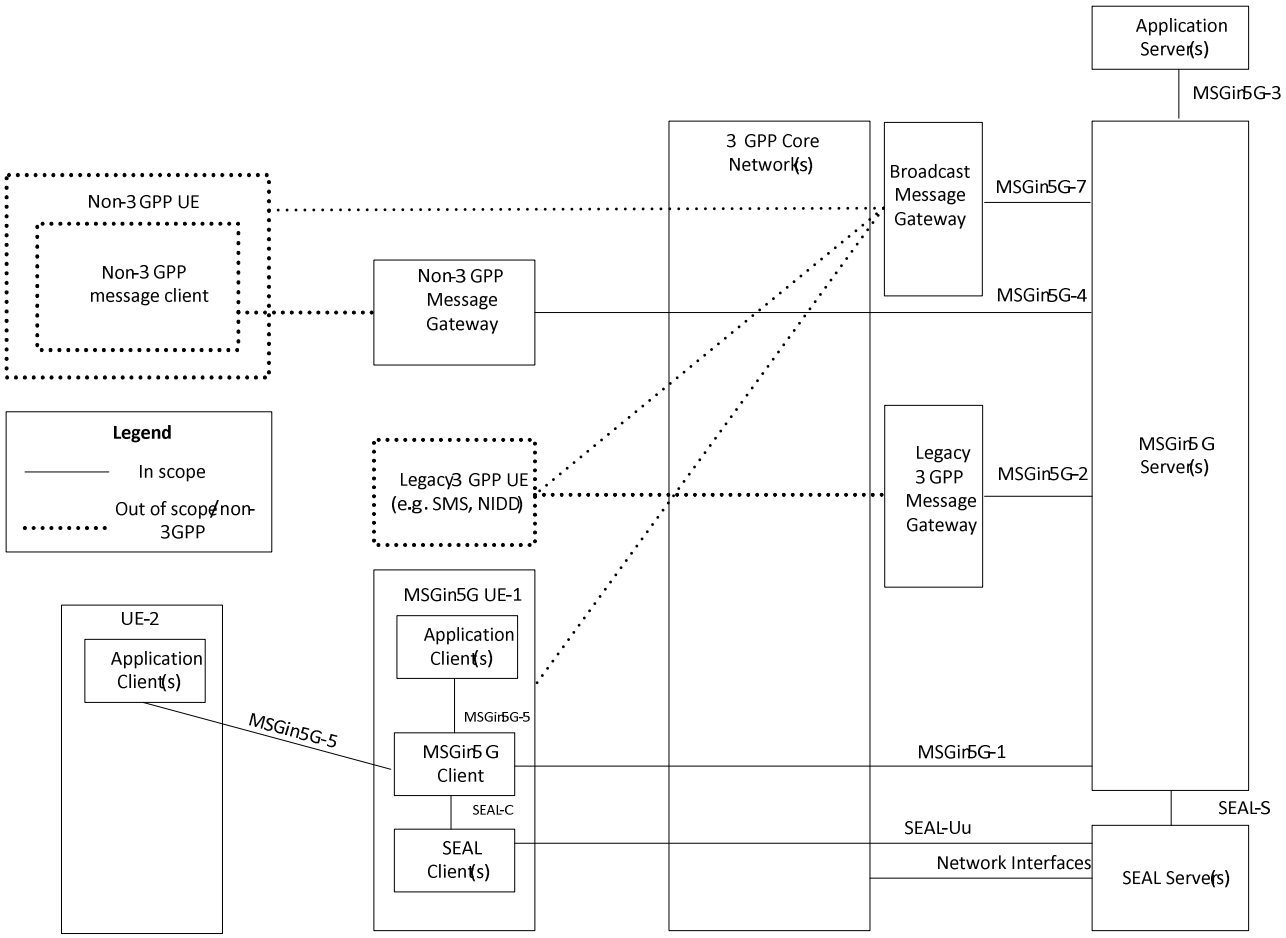


Figure 1: Application Architecture of the MSGin5G Service

Figure 2 shows the application architecture of MSGin5G UE-2 using an UE-1 as a relay. The SEAL Client(s) residing on the UE-1 also acts as relay for the SEAL Client(s) residing on the MSGin5G UE-2 as specified in TS 23.434 [6].

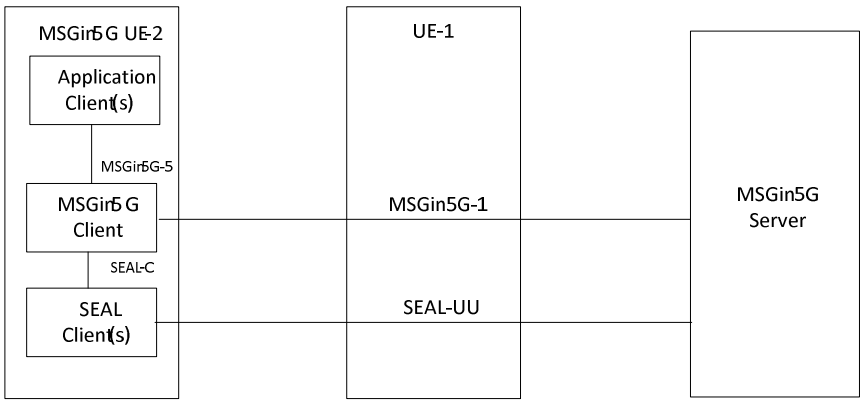


Figure 2: MSGin5G UE-2 using UE-1 as a relay

Figure 3 shows the application architecture of MSGin5G UE-2 with MSGin5G Client interacts with an MSGin5G Gateway UE over the MSGin5G-6 reference point. The SEAL Client(s) residing on the UE-2 communicates with the SEAL Client(s) residing on the UE-1 via SEAL-PC5 reference as specified in TS 23.434 [6].

NOTE: Both MSGin5G Client functionality and MSGin5G Gateway service functionality are internal functionalities of MSGin5G Gateway Client. The interaction between MSGin5G Client functionality in the MSGin5G Gateway Client and the MSGin5G Gateway service functionality is implementation specific.

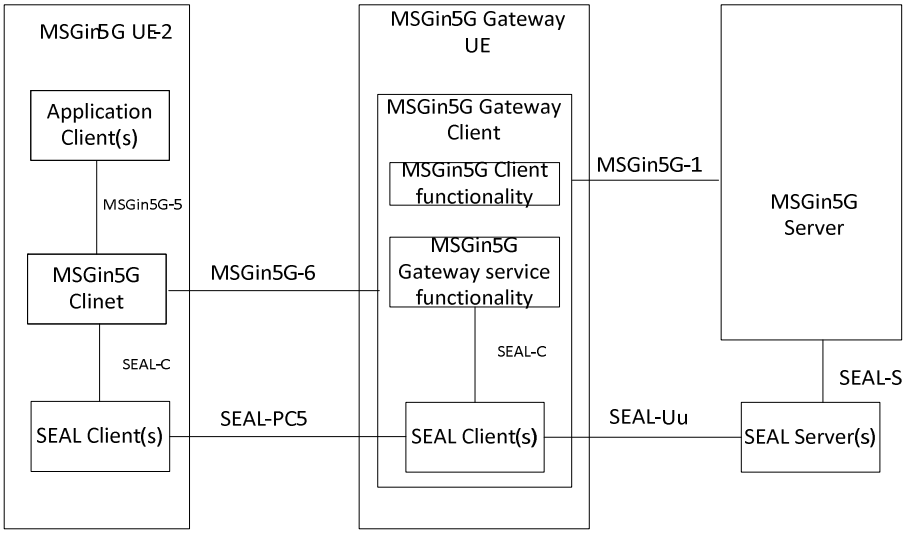


Figure 3: MSGin5G UE-2 with MSGin5G Client interacts with an MSGin5G Gateway UE

Figure 4 illustrates the functional model for interconnection between MSGin5G servers.

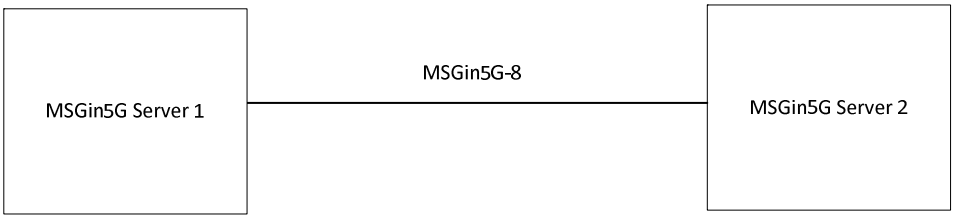


Figure 4: Interconnection between MSGin5G Servers

In addition to the architecture and features specified in Rel-17, the following aspects are enhanced in Rel-18:

- the procedures in multiple MSGin5G Server scenario, i.e. the sender and receiver of message are served by different MSGin5G Servers. The sender and the receiver can be in the same PLMN or different PLMNs. The procedures include the message delivery based on Messaging Topic works in this scenario;
- bulk configuration and bulk registration for UEs, e.g. Non-MSGin5G UEs or constrained devices, and Application Servers;
- the procedures and architectural enhancement to support Broadcast massaging by introducing Broadcast Message Gateway;
- the procedures, e.g. configuration, registration, for MSGin5G Client in constrained device and Gateway UE by using MSGin5G-6 reference point; and
- the service logic between some features, e.g.
  - service logic between message aggregation and segment. If an aggregated message is sent to a recipient whose supported message segment size is smaller than the aggregated message, will the message be split or segmented; and
  - service logic between store forward and device triggering. If store and forward is allowed by an MSGin5G message and device triggering is supported by the recipient, how the MSGin5G Server works; etc.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990116,950026,990019,990099,990041

[1] TS 23.554: "Application architecture for MSGin5G Service; Stage 2;".
[2] TS 22.262: "Message Service within the 5G System".
[3] TS 33.501: "Security architecture and procedures for 5G System".
[4] TS 24.538: " Enabling MSGin5G Service;Protocol specification;".
[5] TS 29.538: " Enabling MSGin5G Service;Application Programming Interfaces (API) specification;".
[6] TS 23.434: "Service Enabler Architecture Layer for Verticals".

27.14 Security Assurance Specification (SCAS) Phase 2

950016	**Security Assurance Specification (SCAS) for 5G Rel-17 Features**	SCAS_5G_Ph2	S3	SP-220192	**Rong Wu, Huawei Technologies Co., Ltd.**

Summary based on the input provided by Huawei in SP-240882.

This work item is a routine work to maintain and enhance the assurance specification that is used by NESAS/SCAS scheme jointly developed by GSMA and 3GPP. The scheme is currently being discussed for adoption by EU5G.

This work item covers more than 20 SCAS specifications. During the course of the release, the scope of the scheme has later been revised following ENISA's feedback to take into account their work on a gap analysis. This is to strengthen the case for the NESAS/SCAS scheme being one of the candidate schemes for adoption by EU5G. The work done in this work item includes at least: clarification of the security assurance level of NESAS/SCAS scheme, revision of several specifications based on requests and feedback from GSMA, additions of new test cases covering the new features of Rel-18.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=950016

27.15 Vehicle-Mounted Relays

930028	**Vehicle-Mounted Relays**	**VMR**		SP-211054	**Francesco Pica, Qualcomm**
890022	*Study on VMR*	FS_VMR	S1	SP-200798	**Francesco Pica**
930021	**Stage 1 of VMR**	VMR	S1	SP-211054	**Francesco Pica, Qualcomm**
980018	**(Stage 2 for VMR) Architecture Enhancements for Vehicle Mounted Relays**	VMR	S2	SP-230105	**Cheng, Hong, Qualcomm,**
990013	CT1 aspects of VMR	VMR	C1	CP-232168	**Kim, Sunghoon, Qualcomm**
990102	CT4 aspects of VMR	VMR	C4	CP-232168	**Kim, Sunghoon, Qualcomm**
940057	*Study on Architecture Enhancements for Vehicle Mounted Relays*	FS_VMR	S2	SP-211636	**Cheng, Hong, Qualcomm,**

Summary based on the input provided by Qualcomm in SP-240893.

