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DECT-2020 New Radio (NR); Part 1: Overview; Release 2

Reference

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Digital Enhanced Cordless Telecommunications (DECT).

The present document is part 1 of a multi-part deliverable covering the DECT-2020 New Radio (NR) technology, as identified below:

- Part 1:** "Overview";
- Part 2: "Radio reception and transmission requirements";
- Part 3: "Physical layer";
- Part 4: "MAC layer";
- Part 5: "DLC and Convergence layers".

DECT-2020 NR is recognized in Recommendation ITU-R M.2150 [i.2] as a component RIT fulfilling the IMT-2020 requirements of the IMT-2020 use scenarios Ultra-Reliable Low Latency Communication (URLLC) and massive Machine Type Communication (mMTC). The Set of Radio Interface Technology (SRIT) called "DECT 5G SRIT" is involving 3GPP NR and DECT-2020 NR.

The present document introduces the system overview covering mMTC and URLLC features.

Modal verbs terminology

In the present document "shall", "shall not", "should", "should not", "may", "need not", "will", "will not", "can" and "cannot" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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1 Scope

The present document provides an overview on DECT-2020 NR including layers, system and network architectures envisioned for this release. Further it provides an overview to ETSI TS 103 636-2 [1], ETSI TS 103 636-3 [2], ETSI TS 103 636-4 [3], ETSI TS 103 636-5 [4] and their interrelation.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

- [1] [ETSI TS 103 636-2](#): "DECT-2020 New Radio (NR); Part 2: Radio reception and transmission requirements; Release 2".
- [2] [ETSI TS 103 636-3](#): "DECT-2020 New Radio (NR); Part 3: Physical layer; Release 2".
- [3] [ETSI TS 103 636-4](#): "DECT-2020 New Radio (NR); Part 4: MAC layer; Release 2".
- [4] [ETSI TS 103 636-5](#): "DECT-2020 New Radio (NR); Part 5: DLC and Convergence layers; Release 2".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI TS 123 501: "5G; System architecture for the 5G System (5GS) (3GPP TS 23.501)".
- [i.2] Recommendation ITU-R M.2150: "Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020)".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

Fixed Termination point (FT): operational mode of RD where RD initiates coordinates local radio resources, provides information how other RDs may connect and communicate with it

operating channel: single continuous part of radio spectrum with a defined bandwidth where RDs transmits and/or receives

Portable Termination point (PT): operational mode of RD where RD selects another RD, which is in FT mode, for association

Radio Device (RD): device with radio transmission and reception capability, which can operate in FT and/or PT mode

resource: variable length time unit defined in subslot(s) or slot(s) in single operating channel that RD is using for transmission or reception of physical layer packet

NOTE: Resource can be contentious or contention free, i.e. scheduled.

sink: RD in FT mode, RD_{FT} , which has internet connectivity

NOTE: The term is used in Mesh operation.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

RD_{FT}	RD operating in FT mode
$RD_{FT,PT}$	RD operating in both FT and PT mode
RD_{PT}	RD operating in PT mode

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3 rd Generation Partnership Project
5G	5 th Generation
ARQ	Automatic Repeat reQuest
BCC	Broadcast Control
BCCH	Broadcast Control CHannel
BLER	BLock Error Ratio
BPSK	Binary Phase Shift Keying
BSC	Beacon Scanning Control
CCC	Connection Configuration Control
CCCH	Common Control CHannel
CP-OFDM	Cyclic Prefix Orthogonal Frequency Division Multiplexing
CRC	Cyclic Redundancy Check
CVG	Convergence (layer)
DCCH	Dedicated Control CHannel
DCH	Dedicated CHannel
DECT	Digital Enhanced Cordless Telecommunications
DL	DownLink
DLC	Data Link Control (layer)
DLC-A	DLC Service type 2: DLC ARQ
DLC-S	DLC Service type 1: Segmentation mode
DLC-T	DLC Service type 0: Transparent mode
DTCH	Dedicated Traffic CHannel