This summary covers system architecture and core network/NAS enhancements related to Vehicle Mounted Relays (VMR). VMR is defined as a Mobile Base Station Relay (referred to as MBSR), providing a NR access link to UEs and connected wirelessly (using NR) through a donor NG-RAN to the 5G Core. Such mobile base station relay can be mounted on a moving vehicle and serve UEs that are located inside or outside the vehicle (or entering/leaving the vehicle). A high-level concept is illustrated here:

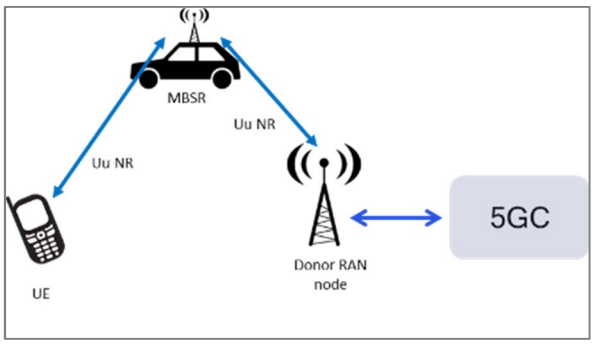


Figure 1: conceptual view of Vehicle-Mounted Relays (VMR)

Preceding stage-1 service requirements for VMR are captured in [13], corresponding RAN enhancements have been introduced via the RAN Work Item NR_mobile_IAB, summarized in sec. 27.3 of this report. Note that the RAN specs use the term “mobile IAB-node”, which is equivalent to the term “MBSR” defined in SA2/CT1/CT4 specs.

From a system architecture (stage-2) perspective, the main enhancements and/or functionalities defined to support mobile base station relays are summarized below (from [1] - [3]). More specific procedures and protocol details can be found in stage-3/CT specs ([4]-[12]).

Some general architecture assumptions are: the MBSR uses the IAB architecture and operates as an IAB node (with an IAB-UE and gNB-DU) with mobility, using a single hop to the IAB-donor node. Roaming of the MBSR is supported, i.e. a MBSR can integrated with a VPLMN's IAB-donor node. In addition, regulatory requirements (e.g. emergency services, priority services) and LCS are supported when UEs access 5GS via a MBSR.

MBSR authorization

For a MBSR, the subscription information stored in the HPLMN indicates whether it is authorized to operate as MBSR, and the corresponding location and time information. When the MBSR (IAB-UE) performs initial registration with the serving PLMN, it indicates the request to operate as a MBSR. The AMF authorizes the MBSR based on the subscription information and provides MBSR authorized indication to the MBSR node over NAS and NG-RAN over NGAP. Upon the reception of MBSR authorization indication (authorized), the MBSR establishes the connection to OAM system using the configuration information for MBSR operation.

If the MBSR operation is not authorized (e.g. due to location or time limitation), the AMF of the MBSR can indicate to the MBSR IAB-UE that it is not allowed to act as an MBSR, as part of registration procedure or UE configuration update procedure. When the MBSR authorization state changes for a registered MBSR node (either authorized, or not authorized), the AMF updates the MBSR and the NG-RAN accordingly.

Configuration of the MBSR

In order for an MBSR to operate as a mobile IAB node, it receives configuration from the OAM system of the serving PLMN. The MBSR IAB-UE establishes a secure and trusted connection to the OAM server only if it is authorized to operate as MBSR in the serving PLMN (see above).

In case a PDU session is used for the MBSR to access the OAM server, the MBSR establishes a dedicated PDU session for the OAM traffic. The MBSR can also be (pre-)configured with UE policy or be provisioned using existing UE Policy mechanism including the OAM access PDU session parameters for the authorized PLMNs.

Control of UE access to MBSR

Existing CAG mechanisms can be used for managing UE's access to MBSR, with additional considerations:

- When the MBSR is allowed to operate as a mobile IAB node for a PLMN, the MBSR is configured with a CAG identifier which is unique within the scope of this PLMN. The MBSR can also be (pre-)configured with a PLMN list in which it is allowed to operate, with corresponding CAG Identifier per PLMN.

- UE, NG-RAN and 5GC support the UE access control based on the CAG identifier associated with the MBSR cell and the allowed CAG identifiers for the UE that supports CAG functionality.

- Time duration restriction can also be provided, together with the CAG Identifier(s), for the MBSR(s) that the UE can access to. The enhanced Allowed CAG list will be provided to UE and AMF for enforcement, to make sure that UEs do no access the MBSR cell outside of the allowed time duration.

For a UE that does not support CAG functionality, UE, NG-RAN and 5GC can use other existing mechanisms e.g. forbidden Tracking Area, to manage UE access to MBSR.

Location Service and Privacy check

The location service procedures have been enhanced, including the following:

- The MBSR which performed the location service procedures for the UE includes its cell ID in the reported UL positioning measurement. The AMF serving the UE provides to the LMF the cell ID of serving cell of the UE and indicates, if possible, that it belongs to a MBSR, together with the additional ULI (User Location Information) received from NG-RAN.

- The LMF uses the reported cell IDs to derive whether the cell ID(s) corresponds to a MBSR. The LMF can derive the location and velocity of the MBSR by triggering the gNB serving the MBSR using NRPPa or by requesting the GMLC to derive the location of the MBSR (UE) using the UE-ID of the MBSR.

- If the positioning of the MBSR is performed for the location estimation of the MBSR acting as a normal UE, not authorized to operate as MBSR based on the subscription information, the UE privacy check procedure is performed. Otherwise, the privacy check is skipped for the MBSR.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930028,890022,930021,980018,990013,990102

[1] TS 23.501 System architecture for the 5G System (5GS)
[2] TS 23.273 5G System (5GS) Location Services (LCS); Stage 2
[3] TS 23.502 Procedures for the 5G System (5GS)
[4] TS 24.501 Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3
[5] TS 29.502 5G System; Session Management Services; Stage 3
[6] TS 29.503 5G System; Unified Data Management Services; Stage 3
[7] TS 29.510 5G System; Network function repository services; Stage 3
[8] TS 29.515 5G System; Gateway Mobile Location Services; Stage 3
[9] TS 29.518 5G System; Access and Mobility Management Services; Stage 3
[10] TS 29.571 5G System; Common Data Types for Service Based Interfaces; Stage 3
[11] TS 29.572 5G System; Location Management Services; Stage 3
[12] TS 23.122 NAS functions related to Mobile Station (MS) in idle mode
[13] TS 22.261 5G service requirements; Stage-1

27.16 SECAM and SCAS for 3GPP virtualized network products

940017	**SECAM and SCAS for 3GPP virtualized network products**	VNP_SECAM_SCAS	S3	SP-211365	**Qi Minpeng, China Mobile**

Summary based on the input provided by China Mobile in SP-240903.

VNP_SECAM_SCAS defines the security assurance methodology and the security assurance requirement for 3GPP virtualized network work items from Release 18. It results from the SECAM and SCAS WIs which are mainly focus on physical based network products. It covers:

- the description of different models, interfaces, procedures, roles and lifetime management, etc. for 3GPP virtualized network products[1].
- the definition of terminology, specific critical assets, threats for generic virtualized network products(GVNP)[2].

It inherits most security requirement and test cases from physical based network product SCAS([3]) except some not fit for GVNPs. It proposes specific security requirements and also some test cases [4].

The definitions of network product class and network product were documented in the TR 33.916 [5]. For implementing 3GPP defined functionalities in network products, some functionalities that relate to the supporting platform (e.g. hardware components, operating system, etc.) also need to be implemented. The platform provides execution environment for 3GPP defined functionalities. For physical network products, the platform and the 3GPP defined functionalities are tightly coupled, while for virtualized network products, the platform and the 3GPP defined functionalities are decoupled. However, Concept of 3GPP VNF is defined in TS 28.500 [5]. The platform of virtualized network products composes of a hardware layer and a virtualization layer, and is common for 3GPP defined functionalities. It brings difference for security assurance as a part of such work depends on hardware implementation before. It needs new methodology, critical assets and threats description and security requirements definition.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940017

[1] TR 33.936: “Security Assurance Methodology (SECAM) for 3GPP virtualized network products”
[2] TR 33.927: “Security Assurance Specification (SCAS); threats and critical assets in 3GPP virtualized network product classes”
[3] TS 33.117: “Catalogue of general security assurance requirements ”
[4] TS 33.527: “Security Assurance Specification (SCAS) for 3GPP virtualized network products”
[5] TS 33.916: “Security Assurance Methodology (SECAM) for 3GPP network products”

27.17 MPS for Supplementary Services

960010	**MPS for Supplementary Services**	MPSSupServ	C1	CP-221271	**Peter Monnes, Peraton Labs**

Summary based on the input provided by Peraton Labs in CP-241235.

A supplementary service is a service which modifies or supplements a basic telecommunication service (see definition in TR 21.905 [1]). Interactions with a supplementary service might occur during set-up or after establishment of an MPS call or session.

The system provides MPS priority for a supplementary service associated with an MPS call or session in progress when the supplementary service is associated with the Service User authorized for MPS.

When a supplementary service (e.g., Communication Diversion) results in an established authorized MPS call or session being redirected or extended, MPS priority will be provided for the redirected or extended call or session.

When a supplementary service (e.g., Conference/Three-Party) is used to join an MPS priority call or session (e.g., to add parties to the established MPS call/session), MPS priority will be retained on that leg when joined to the supplementary service.

The following new MPSSupServ functionalities are included in Rel-18:

Completion of Communications to Busy Subscriber (CCBS)

The CCBS (busy), CCNR (no reply) and CCNL (not logged in) services enable a user encountering a destination that is busy, does not answer or is not logged-in, to have the communication completed at a later point in time without the user having to manually initiate a new communication attempt.

With the MPSSupServ feature, TS 24.642 [6] is updated for the Application Server (AS) to store the Resource-Priority information from the original call and add it to the subscription to the terminating AS for notification when the target becomes available, and set the same Resource-Priority on the eventual new communication.

Communication Diversion (CDIV)

CDIV service enables diverting user, to divert the communications addressed to diverting user to another destination.

With the MPSSupServ feature, TS 24.604 [3] is updated for the AS to set the Resource-Priority information on the terminating call leg based upon the Resource-Priority information in the originating leg.

Explicit Communication Transfer (ECT)

ECT provides a party involved in a communication to transfer that communication to a third party.

With the MPSSupServ feature, TS 24.629 [5] is update for the AS to set the Resource-Priority information from the original dialog on the request to the target of the transfer.

Conference (CONF)

The CONF service enables a user to participate in and control a simultaneous communication involving a number of users, AKA 3-way calling or multi-way calling. It's based upon TS 24.229 conferencing.

With the MPSSupServ feature, TS 24.605 [4] is updated for the AS to set the Resource-Pririty information from the original dialog to the SIP INVITEs to target users and update the originating UE's conference call leg with the same Resource-Pririty information.

General

TS 24.173 [2] is updated to specify priority handling for MPS UEs for database lookups and URL references.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960010

[1] TS 21.905: "Technical Specification Group Services and System Aspects; Vocabulary for 3GPP Specifications".

[2] TS 24.173: "IMS Multimedia telephony communication service and supplementary services; Stage 3".
[3] TS 24.604, “Communication Diversion (CDIV) using IP Multimedia (IM) Core Network (CN) subsystem; Protocol specification”.
[4] TS 24.605, “Conference (CONF) using IP Multimedia (IM) Core Network (CN) subsystem; Protocol specification”.
[5] TS 24.629, “Explicit Communication Transfer (ECT) using IP Multimedia (IM) Core Network (CN) subsystem; Protocol specification”.
[6] TS 24.642: "Completion of Communications to Busy Subscriber (CCBS) and Completion of Communications by No Reply (CCNR) using IP Multimedia (IM) Core Network (CN) subsystem; Protocol specification".

27.18 Rel-18 enhancements of session management policy control

980036	**Rel-18 enhancements of session management policy control**	SMPC18	C3	CP-223208	**Xiaoyun Zhou, Huawei**

Summary based on the input provided by Huawei in CP-241263.

The Session Management Policy Control services and service procedures have been specified during the previous 3GPP releases. During development of the above services, it has been identified that there is a need to apply technical improvements and enhancements (e.g. support the missed requirement in the previous releases, improve the signaling and processing efficiency, increase the flexibility, enhance the reliability, improve specification clarity, etc.).

There is a need to apply the technical improvements and enhancements in Release 18 (e.g. complete the missing non-critical stage-2 requirements, enhancements on the definition of the API in stage-3 level, etc.) to these Session Management Policy Control related services, as such enhancements may not be covered by the other dedicated Rel-18 work items.

SMPC18 specifies the corresponding stage 3 procedures related to the technical improvements identified for the following areas:

- Specified the the behaviour of the SMF to provide the packet filter to the UE for the default QoS flow.
- Completed QoS flow binding descriptions to cover the QoS flow binding indication to UE/UPF and the bearer binding performed by the SMF+PGW-C in the 5GC and EPC interworking scenario (references to the related TSs).
- Clarified the procedure for Usage monitoring with monitoring time when only one threshold is provided.
- Specified the mapping of QoS parameters between Rel-99 QoS parameters, 5G QoS parameters when N7 interface is used (reference to the related TSs), and the EPS ones for the support of GERAN/UTRAN access by SMF+PGW-C.
- Completed the annex for wireless and wireline convergence with missing feature limitation for already specified functionality (e.g. the list of triggers which not supported Policy Control Request Triggers).
- Specified the Handling of RAN/NAS release cause values for the P-CSCF.
- Corrected and updated descriptions of session management policy control missed in the previous 3GPP Releases, which are not covered by the other dedicated Rel-18 work items.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980036

[1] TS 29.512: "5G System; Session Management Policy Control Service; Stage 3".
[2] TS 29.513: "5G System; Policy and Charging Control signalling flows and QoS parameter mapping; Stage 3".
[3] TS 29.514: "5G System; Policy Authorization Service; Stage 3".

27.19 Seamless UE context recovery

980116	**Seamless UE context recovery**	**SUECR**		SP-220810	**Lalith kumar, Samsung**
970020	**Stage 2 of Seamless UE context recovery**	**SUECR**	**S2**	SP-220810	**Lalith kumar, Samsung**
980088	CT1 aspects of Seamless UE context recovery	SUECR	C1	CP-223113	**Hashmi, Danish Ehsan, Samsung**
980089	CT3 aspects of Seamless UE context recovery	SUECR	C3	CP-223113	**Hashmi, Danish Ehsan, Samsung**
980090	CT4 aspects of Seamless UE context recovery	SUECR	C4	CP-223113	**Hashmi, Danish Ehsan, Samsung**

Summary based on the input provided by Samsung in SP-241311.

To execute certain events, for example OS upgrade, silent reset at modem or modem software updates (also commonly called as binary updates), three parties are involved: the device, the operator and the application function. Once the UE has downloaded the binary, the time when the UE performs the upgrade is left for the UE implementation. When UEs become unavailable to execute such events, it can affect critical operations of an application server if it depends on availability of the UE during the unavailability period (i.e. a period of time during which the UE is not available). Thus, there is a need for co-ordination between UE and operator/application function.

In Rel-18, below enhancements are made:

During Registration procedure, the UE provides indication of support of "Unavailability Period" in Registration Request message, and the AMF indicates the support of the "Unavailability Period" in Registration Accept message.

If UE and network support "Unavailability Period" and an event is triggered in the UE that would make the UE unavailable for a certain period of time (e.g. for OS upgrade or device reboot), the UE may store its MM context in USIM or Non Volatile memory to be able to reuse it after its unavailability period. When the UE is ready to execute the event, the UE triggers registration or deregistration procedure including the unavailability period. If the UE is not deregistered, the AMF may provide Periodic Registration Update timer based on unavailability period indicated by the UE, e.g. the AMF may provide a Periodic Registration Update time that does not interfere the unavailability period and the AMF stores the information that the UE is unavailable in UE context, and considers the UE is unreachable until the unavailability period has passed or the UE enters CM-CONNECTED state. While the UE is unreachable, all high latency communication solutions (see clause 5.31.8 of TS 23.501 [1]) may apply if supported, e.g. extended data buffering, downlink data buffering status report, etc. If there is "Loss of Connectivity" event subscription for the UE by AF, the AMF triggers "Loss of Connectivity" event report and includes unavailability period towards the NEF and the unavailability period is reported to the respective subscribed AF.

Once the event which makes the UE unavailable is completed in the UE or the event is delayed to a future time or cancelled in the UE (e.g. due to insufficient storage capacity, insufficient battery level or the event which makes the UE unavailable is completed), the UE triggers registration procedure to resume regular service. The UE does not include the Unavailability Period in the Registration Request message. Depending on the state the UE ends up after the event, the registration procedure can be Initial Registration procedure or Mobility Registration Update procedure.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980116,970020,980088,980089,980090

[1] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".
[2] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".
[3] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".
[4] 3GPP TR 21.916: "Release 16 Description; Summary of Rel-16 Work Items"
[5] 3GPP TR 21.917: "Release 17 Description; Summary of Rel-17 Work Items"

27.20 Extensions to the TSC Framework to support DetNet

980119	**Extensions to the TSC Framework to support DetNet**	**DetNet**		SP-220801	**Miklós, György, Ericsson**
970011	**Stage 2 of Extensions to the TSC Framework to support DetNet**	**DetNet**	**S2**	SP-230172	**Miklós, György, Ericsson**

980093	CT1 aspects of Detnet	DetNet	C1	CP-231195	**Fuencisla García, Ericsson**
980094	CT3 aspects of Detnet	DetNet	C3	CP-231195	**Fuencisla García, Ericsson**
980095	CT4 aspects of Detnet	DetNet	C4	CP-231195	**Fuencisla García, Ericsson**

27.21 Multiple location report for MT-LR Immediate Location Request for regulatory services

980117	**Multiple location report for MT-LR Immediate Location Request for regulatory services**	**TEI18_MLR**		SP-220795	**Joul, Christopher, T-Mobile USA**
970005	**Stage 2 of TEI18_MLR**	**TEI18_MLR**	**S2**	SP-220795	**Joul, Christopher, T-Mobile USA**
980002	**CT4 aspects on TEI18_MLR**	TEI18_MLR	C4	CP-223022	**Jones Yunjie, Lu, Ericsson**

27.22 Enhancement of Application Detection Event Exposure

980120	**TEI18 on Enhancement of Application Detection Event Exposure**	**TEI18_ADEE**		SP-220796	**Aihua Li, China Mobile**
970006	Stage 2 of TEI18_ADEE	**TEI18_ADEE**	**S2**	SP-220796	**Aihua Li, China Mobile**
980030	CT3 aspects of TEI18_ADEE	TEI18_ADEE	C3	CP-223202	**Zhenning Huang, China Mobile**

27.23 General Support of IPv6 Prefix Delegation in 5GS

980121	**General Support of IPv6 Prefix Delegation in 5GS**	**TEI18_IPv6PD**		SP-220797	**Gan, Judy, Ericsson**
970007	**Stage 2 of TEI18_IPv6PD**	**TEI18_IPv6PD**	**S2**	SP-220797	**Gan, Judy, Ericsson**
980096	CT1 aspects of TEI18_IPv6PD	TEI18_IPv6PD	C1	CP-230121	**Maria Tianmei, Liang, Ericsson**
980097	CT3 aspects of TEI18_IPv6PD	TEI18_IPv6PD	C3	CP-230121	**Maria Tianmei, Liang, Ericsson**
980098	CT4 aspects of TEI18_IPv6PD	TEI18_IPv6PD	C4	CP-230121	**Maria Tianmei, Liang, Ericsson**

27.24 MPS when access to EPC/5GC is WLAN

940031	**MPS when access to EPC/5GC is WLAN**	**MPS_WLAN**		SP-211057	**Singh, Ray; Peraton Labs**
930024	**Stage 1 of MPS_WLAN**	MPS_WLAN	S1	SP-211057	**Singh, Ray; Peraton Labs**
940053	**Stage 2 of MPS_WLAN**	MPS_WLAN	S2	SP-230108	**Robert C Streijl; Peraton Labs**
1000021	**CT1 aspects of MPS_WLAN**	MPS_WLAN	C1	CP-232166	**Monnes, Peter, Peraton Labs**
1000046	**CT4 aspects of MPS_WLAN**	MPS_WLAN	C4	CP-232166	**Monnes, Peter, Peraton Labs**

In Release 18, TS 22.153 [1] was updated to include normative stage 1 requirements for Multimedia Priority Service (MPS) when the access to the Evolved Packet Core (EPC) or 5G Core (5GC) is WLAN, and the associated stage 2 and stage 3 features were defined. Support of MPS when the UE has WLAN access is important during certain disaster scenarios such as when 3GPP NG-RAN access networks (LTE and NR) are not unavailable or degraded. In some cases,

WLAN might be the only available access (e.g., inside buildings, hotels, airports, malls and stadiums) and therefore critical for MPS communications.

Stage 1

TS 22.153 [1] Release 18 was updated to include normative stage 1 requirements on:
- MPS for MMTEL voice/video calls when the UE has WLAN access to the EPC/5GC, and
- MPS for Data Transport Service (DTS) sessions when the UE or IoT device has WLAN access to the EPC/5GC.

Stage 2

For WLAN access to the EPC, TS 23.401 [2] and TS 23.402 [3], normative agreements include:
- MPS support for access to the EPC via non-3GPP access via Trusted or Untrusted WLAN.
- Use of the existing MPS subscription for non-3GPP access via Trusted or Untrusted WLAN.
- No changes to ePDG selection.
- UEs with an MPS subscription connecting to the EPC via an Untrusted non-3GPP WLAN network indicate their MPS subscription in a notification payload of the IKE authentication request.
- UEs with an MPS subscription connecting to the EPC via a Trusted non-3GPP WLAN network indicate their MPS subscription in the username of the NAI.
- Besides other subscription information, the HSS also returns MPS subscription, if any, to the 3GPP AAA Server, ePDG, to treat UE with MPS subscription with priority. In case the optional step for authentication before attaching via WLAN to the EPC is supported, the MPS subscription is also provided to the Non-3GPP IP Access (in this case, the untrusted WLAN).
- Exemption from congestion controls for MPS UEs within the 3GPP AAA server and ePDG.
- Various clarifications on the use of DSCP used for access to the EPC via an ePDG for Untrusted non-3GPP WLAN access including allowing the operator to use a different DSCP in the outer ESP tunnel packet than the DSCP of the inner IP packet. For Trusted non-3GPP WLAN access, the TWAG can apply a different DSCP to downstream packets than the DSCP received from the 3GPP system.

For WLAN access to the 5GC, TS 23.501 [4] and TS 23.502 [5], normative agreements include:
- MPS support for access to the 5GC via non-3GPP access via Trusted or Untrusted WLAN.
- Support existing MPS subscription for use via non-3GPP access via Trusted or Untrusted WLAN.
- No changes to N3IWF selection.
- UEs with an MPS subscription connecting via Untrusted non-3GPP WLAN indicate their MPS subscription in a notification payload of the IKE authentication request.
- UEs with an MPS subscription connecting via Trusted non-3GPP WLAN indicate their MPS subscription in the username of the NAI.
- Exemption from congestion controls for MPS UEs by the TNAN/N3IWF.