EP	EndPoint
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FP	Fixed Part
FT	Fixed Termination point
GI	Guard Interval
HARQ	Hybrid Automatic Repeat Request
ID	Identity
IE	Information Element
IMT	International Mobile Telecommunications
IoT	Internet of Things
ITU-R	International Telecommunication Union - Radiocommunication sector
LBT	Listen Before Talk
LRC	Local Radio Control
LSB	Least Significant Bit
MAC	Medium Access Control
MCS	Modulation and Coding Scheme
MIMO	Multiple Input Multiple Output
mMTC	massive Machine Type Communication
MSB	Most Significant Bit
MTCH	Multicast (Broadcast) Traffic CHannel
N3IWF	Non-3GPP Inter-Working-Function
NG-RAN	Next Generation RAN
NR	New Radio
OFDM	Orthogonal Frequency Division Multiplexing
PCC	Physical Control Channel
PCCH	Paging Control CHannel
PCH/BCH	Paging and Broadcast CHannel
PDC	Physical Data Channel
PDU	Protocol Data Unit
PHY	PHYsical layer
PLMN	Public Land Mobile Network
PT	Portable Termination point
PTC	Paging Transmission Control
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RAC	Random Access Control
RACH	Random Access CHannel
RAN	Radio Access Network
RD	Radio Device
RF	Radio Frequency
RIT	Radio Interface Technology
RSSI	Received Signal Strength Indicator
RX	Receiver
RX-TX	Receive-Transmit
SAP	Service Access Point
SDU	Service Data Unit
SRIT	Set of RITs
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TNGF	Trusted Non-3GPP Gateway Function
TX	Transmitter
UE	User Equipment
UL	UpLink
ULE	Ultra Low Energy
URLLC	Ultra-Reliable Low Latency Communication
WAN	Wide Area Networks

4 General

4.1 Introduction

DECT-2020 NR is a Radio Interface Technology (RIT) designed to provide a slim but powerful technology foundation for wireless applications deployed in various use cases and markets. This radio interface technology supports all kind of applications including, but not limited to Cordless Telephony, Audio Streaming Applications, Professional Audio Applications, consumer and industrial applications of Internet of Things (IoT) such as industry and building automation and monitoring, utility and smart city applications, and in general solutions for local area deployments (indoor or outdoor) for Ultra-Reliable Low Latency Communication (URLLC) and massive Machine Type Communication (mMTC) as envisioned by ITU-R for IMT-2020.

DECT-2020 NR is recognized in Recommendation ITU-R M.2150 [i.2] as a component RIT fulfilling the IMT-2020 requirements of the IMT-2020 use scenarios URLLC and mMTC. The Set of Radio Interface Technology (SRIT) called "DECT 5G SRIT" is involving 3GPP NR and DECT-2020 NR.

In general, DECT-2020 NR as a technology foundation is targeted for local area wireless applications, which can be deployed anywhere by anyone at any time. The technology supports autonomous and automatic operation with minimal maintenance effort. Where applicable, interworking functions to Wide Area Networks (WAN). e.g. PLMN, satellite, fibre, and internet protocols foster the vision of a network of networks.

DECT-2020 NR can be used as a foundation for:

- very reliable Point-to-Point and Point-to-Multipoint Wireless Links provisioning (e.g. cable replacement solutions);
- local area Wireless Access Networks following a star topology as in classical DECT deployment supporting URLLC use cases; and
- self-organizing Local Area Wireless Access Networks following a mesh network topology, which enables to support mMTC use cases.

DECT-2020 NR applies similar design principles as in legacy DECT and DECT ULE. Especially the inherent feature of automatic interference management allows deployments without extensive frequency planning. The Mesh networking capability of DECT-2020 NR enables application-driven network topologies and deployments in e.g. IoT and mMTC use scenarios such that the link budget of classical cellular base-station to user equipment constellations is no longer a limiting factor.

The DECT-2020 NR physical layer is in principle suited for addressing frequency bands below 6 GHz. The physical layer employs Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) combined with Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) in a Time Division Duplex (TDD) communication manner. The physical layer employs multiple numerologies, with different subcarrier spacings and corresponding Cyclic Prefix lengths and FFT sizes, allowing operation with different channel bandwidths, and optimize operations in different frequency bands and propagation environments. The physical layer supports advanced channel coding (Turbo coding) for both control and physical channels and Hybrid ARQ with incremental redundancy, which enables fast re-transmission. Advanced channel coding together with Hybrid ARQ ensures very reliable communication.

Additionally, the physical layer supports, fast link adaptation, transmit and receiver diversity, as well as MIMO operations up to 8 streams.

DECT-2020 NR (i.e. PHY layer numerology and MAC algorithms) is designed to enable coexistence with legacy DECT and DECT evolution in current frequency bands allocated to DECT.

4.2 Overview of the parts of DECT-2020 Technical Specifications

Release 2 of the DECT-2020 NR technical specifications defines the Radio Interface Technology (RIT) by the following parts:

- ETSI TS 103 636-1 (the present document): "DECT-2020 New Radio (NR); Part 1: Overview".
- ETSI TS 103 636-2 [1]: "DECT-2020 New Radio (NR); Part 2: Radio reception and transmission requirements".
- ETSI TS 103 636-3 [2]: "DECT-2020 New Radio (NR); Part 3: Physical layer".
- ETSI TS 103 636-4 [3]: "DECT-2020 New Radio (NR); Part 4: MAC layer".
- ETSI TS 103 636-5 [4]: "DECT-2020 New Radio (NR); Part 5: DLC and Convergence layers".