Stage 3

For untrusted WLAN access to the EPC:
- Updated TS 24.302 [8] to specify that the UE informs the network about its priority status (high priority access) using an attribute on the first IKE_AUTH message.
- Updated TS 29.273 [11] to specify that the ePDG relays a received priority indicator from the WLAN to the 3GPP AAA server. Subsequently, both the 3GPP AAA server and the ePDG treat the UE with priority.
- Updated TS 29.273 [11] to specify that the 3GPP AAA server relays a received priority indicator from the HSS to the ePDG. Subsequently, both the 3GPP AAA server and the ePDG treat the UE with priority.
- Added requirements to TS 24.302 [8] for exemption from congestion controls for MPS UEs within the 3GPP AAA server and the ePDG.

For trusted WLAN access to the 5GC:
- Updated TS 24.302 [8] to specify that the UE informs the network about its priority status (high priority access) using NAI decoration in the EAP/Response Identity message.
- Updated TS 29.273 [11] to specify that the TWAN relays a received priority indicator from the UE to the 3GPP AAA server. Subsequently, both the 3GPP AAA server and the TWAN treat the UE with priority.
- Updated TS 29.273 [11] to specify that the 3GPP AAA server relays a received priority indicator from the HSS to the TWAN. Subsequently, both the 3GPP AAA server and the TWAN treat the UE with priority.

- Added requirements to TS 24.244 [7] for exemption from congestion controls for MPS UEs by the TWAG.

For WLAN access to the EPC general:
- Adds uplink and downlink DSCP details to TS 24.302 [8].
- Adds uplink DSCP details to TS 29.274 [12] for the ePDG and the TWAN.

For untrusted WLAN access to the 5GC:
- Updated TS 24.502 [10] to specify that the UE informs the network about its priority status (MPS access) using an attribute on the first IKE_AUTH message.
- Updated TS 24.502 [10] to specify that the N3IWF, upon receipt of an indication from the UE of MPS priority, treats further messages for the UE with priority.
- Added requirements to TS 24.502 [10] for exemption from congestion controls for MPS UEs by the 3GPP N3IWF.

For trusted WLAN access to the 5GC:
- Updated TS 24.502 [10] to specify that the UE informs the network about its priority status (MPS access) using NAI decoration in the EAP/Response Identity message.
- Updated TS 24.502 [10] to specify that the TNAN, upon receipt of an indication from the UE of MPS priority, treats further messages for the UE with priority.
- Added requirements to TS 24.502 [10] for exemption from congestion controls for MPS UEs by the TNGF.

For WLAN access to the 5GC in general:
- Adds uplink and downlink DSCP details to TS 24.502 [10] for the N3IWF and TNGF.

General:
- Updated TS 23.003 [2] to define NAI decorations to convey high priority access or MPS access from the UE to the network in an EAP/Identity response message.
- Updated TS 24.368 [9] to define a managed object to configure a UE to enable or disable NAI decoration for high priority access or MPS as defined in TS 23.003 [2].
- Updated TS 31.102 [13] to add 4 bits to EFNASCONFIG in the "Additional NAS configuration parameters" to hold the Booleans specifying UE support for NAI decoration as defined in TS 23.003 [2] for: MPS, high priority access, MPS for operation in SNPNs, and high priority access for operation in SNPNs.
- Added new MO leaf for enabling NAI decoration for MPS in TS 24.368 [9].

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940031,930024,940053,1000021,1000046

[1] TS 22.153: "Multimedia priority service".
[2] TS 23.003: "Numbering, addressing and identification"
[3] TS 23.401: “General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access”
[4] TS 23.402: “Architecture Enhancements for non-3GPP accesses”
[5] TS 23.501: “System architecture for the 5G System (5GS); Stage 2”
[6] TS 23.502: “Procedures for the 5G System (5GS); Stage 2”
[7] TS 24.244: "Wireless LAN control plane protocol for trusted WLAN access to EPC; Stage 3"
[8] TS 24.302: "Access to the 3GPP Evolved Packet Core (EPC) via non-3GPP access networks; Stage 3"
[9] TS 24.368: "Non-Access Stratum (NAS) configuration Management Object (MO)"
[10] TS 24.502: "Access to the 3GPP 5G Core Network (5GCN) via non-3GPP access networks"
[11] TS 29.273: "Evolved Packet System (EPS); 3GPP EPS AAA interfaces"
[12] TS 29.274: "3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3"
[13] TS 31.102: "Characteristics of the Universal Subscriber Identity Module (USIM) application"

27.25 Data Integrity in 5GS

910035	**Data Integrity in 5GS**	DI_5G	S1	SP-210213	**Qun wei, China Unicom**

27.26 Security Enhancement on RRCResumeRequest Message Protection

960040	**Security Enhancement on RRCResumeRequest Message Protection**	SERP	S3	SP-220538	**Ivy Guo, Apple**

28 Administration, Operation, Maintenance-centric Features

28.1 Introduction

This section presents all the standalone management functionalities. Management aspects related to other features are reported in the relevant section. For instance, “management for AI/ML" is reported in the section on "Artificial Intelligence (AI)/Machine Learning (ML)".

28.2 Intent driven Management Service for Mobile Network phase 2

990030	Intent driven Management Service for Mobile Network phase 2	IDMS_MN_ph2	S5	SP-230180	**Xu Ruiyue, Huawei**
910023	*Study on enhanced security for network slicing Phase 2*	FS_eNS2_SEC	S3	SP-210106	**Zander Lei, Huawei**
960048	*Study on Media Streaming aspects of Network Slicing Phase 2*	FS_MS_NS_Ph2	S4	SP-220675	**Prakash Kolan, samsung**

Summary based on the input provided by Huawei in SP-231592.

This work item was the continuation of Intent driven Management Service for Mobile Network work items from Release 17. It focused on following main topics:

- Requirements and solutions for new scenarios for intent driven management for 3gpp network and services.

- New capabilities and solutions for intent driven management.

5G advanced networks bring more operational complexities due to the large number of devices and diversity of services. Network automation/intelligence is one of the important topics for 5G advanced networks, which aims to reduce the operating expenditure (OPEX) and improve the service experience to enable various vertical industries (e.g. autonomous vehicle, smart city) through a variety of intelligence and automation mechanisms. As technologies are evolving and the level of complexity explodes, the need for abstraction of the operational requirements, as supported by intents, becomes more apparent.

An intent is an expression of the desired state of a system used to describe an intended network or service. Intents do not define specific network or service configuration, nor do they prescribe management tasks to be performed by a system. Intents allow customers to request networks and services without detailed knowledge of how they will be provided. Inherently, this assumes that the system can learn the behaviour of networks and services and use intelligence and automation mechanisms to fulfil the requests expressed via intents. This not only relieves the consumer of the burden of knowing implementation details but also provides flexibility allowing the producer to explore alternative options to find optimal solutions.

Based on the intent driven management solution defined in R17, This WI further specifies the new use case and management capability for intent driven management for mobile network.

Following content is added in TS 28.312 [1].

1.New use cases and corresponding requirements for intent driven management, including Intent containing an expectation:
- for delivering a radio service;
- on radio capacity performance to be assured;
- for RAN energy saving;
- for 5GC network
- for end-to-end network optimization

2.New generic capabilities for intent driven management, including
- Intent handling capability obtaining, enabling an MnS consumer to obtain intent handling capabilities.
- Intent report, enabling an MnS consumer to obtain intent report information with intent fulfilment information (including fulfilment status and achieved values for targets), intent fulfilment feasibility check information and intent conflict information.
- Intent-related conflicts, including detecting and resolve intent-related conflicts.

3.Provide Stage 2 solution to support above use case and generic capabilities, including:
-Introduce IntentHandlingFunction object to model the intent handling capabilities.
-Introduce IntentReport object to model the intent report information (including intent fulfilment information, intent fulfilment feasibility check information and intent conflict information).
-Enhance the RadioNetworkExpectation to including radio network capacity related targets and RAN energy saving related targets to support use cases of intent containing an expectation on radio capacity performance to be assured and intent containing an expectation for RAN energy saving.
-Introduce the new RadioServiceExpectation to support use case of intent containing an expectation for delivering a radio service.
-Introduce the new 5GCNetworkExpectation to support use case of intent containing an expectation for 5GC network.
-Introduce the new End-to-endNetworkResourceOptimizationExpectation to support use case of -Intent containing an expectation for end-to-end network optimization.

4. Provide Stage3 OpenAPI solution set and YAML document examples for the enhancement of intent driven management service definition.

References

[1] TS 28.312: "Intent driven management services for mobile networks"
[2] Related CRs: set "TSG Status = Approved" in: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990030#/

28.3 Management of cloud-native Virtualized Network Functions

1000007	**Management of cloud-native Virtualized Network Functions**	MCVNF	S5	SP-230764	**China Mobile Guangjing Cao**

Summary based on the input provided by China Mobile in SP-240283.

This work item added management enhancements to support the capability of cloud native VNF management in TS 28.526 [1], TS 28.531 [2] and TS 28.533[3].

This MCVNF work item has addressed the following issues:

- Enhance the descriptions on cloud native VNF management and related interactions with ETSI NFV-MANO which are important for containerized VNF LCM in TS 28.526 [1], TS 28.531 [2] and TS 28.533[3].

- Add clarification in the scope section of TS 28.531[2] to indicate that use cases and procedures for management of VNF are specified when ETSI NFV specifications are used, which can makes the its scope unambiguous.

- Remove some VNF Package procedures in TS 28.526 [1] which cannot be executed because ETSI does not support these processes.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=1000007

[1] TS 28.526: "Telecommunication management; Life Cycle Management (LCM) for mobile networks that include virtualized network functions; Procedures."
[2] TS 28.531: "Management and orchestration; Provisioning."
[3] TS 28.533: "Management and orchestration; Architecture framework."

28.4 Management of Trace/MDT phase 2

980029	**Management of Trace/MDT phase 2**	5GMDT_Ph2	S5	SP-230777	**Swaminathan, Sivaramakrishnan, Nokia**

Summary based on the input provided by Nokia in SP-240286.

This WID focussed on the enhancements of Management of Trace and MDT continuing from the work done in the phase 1 on the same topic. The primary focus of this phase2 WI is to normatively standardize the solutions to the problems identified and agreed in the corresponding SI on the same topic. The main focus of this WI were:

- Enhancements aligning with SBMA framework.

- Enhancements to data collection of MDT framework.

- Enhancements to SA5 based on RAN work on the SON MDT topics.

This WI, Management of Trace and MDT phase 2 focusses on enhancements aligning with SBMA framework, data collection of MDT framework and the alignment of SON MDT topics from RAN3.

The details are as follows:

- The PerfMetric job and the Trace job are specified in SA5 that helps the consumer and producer to configure, produce and report the core management data of performance measurements and trace data. Both jobs are built based on SBMA principles. It is required that these two jobs follow similar kind of reporting and notification framework so that the implementation of these NRM fragments are effective in the products. As part of this SBMA aware exercise, the Trace job has been aligned with PerfMetric job for allowed notifications in the NRM definitions in TS 28.622 [1].

- In the SA5 NRM, the TraceJob managed object instance (MOI) is name contained by a SubNetwork, or a ManagedElement, or a ManagedFunction instance. It is not clear how to treat TraceJob MOI in NRM in case of handover for signalling based trace activation. The enhancements and clarifications have been added to the existing NRM on this topic. The UDM has been identified as the best candidate for containment in this scenario and appropriate changes have been done in TS 28.622 [1].

- The TraceJob definition in NRM contained very large amount of attributes, some of them are required for Trace and some for MDT configurations. It was ambiguous and confusing for the consumer to deal with a large number of attributes and configure the required attributes for the specific use case. This has been solved by simplifying the TraceJob attributes by introducing data types for trace and MDT separately. The MDT datatype is further divided into Immediate and Logged MDT data types containing the appropriate attributes. The mentioned changes are made in TS 28.622 [1] and TS 28.623 [2].

- The Report Amount attribute in the TraceJob was a common configuration for all the MDT measurements configured in a given TraceJob. This was not allowing the consumer to have different reporting amount value for different MDT measurements based on the use case. New parameters have been added for measurement specific reporting amount for M4, M5, M6 and M7 measurements in TS 32.422 [4].

- The measurements on PDCP data volume and average UE throughput measurements are defined in TS 28.552 [6]. The measurements on packet delay and packet loss measurements are defined in TS 38.314 [7]. These measurements are defined per direction (UL/DL), per DRB and per UE. But the trace data file XML schema for MDT measurements lacked the means to report them according to the definition. Hence the trace data file XML schema has been enhanced with the reporting of measurements per direction per UE and per DRB in TS 32.423 [5].

- The support for Non-Public Networks (NPN) has been discussed in RAN specifications. The support to configure the MDT functionality for NPN networks has been performed as part of this exercise. The business requirements in TS 32.421 [3] has been updated. The definitions of new attributes required and the changes to the procedures are defined in TS 32.422 [4]. The changes required to the TraceJob NRM are done in TS 28.622 [1] and TS 28.623 [2].

- The stage 3 changes of all the applicable work done as part of this WI can be found in the below SA5 forge repository. https://forge.3gpp.org/rep/sa5/MnS

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980029

[1] TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
[2] TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".
[3] TS 32.421: "Telecommunication management; Subscriber and equipment trace; Trace concepts and requirements"
[4] TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management"
[5] TS 32.423: "Telecommunication management; Subscriber and equipment trace; Trace data definition and management"
[6] TS 28.552: "Management and orchestration; 5G performance measurements"
[7] TS 38.314: "NR; Layer 2 measurements"
[8] List of related CRs: https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980029

28.5 Security Assurance Specification for Management Function (MnF)

940014	**Security Assurance Specification for Management Function (MnF)**	SCAS_5G_MF	S3	SP-211362	**Noamen Ben Henda, Huawei Technologies Co., Ltd.**

Summary based on the input provided by Huawei in SP-231621.

This work item delivered a new security assurance specification for the Management Function (MnF) in TS 33.526 [1], and a new Annex V in TR 33.926 [2] describing the associated security model for MnF network products in accordance to the security assurance process described in TR 33.916 [3]. This work item is similar but not directly related to other security assurance-related work items. It is part of SA3's regular activities related for the Network Equipment Security Assurance Scheme (NESAS), jointly defined by 3GPP and GSMA as described in SA3's Terms of Reference [4].

As any other SCAS work item, this one is independent and does not have any system impact. A SCAS specification defines the security assurance requirements and corresponding test cases for network equipment implementing one or more 3GPP NFs. For this particular work the target is the Management Function MnF as specified in TS 28.533 [5].

The new Annex V of TR 33.926 [2] for the MnF class of network products describes the assets and identifies two new specific threats to such products in addition to the ones pertaining to the generic network product model of [2].

The new SCAS MnF specification in TS 33.526 [1] describes the specific security assurance requirements and related test cases for such a class of products. As for any other SCAS specification, this is done with reference to the generic requirement and test catalogue in TS 33.117 [6]. For the MnF product class, most of these generic requirements and tests cases could be reused except for few network features and interfaces where they were deemed not applicable for MnF products.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=940014

[1] TS 33.526: "Security assurance specification for the Management Function (MnF)"
[2] TR 33.926: "Security Assurance Specification (SCAS) threats and critical assets in 3GPP network product classes"
[3] TR 33.916: "Security Assurance Methodology (SECAM) for 3GPP network products"
[4] SP-201085 "Terms of Reference (ToR) for TSG SA WG3 (SA3)"
[5] TS 28.533: "Management and orchestration; Architecture framework"
[6] TS 33.117: "Catalogue of general security assurance requirements"

28.6 5G performance measurements and KPIs phase 3

960025	**5G performance measurements and KPIs phase 3**	PM_KPI_5G_Ph3	S5	SP-220690	**Chen, Xiumin, China Telecom**

Summary based on the input provided by China Telecom in SP-240329.

This work item is the continuation of 5G performance measurements and KPIs work items from Release 17. It focuses on the following main topics:

- New 5G performance measurements and KPIs to support monitoring of 5G advanced features.

- Further enhancement for performance data streaming, including GPB serialization format.

- New UE level measurements and collection/reporting mechanisms updates.

The 5G performance measurements and KPIs, which are essential for performance assurance, need to be enhanced to support monitoring of 5G advanced features. On the other hand, there are still some performance measurements and KPIs missing for some features defined in Rel-17. Moreover, the GPB (Google Protocol Buffers) encoding has been used widely in the industry for data streaming (e.g., for Trace and MDT data streaming). The GPB encoding is needed to define for performance data streaming.

Additionally, new UE level measurements are needed to enable ML model training at OAM to support 1) AI/ML functionalities in NG-RAN as defined by 3GPP RAN3 WG, and 2) analytics conducted by NWDAF.

PM_KPI_5G_Ph3 specifies:

1. The new or enhanced 5G performance measurements are defined for NG-RAN and 5GC in Rel-18 in TS 28.552 [1], covering the following aspects:

   For NG-RAN: SRS-RSRP measurement, MIMO layers coverage map, UL packet delay, PRB Usage, SDU packets measurement, NgU data volume, Dual Connectivity, DL GTP packet delay, MRO management, per SSB RSRQ and SINR measurements, UE throughput, paging measurement, packet loss rate, Idle-state RRC release, Inter SN CPC preparation, QoS flow release, average value of Timing Advance, connected mode power saving Wake-Up Signal management, UAI management

   For SMF: MA PDU sessions for ATSSS

   For UPF: UL packet delay

2. New KPIs for TS 28.554 [2] to support monitoring of 5G advanced features, including throughput for Network Slice at gNB; KPI on air-interface efficiency based on MCS; KPIs for Inactive and Idle Mode Paging Accessibility; and KPI on average air-interface efficiency for NRCellDU.

3. Performance data streaming schema is enhanced in TS 28.550 [3], including the update of the ASN.1 definition for performance data stream units and the addition of GPB schema for performance data stream units.

4. UE level measurements in a new TS 28.558 [4] and collection and reporting mechanisms, including

- UE level measurement: Packet delay between PSA UPF and UE, between PSA UPF and NG-RAN, and between NG-RAN and UE; UE throughput; Packet loss for split/non-split gNB deployment scenario.

- The collection/reporting mechanisms: enhancements on TraceJob for UE level measurements collection in TS 28.622 [5], 28.623 [6]; and extension of Trace for UE level measurements collection in TS 32.423 [7], TS 32.422 [8].

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=960025

[1] TS 28.552: “Management and orchestration; 5G performance measurements”
[2] TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)."
[3] TS 28.550: "Management and orchestration; Performance assurance".
[4] TS 28.558: "Management and orchestration; UE level measurements for 5G system".
[5] TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[6] TS 28.623: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Solution Set (SS) definitions".
[7] TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".
[8] TS 32.423: "Telecommunication management; Subscriber and equipment trace; Trace data definition and management".

28.7 Access control for management service

930033	**Access control for management service**	**MSAC**	**S5**	SP-210859	**Jing Ping, Nokia**
890016	*Study on access control for management service*	FS_MNSAC	S5	SP-200853	**Jing Ping, Nokia**
930010	Access control for management service	MSAC	S5	SP-210859	**Jing Ping, Nokia**

Summary based on the input provided by Nokia in SP-240247.

This Work Item introduces the access control capabilities for Management Services developed in 3GPP SA5. This work item has been instigated from 3GPP SA3 where the need for access control for Management Services developed was elaborated in more detail. Post a detailed study in Rel -17 as part of [2], the work item took shape in Rel-18. A TS has been created in [1] which defines the basic concepts as well as implementing access control moving from Stage 1, Stage 2 and Stage 3.

The work item on access control of Management Services exhibits the below:

- The stage 1 lays the foundation of access control with the Role Based Access Control (RBAC) concept. It furthers explains the interaction of the authentication and authorization function and related security information required across the consumers and producers to achieve access control. The requirements cater to access control of the NRM (Network Resource Model) objects in the network management system. Additionally, the implicit and explicit authentication and authorization mechanisms are introduced in [3].

- The TS in [1] opens up the information model in stage 2 to define the required classes related to identity, roles and access rules as well as their dependencies. Access rules define allowed CRUD operations for interacting with a NRM, and notifications and performance metrics that a MnS consumer is allowed to receive.

- Further, stage 3 elaborates the REST based solution of the design for the required infrastructure to be in place for access control with the use of access rules. Refer to [1] and the below link for the SA5 Forge repository: https://forge.3gpp.org/rep/sa5/MnS.

References

List of related CRs:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=930033,890016,930010

[1] TS 28.319: “Access control for Management services”
[2] TR 28.817: “Study on access control for management service”
[3] TS 28. 533: “Management and orchestration; Architecture framework”

28.8 Management Aspects related to NWDAF

990031	Management Aspects related to NWDAF	MANWDAF	S5	SP-230181	**Niu, Yuxia, China Telecom**
940034	*Study on Enhancement of the management aspects related to NWDAF*	FS_MANWDAF	S5	SP-211435	**ZHAO, Song, China Telecom**

Summary based on the input provided by China Telecom in SP-240219.

This work item is the Phase I work on the management aspects related of NWDAF. It is based on the recommendation provided in TR 28.864[1] which introduces the potential management enhancements to monitor the NWDAF deployed in the system.

The NWDAF was first introduced in the Rel-15. As the requirement on network automation kept increasing and the solutions based on artificial intelligence becoming more and more feasible, the NWDAF is expected to play a very unique and important role when deployed in the 5GC.

In order to provide the necessary management of the NWDAF deployed in the system, this work item focuses on the NRM enhancements for NWDAF and the Performance Management(PM) enhancements to support the features of NWDAF introduced in Rel-17.

The NRM enhancements update the NWDAFFunction IOC to support the logical decomposition of the NWDAF deployed and the coordination between multiple NWDAFs.

- In order to support logical decomposition, the NWDAFFunction IOC is updated to reflect the possible combinations of the services provided by NWDAF, so that the NWDAF instance deployed for inference (i.e the NWDAF contains the AnLF) and the NWDAF instance deployed for model training (i.e. the NWDAF contains MTLF) can be distinguished for different management purpose, such as resource allocation.

- In order to support the coordination between multiple NWDAFs, the NWDAFFunction IOC is updated to reflect the role of a NWDAF in the coordination relationship, i.e the Aggregator NWDAF, FL Client NWDAF or FL Server NWDAF.

The PM enhancements are to provide the measurement about NWDAF on two aspects:

- Statistic information on the requesting and responding of a specific NWDAF service. The NWDAF service include the analytic service on a specific analytic purpose provided to the other NFs in 5GC or to the other NWDAFs, the model provisioning services and the data management services towards a specific data source.

- The time related measurements and the event counters for the time sensitive inference services and time-consuming model provisioning services provided by NWDAF.

The NRM enhancements are specified in TS 28.541[2] and the PM enhancement are specified in TS 28.552[3] and the corresponding changes on YAML are updated on Forge.

References

List of related CRs: select “TSG Status = Approved” in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990031

[1] TR 28.864: “Study on Enhancement of the management aspects related to NWDAF”
[2] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3”
[3] TS 28.552: “Management and orchestration; 5G performance measurements”

28.9 Management Aspect of 5GLAN

950030	*Study on Management Aspect of 5GLAN*	FS_5GLAN_Mgt	S5	SP-220324	**Xiaowen Sun, CMCC**
990027	Management Aspect of 5GLAN	5GLAN_Mgt	S5	SP-230175	**Yushuang Hu, CMCC,**

Summary based on the input provided by China Mobile in SP-240423.

5G LAN-type service requirement has been specified in TS 22.261[1]. 5G LAN-type services have also been specified in TS 23.501[2] and TS 23.502[3]. This work item added management enhancements to support the capability of 5G LAN-type services in TS 28.541[4], TS 28.552 [5], TS 28.554 [6].

This work item specifies the 5G management system enhancements to support 5G LAN-type services , specified in TS 28.541[4], TS 28.552 [5], TS 28.554 [6]. It includes the following aspects:

- Enhance the SMF to support the identification of 5G VN groups in NRM IOC for 5G VN group communication.

- The performance measurements and KPIs for SMF, UPF, and NEF are being enhanced to include sub-counters for 5G VN group communication..

- The adding, updating and deleting management operations are considered as the management capability for OAM to support the 5G VN group member management.

References

List of related CRs: select “TSG Status = Approved” in:

https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=990027

[1] TS 22.261: "Service requirements for next generation new services and markets; Stage 1".
[2] TS 23.501 "System architecture for the 5G System (5GS)".
[3] TS 23.502: "Procedures for the 5G System; Stage 2".
[4] TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".
[5] TS 28.552: "Management and orchestration; 5G performance measurements".
[6] TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)"3 Definitions of terms, symbols and abbreviations.

28.10 Management Data Analytics phase 2

970031	**Management Data Analytics phase 2**	eMDAS_Ph2	S5	SP-220981	**Yao, Yizhi, Intel**

Summary based on the input provided by Thales in SP-240203.

The MDA is a management functionality that utilizes the collection of current and historical management and network data (including e.g., communication service, slicing, management and/or network functions related data) to perform analytics that could enable intelligent and automated network operations and service assurance.

MDA allows a consumer, referred to according to the Management Based Service Architecture (MBSA) terms as “MnS consumer”, to request and obtain analytics related to a specific use case (MDA type).

SA5 has accomplished a comprehensive study of MDA feature in TR28.809 [1] leading to the initiation of the Rel-17 enhanced MDA (eMDAS) normative work, which is documented in TS 28.104 [2].

Rel-17 specification addressed the following:

- MDA functionality and service framework,

- MDA role in the management loop,

- MDA capabilities related to coverage related analytics, SLS analysis, MDA assisted fault management, MDA assisted Energy Saving, MDA assisted mobility management, and MDA assisted critical maintenance management,

- MDA MnS for MDA requesting and output reporting.

Rel-18 work item addressed additional new use cases and requirements and introduced further enhancements to the MDA functionality and services in terms of MDA request and control as well as the support for cross-domain analytics.

The Rel-18 MDA phase 2 (eMDAS_Ph2) introduced number of enhancements including,

- New use cases and corresponding requirements including the corresponding enabling (input) data and analytics output (MDA reports). The new use cases include:

- Prediction and statistics of existing management data including Mobility management performance related predictions, Coverage related predictions, SLS prediction, Critical maintenance management related predictions and Energy saving predictions,

- NF resource utilisation analyses (including physical & virtualised resources analyses), and 5GC Control plane congestion analysis.

- Enhancements to MDA request and control:

- adding the capability to allow an authorized MDA MnS consumer to indicate the scope for which no recommendations shall be included in the analytics report, and

- flexibility to configure the MDA reporting control to provide analytics indefinitely.

- Enhancements relating to service experience and service failure recovery MDA capabilities to support analytics across, or within domains.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=970031

[1] TR28.809: “Study on enhancement of management data analytics”

[2] TS28.104: “Management and orchestration; Management Data Analytics (MDA)”

28.11 5G System Enabler for Service Function Chaining

980115	**5G System Enabler for Service Function Chaining**	**SFC**		SP-220802	**Meghashree Dattatri Kedalagudde, Intel**
970012	**Stage 2 of 5G System Enabler for Service Function Chaining**	**SFC**	**S2**	SP-230120	**Meghashree Dattatri Kedalagudde, Intel**
980091	CT3 aspects of SFC	SFC	C3	CP-231193	**Thomas Luetzenkirchen, Intel**
980092	CT4 aspects of SFC	SFC	C4	CP-231193	**Thomas Luetzenkirchen, Intel**
940052	*Study on System Enabler for Service Function Chaining*	FS_SFC	S2	SP-220415	**Meghashree D Kedalagudde, Intel**
940054	*Study on Extensions to the TSC Framework to support Deterministic Networking (DetNet)*	FS_DetNet	S2	SP-211633	**Miklós, György, Ericsson**
900028	**Support for Service Function Chaining**	SFChain	S1	SP-201040	**Ellen Liao; Intel**

Summary based on the input provided by Intel in SP-240378.

The SFC work item specifies 5GS enhancements to traffic steering policy related to the mechanism enabling traffic steering to the N6-LAN, DN and/or DNAIs associated with N6 traffic routing requirements provided by the AF and exposure to enable AF to request predefined SFC for traffic flow(s) related to target UE(s). The Feature enhancement to 5G core network to support SFC is specified in TS 23.501 [2], TS 23.502 [3] and TS 23.503 [4].

The conclusions of the corresponding study phase are documented in TR 23.700-18 [1].

SA and CT aspects

The following features were specified as part of the SFC work item:

- To enable AF to request predefined SFC for traffic flow(s) related to target UE(s), the Nnef_TrafficInluence API is enhanced to include additionally an SFC policy identifier corresponding to a pre-defined Service Function Chain policy i.e., separate SFC policy identifiers for uplink and downlink traffic of the subscribed traffic.

- The 5GC receives from AF policies associating for one UE, a group of UE(s) or all UE(s) some traffic (filter) with SFC policy IDs together with optional metadata where the PCF checks whether the indicated SFC policy IDs and Metadata correspond to an authorized SFC policy.

- Based on the request from the AF, the PCF determines a policy per SDF/application for the purpose of steering the subscriber's traffic to appropriated N6-LAN service functions deployed by the operator or a 3rd party service provider where the policy is expressed in a Traffic Steering Policy (TSP) IDs that may be different in UL and DL directions.

- The PCF maps the SFC policy identifier to a corresponding identifier within the PCC rule (TSP IDs that refers to a traffic steering behaviour that is configured in the SMF/UPF) and support the N6-LAN traffic steering control and AF-influenced traffic steering control to be applicable to the same traffic simultaneously. The PCF provides the TSP ID(s) and the metadata (if available) in the PCC rules to SMF. The SMF provisions corresponding PDRs, FARs, QERs to support SFC.

- The UPF serving as PSA uses TSP ID to steer traffic over N6-LAN. The UPF performs the necessary actions to enforce the Forwarding Policy. The UPF provides the metadata (if available) together with the traffic sent to the N6-LAN service functions.

References

List of related CRs: select "TSG Status = Approved" in:
https://portal.3gpp.org/ChangeRequests.aspx?q=1&workitem=980115,970012,980091,980092,940052,940054,900028

[1] TR 23.700-18: "Study on system enablers for service function chaining"
[2] TS 23.501: "System architecture for the 5G System (5GS)".
[3] TS 23.502: "Procedures for the 5G System; Stage 2".
[4] TS 23.503: "Policy and charging control framework for the5G System (5GS)".
[5] 3GPP SP-230120: "Revised WID on 5G System Enabler for Service Function Chaining".

28.12 Other Management-centric items

870027	**Enhancement of QoE Measurement Collection**	eQoE	S5	SP-200193	**Bagher Zadeh, Ericsson**
950036	**Enhanced Edge Computing Management**	eECM	S5	SP-230775	**Deepanshu Gautam, Samsung**
940033	Network slice provisioning enhancement	eNETSLICE_PRO	S5	SP-211434	**Deepanshu Gautam, Samsung**
970030	Methodology for deprecation	OAM_MetDep	S5	SP-220843	**Lengyel, Balázs, Ericsson**
990034	**Management of non-public networks phase 2**	OAM_NPN_Ph2	S5	SP-230184	**ZHANG, Kai, Huawei**

Summaries not provided.

890017	*Study on YANG PUSH*	FS_YANG	S5	SP-200765	**Lengyel, Balazs, Ericsson**
910028	*Study on Continuous integration continuous delivery support for 3GPP NFs.*	FS_CICDNS	S5	SP-211427	**Vaishnavi, Ishan, Lenovo**
940035	*Study on enhancement of management of non-public networks*	FS_OAM_eNPN	S5	SP-230185	**ZHANG, Kai, Huawei**
940036	*Study on new aspects of EE for 5G networks Phase 2*	FS_EE5G_Ph2	S5	SP-211440	**Cornily Jean-Michel, Orange**
940038	*Study on Deterministic Communication Service Assurance*	FS_DCSA	S5	SP-211442	**<Zhang>, <Jian>, <Huawei>**
940041	*Study on evaluation of autonomous network levels*	FS_ANLEVA	S5	SP-211445	**Cao Xi, China Mobile**
940042	*Study on enhancement of autonomous network levels*	FS_eANL	S5	SP-211446	**Cao Xi, China Mobile**
940046	*Study on enhanced intent driven management services for mobile networks*	FS_eIDMS_MN	S5	SP-211450	**Xu Ruiyue, Huawei**
950029	*Study on alignment with ETSI MEC for Edge computing management*	FS_MEC_ECM	S5	SP-220147	**Shitao Li, Huawei**
950032	*Study on Management of Cloud Native Virtualized Network Functions*	FS_MCVNF	S5	SP-220150	**China Mobile Guangjing Cao**
950033	Study on Management Aspects of 5G MOCN Network Sharing Phase2	FS_MANS_ph2	S5	SP-220151	**Zhaoning Wang, ChinaUnicom**
1000012	Management Aspects of 5G Network Sharing Phase2	MANS_ph2	S5	SP-230629	**Wang Zhaoning, China Unicom,**
950034	*Study on Management of Trace/MDT phase 2*	FS_5GMDT_Ph2	S5	SP-230773	**Sivaramaskrishnan Swaminathan, Nokia**
950035	*Study on Fault Supervision Evolution*	FS_FSEV	S5	SP-220153	**Deng LingLi (China Mobile)**
960024	*Study on measurement data collection to support RAN intelligence*	FS_MEDACO_RAN	S5	SP-220488	**Chou, Joey, Intel**
970029	*Study on Data management phase 2*	FS_MADCOL_ph2	S5	SP-220842	**Pollakowski, Olaf, Nokia**

Summaries not expected.

29 Charging-centric Features

29.1 Introduction

This section presents all the standalone charging functionalities. Charging Management aspects related to other features are reported in the relevant section. For instance, charging management for “Network Slicing" is reported in the section on " Network Slicing" .

29.2 Charging Aspects of B2B

1010015	**Charging Aspects of B2B**	B2B_CH	S5	SP-231155	**Deng, Yimeng, Huawei**

Summary based on the input provided by Huawei in SP-240074.

This work item specifies the structure of B2B charging, by describing the reference of the applicable charging principles and architectures for B2B charging, and specifying the common charging information for B2B charging.

Three B2B charging architectures and related charging principles are described in the Annex G in TS 32.240 [1].

The first architecture supports the direct interaction between NF(CTF) and B-CHF, described in TS 32.240 [1] Annex G.2.2.

The second architecture supports the intermediate interaction between NF(CTF) and B-CHF via C-CHF, described in TS 32.240 [1] Annex G.2.3.

The third architecture supports the intermediate interaction between NF(CTF) and C-CHF via B-CHF, described in TS 32.240 [1] Annex G.2.4.

The interaction between CHFs is supported by the Nchf service-based interface in TS 32.290 [3]. To support the identification of business subscriber, the “tenant identifier” is specified as a common charging information, specified in TS 32.290 [2] Table 7.1.

References

[1] TS 32.240: "Telecommunication management; Charging management; Charging architecture and principles".
[2] TS 32.290: "Telecommunication management; Charging management; 5G system; Services, operations and procedures of charging using Service Based Interface (SBI).

29.3 CHF Distributed Availability

990029	CHF Distributed Availability	DIST_CH	S5	SP-230179	**João Rodrigues, Nokia**

Summary based on the input provided by Nokia in SP-240413.

This work item describes how CHF can be deployed in a distributed manner in order to support:

- Use cases that require real-time charging (e.g. URLLC)
- Workload distribution across 5GS (increase redundancy and availability)
- UE mobility between Edges
- Distributed CCS discovery

3GPP SA2 has specified in TS 23.501 the CHF discovery and selection which enables the capability to choose between different Charging Function (CHF) instances (as part of a CHF group), which would allow the possibility to select a CHF in different locations, though it is not possible to have more than one Rating Function (RF) or Account Balance Management Function (ABMF) close either to CHF or even to Edge, which would lead to flexibility increase of 5GS and Converged Charging System (CCS) by allowing the distribution of RF and ABMF.

Currently, the CHF is usually deployed in a centralized model, though, it can be possible to deploy it at the Edge, and this option was unclear, though the current Charging specification did not limit either options. The possibility of deploying the CHF at the Edge is quite relevant for facilitating the support of real-time charging use cases, and would enable the selection of the CHF which is closer to the Edge Enablement Server (EES).

Therefore, a new annex (F) was included in TS 32.240 [1] with the following information:

- Functional architecture of a centralized and Local/Edge CHF Deployment Model. It makes visible the possibility of having the CHF deployment in a distributed manner.

References

[1] TS 32.240: " Charging management; Charging architecture and principles"

29.4 Other Charging-centric items

960023	**Multimedia Messaging Service Charging using service-based interface**	MMS_CH_SBI	S5	SP-220689	**Törnkvist, Robert, Ericsson AB**
1010017	**Charging for roaming and additional actor using CHF to CHF interface**	CHRACHF	S5	SP-231153	**Törnkvist, Robert, Ericsson AB**

No summary provided.

980026	*Study on CHF Segmentation*	FS_CHFSeg	S5	SP-221160	**João Rodrigues, Nokia**

920020	*Study on Nchf charging services phase 2*	FS_NCHF_Ph2	S5	SP-210390	**Tornkvist, Robert, Ericsson AB**
920021	*Study on 5G roaming charging architecture for wholesale and retail scenarios*	FS_CHROAM	S5	SP-210391	**Tornkvist, Robert, Ericsson AB**

No summary expected.

30 Other Rel-18 Topics

Specific items such as signalling improvements or Studies are not summarised in this document.

These are:

960055	**Stage-3 5GS NAS protocol development 18**	**5GProtoc18**		CP-221268	**Sedlacek, Ivo, Ericsson,**
960007	Stage-3 5GS NAS protocol development 18 general aspects	5GProtoc18	C1	CP-221268	**Sedlacek, Ivo, Ericsson,**
960056	Stage-3 5GS NAS protocol development 18 non 3GPP aspects	5GProtoc18-non3GPP	C1	CP-221268	**Sedlacek, Ivo, Ericsson,**
960057	**Stage-3 SAE Protocol Development**	**SAES18**		CP-221269	**Sethi, Anuj, InterDigital**
960008	Stage-3 SAE Protocol Development general	SAES18	C1	CP-221269	**Sethi, Anuj, InterDigital**
960058	Stage-3 SAE Protocol Development CSFB	SAES18-CSFB	C1	CP-221269	**Sethi, Anuj, InterDigital**
960059	Stage-3 SAE Protocol Development non 3GPP	SAES18-non3GPP	C1	CP-221269	**Sethi, Anuj, InterDigital**
960009	**Protocol enhancements for Mission Critical Services**	**MCProtoc18**		CP-232163	**AXELL, Jörgen, Ericsson**
980105	CT1 aspects of MCProtoc18	MCProtoc18	C1	CP-232163	**Magnus Tränk, Ericsson**
980106	CT3 aspects of MCProtoc18	MCProtoc18	C3	CP-232163	**Magnus Tränk, Ericsson**
980107	CT4 aspects of MCProtoc18	MCProtoc18	C4	CP-232163	**Magnus Tränk, Ericsson**
970035	**IMS Stage-3 IETF Protocol Alignment**	**IMSProtoc18**		CP-223102	**Won, Sung Hwan, Nokia**
970047	CT1 aspects of IMSProtoc18	IMSProtoc18	C1	CP-223102	**Won, Sung Hwan, Nokia**
970048	CT3 aspects of IMSProtoc18	IMSProtoc18	C3	CP-223102	**Won, Sung Hwan, Nokia**
980004	**Enhancement of Shared Data ID and Handling**	ShDatID_H	C4	CP-232030	**Jing, Hao, Huawei**
1010003	Study on IMS Disaster Prevention and Restoration Enhancement	FS_IMS_RES	C4	CP-232281	**Liu, Liu, China Telecom**
1010026	**Modified PRINS for roaming service providers in 5G**	**Roaming5G**	**S1**	SP-231190	**Targali, Yousif, Verizon**
1010027	Stage 1 of Roaming5G	Roaming5G	S1	SP-231190	**Targali, Yousif, Verizon**
1010028	Stage 3 of Roaming5G	Roaming5G	S3	SP-231190	**Targali, Yousif, Verizon**

0	**Rel-18 RAN Studies**	-		-	**-**
991031	*Study on enhancement for sub-1GHz NR band combinations*	FS_NR_sub1GHz_combo_enh	R4	RP-231141	**Zhang, Peng, Huawei**
991030	*Study on self-evaluation towards the IMT-2020 submission of the 3GPP Satellite Radio Interface Technology*	FS_IMT2020_SAT_eval	RP	RP-231945	**Asbj rn Gr vlen, Ericsson**
970078	*Study on Ambient IoT (Internet of Things) in RAN*	FS_Ambient_IoT_RAN	RP	RP-232404	**Matthew Webb, Huawei**
950067	*Study on simplification of band combination specification for NR and LTE*	FS_SimBC	R4	RP-231468	**Zhifeng Ma, ZTE Corporation**
950068	*Study on NR frequency range 2 (FR2) Over-the-Air (OTA) testing enhancements*	FS_NR_FR2_OTA_enh	R4	RP-230814	**Bin Han, Qualcomm**
950069	*Study on NR base station (BS) RF requirement evolution*	FS_NR_BS_RF_evo	R4	RP-222501	**Liehai Liu, Huawei**

950070	*Study on enhancement for 700/800/900MHz band combinations for NR*	FS_NR_700800900_combo_enh	R4	RP-222554	**Huiping Shan, CATT**
780060	*Study on 6 GHz for LTE and NR*	FS_6GHz_LTE_NR	RP	RP-230415	**Dominique Everaere, Ericsson**
850071	*Study on enhanced test methods for FR2 NR UEs*	FS_FR2_enhTestMethods	R4	RP-221574	**Anatoliy IOFFE, Apple Inc**
890040	*Study on efficient utilization of licensed spectrum that is not aligned with existing NR channel bandwidths*	FS_NR_eff_BW_util	R4	RP-222618	**Esther Sienkiewicz, Ericsson**

Annex A:
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2023-12	TSG#102					Initital draft, call for contributions	0.1.0
2024-02	TSG#103					Inclusion of summaries approved/endorsed at TSG#102, i.e.: RP-232792 WI Summary NR RF requirements enhancement for frequency range 2 (FR2), Phase 3 Nokia, Xiaomi => not implementable (it covers only Stage 1, not the Feature) RP-232865 WI summary for NR Timing Resiliency and URLLC enhancements Nokia, Nokia Shanghai Bell. RP-232884 WI summary for NR network-controlled repeaters ZTE. RP-232914 WI summary for WI Core part: NR MIMO evolution for downlink and uplink Samsung. RP-232939 WI summary for 4Rx handheld UE for low NR bands (<1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC OPPO -> incorporated but e-mail sent 14/02 to ask to rewrite RP-232943 WI summary: Mobile Terminated-Small Data Transmission (MT-SDT) for NR ZTE Corporation (rapporteur). RP-232973 WI Summary for NR Sidelink Relay Enhancements LG Electronics. RP-232988 WI Summary for XR Enhancements Nokia (Rapporteur) RP-232994 WI summary for Enhancements of NR Multicast and Broadcast Services CATT RP-233072 WI summary: Dual Transmission Reception (TxRx) Multi-SIM for NR vivo -> moved to Rel-18 also in WP (was Rel-17) RP-233074 WI summary: Enhancement of UE TRP (Total Radiated Power) and TRS (Total Radiated Sensitivity) requirements and test methodologies for FR1 (NR SA and EN-DC)vivo RP-233188 WI summary for Further RF requirements enhancement for NR and EN-DC in frequency range 1 (FR1) Huawei, HiSilicon, NTT DOCOMO, INC. RP-233257 WI Summary: Further enhancements on NR and MR-DC measurement gaps and measurements without gaps Rapporteur (MediaTek, Intel corporation) RP-233261 WI summary: IoT (Internet of Things) NTN (non-terrestrial network) enhancements Rapporteur (MediaTek) RP-233308 WI summary for Introduction of the satellite L-/S-band Apple, Globalstar RP-233321 WI summary for Mobile IAB for NR Qualcomm Incorporated RP-233387 WI Summary for Rel-18 NR Support for UAV (Uncrewed Aerial Vehicles) Nokia, Nokia Shanghai Bell RP-233390 WI Summary for Enhanced LTE Support for UAV (Uncrewed Aerial Vehicles) Nokia, Nokia Shanghai Bell RP-233439 WI summary for Further enhancement of data collection for SON (Self-Organising Networks)/MDT (Minimization of Drive Tests) in NR standalone and MR-DC (Multi-Radio Dual Connectivity) CMCC RP-233442 WI summary for WI Artificial Intelligence (AI)/Machine Learning (ML) for NG-RAN CMCC, Ericsson RP-233444 WI summary of R18 ATG CMCC RP-233486 WI Summary for In-Device Co-existence (IDC) enhancements for NR and MR-DC Xiaomi RP-233495 WI summary of R18 Even Further RRM enhancement for NR and MR-DC Apple RP-233547 WI summary: Multi-carrier enhancements for NR NTT DOCOMO, INC. RP-233559 WI Summary for Further NR coverage enhancements China Telecom RP-233568 WI Summary for Non-Public Networks Phase 2 NG-RAN aspects China Telecom RP-233585 WI summary for NR demodulation performance evolution China Telecom RP-233604 WI Summary for Enhancement on NR QoE management and optimizations for diverse services China Unicom RP-233638 WI summary for Enhanced support of reduced capability NR devices Ericsson RP-233657 WI summary for Network energy savings for NR Huawei, HiSilicon	

						RP-233684 WI summary on BS/UE EMC Enhancements for NR and LTE Ericsson LM RP-233713 WI Summary for Addition of FDD bands using the uplink from n28 and the downlink of n75 and n76 Vodafone RP-233743 WI Summary for Enhancement of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) test methodology and requirements for NR UEs CAICT RP-233798 WI summary for Adding new NR FDD bands for RedCap (Reduced Capability) in Rel-18 Ericsson RP-233808 WI summary for Rel18 WI on Enhancement of NR Dynamic spectrum sharing (DSS) Ericsson RP-233859 WI summary for Enhancements of NR shared spectrum bands Apple RP-233926 WI summary: Requirement for NR frequency range 2 (FR2) multi-Rx chain DL reception Qualcomm RP-233947 WI summary: Core part: Network Slicing Phase 3: NR aspectsZTE RP-233982 WI summary for Rel-18 NR Sidelink Evolution Rapporteur (OPPO) RP-234000 WI summary for Complete the specification support for BandWidth Part operation without restriction in NR Vodafone, vivo RP-234062 WI Summary for NR support for dedicated spectrum less than 5MHz for FR1 Nokia, Nokia Shanghai Bell RP-234071 WI summary: NR channel raster enhancement Ericsson SP-231516 Template for contributing to TR 21.918 ('Release 18 Description') MCC (Work Plan Manager) SP-231535 Summary of R18 eNS_Ph3 ZTE, LG Electronics SP-231536 Summary of R18 eNSAC ZTE Corporation SP-231582 Summary for Low Power High Accuracy Positioning for Industry IoTHuawei SP-231586 Summary for Personal IoT Networks vivo SP-231590 Summary for PINAPP vivo SP-231591 Summary for Rel-18 Enhancements of EE for 5G Phase 2 Huawei SP-231592 Summary for Rel-18 Intent driven Management Service for Mobile Network phase 2 Huawei SP-231613 Summary for 5GSATB CATT SP-231614 Summary for TEI18_DCAMP_Ph2 China Telecomunication Corp. SP-231615 Summary for AMP China Telecom Corporation Ltd. SP-231621 Summary for Security Assurance Specification for Management Function Huawei Tech.(UK) Co.. Ltd SP-231635 Summary for Automated Certificate Management in SBA Nokia, Nokia Shanghai Bell SP-231655 Summary for the IETF OSCORE protocol profiles for GBA and AKMA L.M. Ericsson Limited CP-233299 Template for contributing to TR 21.918 ("Release 18 Description") ETSI MCC (Work Plan Manager) CP-233306 Summary for UE pre-configuration for 5MBS Huawei /Christian (rapporteur) CP-233318 WI Summary - eNS_UICC Thales	
2024-06	TSG#104					Inclusion of summaries endorsed at TSG#103, i.e.: RP-240077 WI summary for High Power UE (Power Class 2) for LTE FDD Band 14 RP-240100 WI summary for Support of intra-band non-collocated EN-DC NR-CA deployment RP-240138 Updated WI summary: Enhancement of UE TRP (Total Radiated Power) and TRS (Total Radiated Sensitivity) requirements and test methodologies for FR1 (NR SA and EN-DC) RP-240303 WI summary for WI Core part: Expanded and Improved NR positioning RP-240306 Updated WI summary for 4Rx handheld UE for low NR bands (<1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC RP-240444 WI summary: Further NR mobility enhancements SP-240069 Summary for Self-Configuration of RAN network entities SP-240070 Summary for Guidelines for Extra-territorial 5G Systems SP-240071 Summary for Additional NRM features phase 2 SP-240072 Work Item Summary of 5G Real-time Media Transport Protocol Configurations (5G_RTP) SP-240074 Summary for Rel-18 B2B Charging SP-240075 Summary for Rel-18 TSN Charging SP-240142 Summary for Rel-18 Service based management architecture SP-240189 Summary for IETF DTLS protocol profile for AKMA and GBA	0.3.0

						SP-240203 Summary for Management Data Analytics (MDA) phase 2 SP-240204 Summary for AI/ML management SP-240206 Summary for Rel-18 AIMLsys SP-240207 Summary for AIMLsysNEF_CH SP-240209 Summary for Media Capabilities for Augmented Reality SP-240218 Work Item Summary for Multiparty Real-Time Text (MP_RTT) SP-240219 Summary for Management Aspects related to NWDAF SP-240247 Summary for Access Control for Management Services SP-240249 Summary for Management aspects of 5G system supporting satellite backhaul SP-240283 Summary for Management of cloud-native Virtualized Network Functions SP-240285 Summary for Management aspects of NTN SP-240286 Summary for Management of Trace/MDT phase 2 SP-240289 Summary for work item NR RedCap UE with long eDRX for RRC_INACTIVE state SP-240323 Charging Aspects of Network Slicing Phase 2 SP-240324 Charging Aspects of NSSAA SP-240326 Summary for Smart Energy and Infrastructure SP-240327 Summary for 5G performance measurements and KPIs phase 3 SP-240328 Summary for TEI18_MBS4V2X SP-240333 Summary for Charging Aspects of IMS Data Channel SP-240334 Summary for Charging Aspects for Enhanced Support of Non-Public Networks SP-240336 Summary for Charging Aspects for SMF and MB-SMF to Support 5G Multicast-broadcast Services SP-240337 Summary for RNAA SP-240378 Summary for WI 5G System Enabler for Service Function Chaining SP-240380 Feature summary for Network and Service Operations for Energy Utilities SP-240381 Summary for Enhanced support of Non-Public Networks Phase 2 SP-240382 Summary for Wireless and Wireline Convergence Phase 2 SP-240383 Summary for Secondary DN Authentication and authorization in EPC IWK cases SP-240387 Summary for 5G_ProSe_Ph2 SP-240389 Summary of R18 5G_eLCS_Ph3 SP-240390 Charging enhancement for Network Slice based wholesale in roaming SP-240392 Summary for Signal level Enhanced Network Selection - SENSE SP-240400 Summary for charging aspects of Satellite Access in 5GS SP-240401 Summary for charging aspects of Satellite Backhaul in 5GS SP-240402 Summary for 5GSAT_Ph2, SA part SP-240413 Summary for CHF Distributed Availability SP-240415 Summary for Security Aspects of the 5G Service Based Architecture Phase 2 SP-240423 Summary for Management Aspect of 5GLAN SP-240428 Summary for WI 5G-Advanced media PROfiles for MessagIng SErvices (PROMISE) SP-240468 Summary for WI Enhancement of 5G UE Policy CP-240084 Summary for eSMS_SBI CP-240303 Summary for "NRF API enhancements to avoid signalling and storing of redundant data" CP-240304 Summary for Rel-18 WID ShDatID_H	
2024-06	TSG#103					Added: SP-240143Summary for Management part of non-public networks phase 2 RP-232943 941100 Core part: Mobile Terminated-Small Data Transmission (MT-SDT) for NR NR_MT_SDT-Core R2 RP-232994 940199 Core part: Enhancements of NR Multicast and Broadcast Services NR_MBS_enh-Core R2 RP-231731 950179 Core part: Enhanced NR support for high speed train scenario in frequency range 2 (FR2) NR_HST_FR2_enh-Core R4 RP-232865 991136 Core part: NR Timing Resiliency and URLLC enhancements_TRS_URLLC-NR-Core_R3	0.4.0
2024-07	Post TSG#104					Cleaning-up of SA5-related issues Renumber 29.x in 28.x	1.0.0

						Inclusion of summaries endorsed/approved at TSG#104, i.e.: RP-240922 WI summary for REL-18 WI NR NTN (Non-Terrestrial Networks) enhancements THALES SP-240576 Network Slice Replacement charging MATRIXX Software SP-240700 Summary for WI 'Immersive Audio for Split Rendering Scenarios (ISAR)' Dolby Sweden AB (Rapporteur) SP-240779 Summary for Immersive Real-time Communication for WebRTC Samsung R&D Institute UK SP-240781 Summary for NSCALE China Mobile Com. Corporation SP-240782 Summary for 5G Security Assurance Specification (SCAS) for the Policy Control Function (PCF) BSI (DE) SP-240783 Summary of Tactile and multi-modality communication services China Mobile SP-240798 Summary for 5GMARCH_Ph2 China Mobile SP-240854 Summary for 5G Timing Resiliency System (5TRS) Nokia SP-240860 Summary for WI 'Enhancements to UE Testing' (eUET) HEAD acoustics GmbH, Orange (Rapporteurs) SP-240863 Summary for Rel-18 EDGEAPP_Ph2 Samsung R&D Institute India SP-240866 Summary for IMS-based AR Conversational Services (IBACS) KPN N.V. SP-240867 Summary for Rel-18 5G-enabled fused location service capability exposure CATT SP-240869 Summary for 5G system with satellite access to Support Control and/or Video Surveillance Xiaomi SP-240882 Summary for SA WG3 SCAS_5G_Ph2 Huawei SP-240883 Summary for SA WG3 UC3S_SEC_Ph2 Huawei SP-240884 Summary for SA WG3 SEALDDHuawei SP-240885 Summary for SA WG3 HN_Auth Huawei SP-240886 Summary for SA WG3 NG_RTC_SEC Huawei SP-240887 Summary for SA WG3 EDGE_Ph2 Huawei SP-240888 Summary for PALS Qualcomm SP-240889 Summary for UAS-ph2 Qualcomm SP-240892 Summary for SCAS for split gNB Qualcomm SP-240893 Summary for VMR Qualcomm SP-240894 WI summary for Split Rendering Media Service Enabler Qualcomm SP-240895 Summary for WI '5G Media Streaming Protocols Phase 2 (5GMS_Pro_Ph2)' Qualcomm, Tencent, BBC SP-240896 Summary for UPF enhancement for Exposure and SBA China Mobile SP-240897 Summary for Architecture Enhancements for XR (Extended Reality) and media service China Mobile SP-240898 Work Item Summary for EVS Codec Extension for Immersive Voice and Audio Services (IVAS_Codec) Huawei Technologies Co., Ltd. (Rapporteur) SP-240901 Summary for SCAS_5G_AAnF China Mobile SP-240902 Summary for AKMA_Ph2 China Mobile SP-240903 Summary for SECAM and SCAS for 3GPP virtualized network products China Mobile SP-240905 Summary for Rel-18 ADAES Lenovo SP-240907 Summary for Ranging-based Service and sidelink positioning Xiaomi SP-240930 Summary for UASAPP_Ph2Interdigital CP-241235 Summary for Rel-18 WID MPSSupServ Peraton Labs CP-241259 Work Item Summary for eNetAE Huawei CP-241263 Work Item Summary for SMPC18 Huawei CP-241265 Summary for Rel-18 WID UEP18 Ericsson GmbH, Eurolab CP-241268 Summary for GBA_U Based APIs China Mobile CP-241275 Summary for Rel-18 Enhancements of 3GPP Northbound Interfaces and Application Layer APIs Huawei	
2024-08						Clean-up, in particular with respect to OAM aspects	1.1.0
2024-09	TSG#105	CP-242240 / RP-242331 / SP-241065				Further clean-up, deletion of duplicated sections	1.2.0
2024-09	TSG#105	SP-241053				Correction on ADAES (had wrong header, misplaced)	1.2.1
2025-01	Post TSG#106					Added:	2.0.0

						SP-241076 Summary for Interconnection and Migration Aspects for Railways (IRail) Nokia SP-241077 Summary for Gateway UE function for Mission Critical Communication (MCGWUE) Nokia SP-241079 Summary for Mission Critical Security Motorola Solutions, Inc SP-241080 Summary for FFAPP ZTE Corporation SP-241161 Summary for EXPOSE - Service exposure interfaces for industry Siemens AG SP-241291 Summary for MPS when access to EPC/5GC is WLAN Peraton Labs SP-241297 Summary for Rel-18 SEAL_Ph3 Samsung SP-241309 Summary for TEI18_SLAMUP Oracle, China Telecom SP-241311 Summary for Rel-18 SUECR Samsung SP-241337 Summary for Rel-18 AHGC Samsung SP-241341 Summary for Generic group management, exposure and communication Huawei (rapporteur) SP-241342 Summary for SEAL data delivery enabler for vertical applications Huawei (rapporteur) SP-241343 Summary for Mission critical services over 5GProse Huawei (rapporteur) Not included (this is a Rel-19 Feature): SP-241623 UPEAS_Ph2 WID summary ZTE, Vodafone	
2025-03	TSG#107	CP-250239 ; RP-250759 ; SP-250317				Inclusion of: pCR in SP-241858 on Charging aspects. 970014 System architecture for Next Generation Real time Communication services NG_RTC SP-241683 Summary for ATSSS Phase 3 Lenovo Missing Summaries : 960011 Edge Application Standards in 3GPP and alignment with External Organizations EDGEAPP_EXT 830005 Terminal Audio quality performance and Test methods for Immersive Audio Services ATIAS 980009 5G Media Streaming Audio codec phase 2 for 5G-Advanced 5GMS_Audio_Ph2 960047 5G Media Streaming Architecture Phase 2 5GMS_Ph2 920036 Evolution of IMS Multimedia Telephony Service eMMTEL	2.1.0
2025-03	TSG#107	SP-250350				Inclusion of: 960011 Edge Application Standards in 3GPP and alignment with External Organizations EDGEAPP_EXT 980009 5G Media Streaming Audio codec phase 2 for 5G-Advanced 5GMS_Audio_Ph2 960047 5G Media Streaming Architecture Phase 2 5GMS_Ph2 920036 Evolution of IMS Multimedia Telephony Service eMMTEL (no imput received, put assumed covered by NG_RTC summary) Missing: 830005 Terminal Audio quality performance and Test methods for Immersive Audio Services ATIAS	2.2.0
2025-03						Raised to v.18.0.0 following approval of SP-250350 at TSG#107	18.0.0

History

Document history		
V18.0.0	April 2025	Publication