ETSI TS 103 636 series will be accompanied by a feature and/or application-driven technical specification set, which is organized as a multi-part deliverable, delivering profiles and application specific solutions for various industries.

ETSI TS 103 636-1 is the present document.

ETSI TS 103 636-2 [1] establishes the minimum RF requirements for DECT-2020 New Radio (NR) Radio Devices (RDs). These requirements cover both Fixed Termination point (FT) as well as Portable Termination point (PT). That document also provides a list of supported frequency bands.

ETSI TS 103 636-3 [2] specifies the physical layer (PHY) and interaction between PHY and MAC layer.

ETSI TS 103 636-4 [3] specifies MAC layer and interaction between MAC layer and physical layer and higher layers.

ETSI TS 103 636-5 [4] specifies the Data Link Control (DLC) and Convergence layers.

5 System and Network Architectures

5.1 Wireless Point-to-Point and Point-to-Multipoint Links

Wireless Point-to-Point links involve two radio devices communicating with each other. A typical application is the cable replacement by a wireless link established between two radio devices requiring communicating with each other.

Compared to wireline systems, wireless comes with the benefit that point to multipoint communication is an inherent feature of radio propagation, so that the support of broadcast and multicast messages from one point to multiple points is just a matter of protocol.

The radio connection between two or more radio devices is enabled by one RD selecting to operate in FT mode (RD_{FT}) and initiate radio resource coordination and beacon transmissions. Other RD(s) perform association procedure in PT mode (RD_{PT}) with the RD_{FT} .

5.2 Local Area Wireless Access Networks in Cellular Network Topology

A single-cell network topology involves in principle two types of Radio Devices (RDs): an RD operates in FT mode (RD_{FT}) as a base station, which is a component of the fixed network infrastructure, other RDs operate PT mode (RD_{PT}).

RD_{FT} is coordinating radio resources, and serves a communication cell by being the central communication point for RD_{PT} , which can be portable device.

A multi-cell topology is a deployment of multiple RD_{FT} as base stations in a fixed network infrastructure, where each base station is serving its own dedicated cell area and RD_{PT} can move from one cell area to the other.

5.3 Mesh network topology

5.3.1 Introduction

In DECT-2020 mesh network devices can communicate directly to each other extending the range of network and increasing the reliability of communication. The mode of the involved radio devices may change autonomously depending on the context of the communication. Each radio device can act as a node transmitting a message, as a node forwarding any message from another radio device or as a node being the destination of a message. Each radio device can communicate directly (device to device) or, if not in range, indirectly - via other radio devices establishing a communication route - with each other which minimizes the probability of outage.

Mesh topology can support high device densities and the autonomous routing provides the ability to adapt dynamically mobile users and interference.

Mesh operation supports autonomous routing. In order to achieve efficient mMTC operation the mesh system is scalable to a very high number of devices in a network. The uplink routing is based on cost values, without the need to maintain routing tables in each device. A number of choices are given for Downlink routing, see clause 5.3.4.

The key requirements of how the scalability can be achieved are:

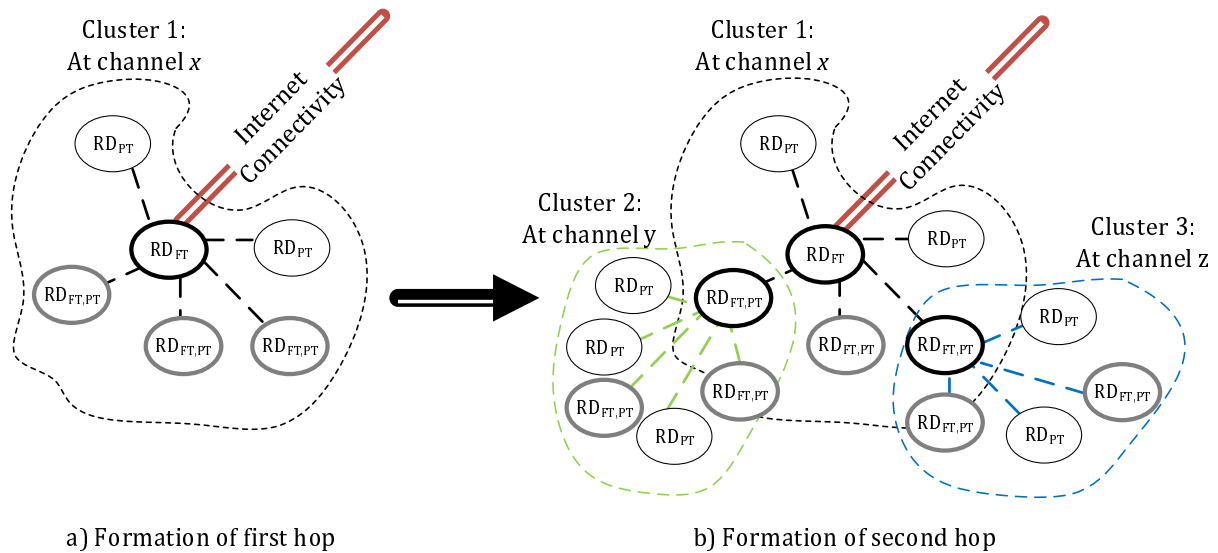
- All radio devices can route data. Whether RD is routing data is based on an autonomous decision of the RD. In addition, an RD may be configured to operate in PT mode only, e.g. due to low battery resources.
- Radio devices take local decisions of the radio resources, e.g. how radio devices use Hybrid ARQ, select modulation and coding and so forth in each radio link.
- Radio devices may change their operating mode between FT mode (RD_{FT}), PT mode (RD_{PT}), or both FT and PT modes ($RD_{FT,PT}$), autonomously based on local decisions.
- No central coordinator(s), enabling the massive scale of the network.
- Radio device operating in RD_{FT} or $RD_{FT,PT}$ mode coordinates local radio resources.
- Support of multiple backend connected Radio devices that operate in FT mode (RD_{FT}).
- RDs can operate with multiple radio channels.

5.3.2 Mesh system operation

The mesh system operation is based on a clustered tree topology where each RD decides the next hop individually based available routes towards the RD providing the connection to the external internet in FT mode (RD_{FT}). Each radio device has knowledge of the next uplink and downlink hop in the clustered tree and RD_{FT} , or $RD_{FT,PT}$ mode in each cluster controls radio resources and transmissions independently.

The formation of clustered tree topology has the following steps:

- An RD which has internet connectivity, RD_{FT} , in FT mode i.e. *Sink* selects operating frequency (or frequencies) and initiates a beacon transmission indicating that it has a route to the external world. This enables other RDs to detect it and associate with it. Beacons indicate all necessary parameters how to perform association, such as frame timing and how radio resources are used and the set of routing parameters. This association procedure does not differentiate from the association process in other system architectures described in clauses 5.1 and 5.2.
- RD detecting a beacon from another RD evaluates the connection based on the information included in the received beacon. Based on the information and signal quality the RD does an independent decision to which RD_{FT} or $RD_{FT,PT}$ to associate. RD monitors its neighbourhood and may autonomously initiate an association process towards another RD based on routing cost.
- Process continues to next hops and so on and it is illustrated in Figure 5.3.2-1.



NOTE 1: At the formation of the first hop a) one or more RD_{PT} or $RD_{FT,PT}$ associates with an RD_{FT} .

NOTE 2: The second hop b) is formed by RD_{PT} or $RD_{FT,PT}$ that associate with the first hop $RD_{FT,PT}$.

NOTE 3: Black thick circle: RD with associated members, grey thick circle: RD that is available routing, but yet has no associated members, black thin circle: RD in PT only mode.

Figure 5.3.2-1: Formation of the clustered tree mesh network topology

Once the RD has connectivity to the next hop, it can start sending data towards the RD in FT-mode. It can simply use a specific address value to indicate that the data is addressed to a backend. A backend system or other RDs can send DL data to the associated RD. The network can have multiple back-ends sharing the same mesh network connectivity.

The basic beaconing and association procedures between RDs in mesh topology and in star topology are same. To enable battery powered RDs which are capable for routing data, the beacon transmission interval can be set longer.

Beaconing intervals extend to several seconds depending on the actual use case enabling low power RDs and routing RDs operations. On the other hand, when RD is mains powered, the beaconing period could be more frequent.

The system operation with multiple RDs in FT mode (*sinks*) is illustrated in Figure 5.3.2-2. The process of forming clusters is identical and an RD may choose to change its association to the next hop RD regardless if the next hop RD will provide connectivity to a different RD_{FT} having the backend connection. Figure 5.3.2-2 also illustrates the case when there is $RD_{FT,PT}$ that does not yet have any associated RD_{PT} .

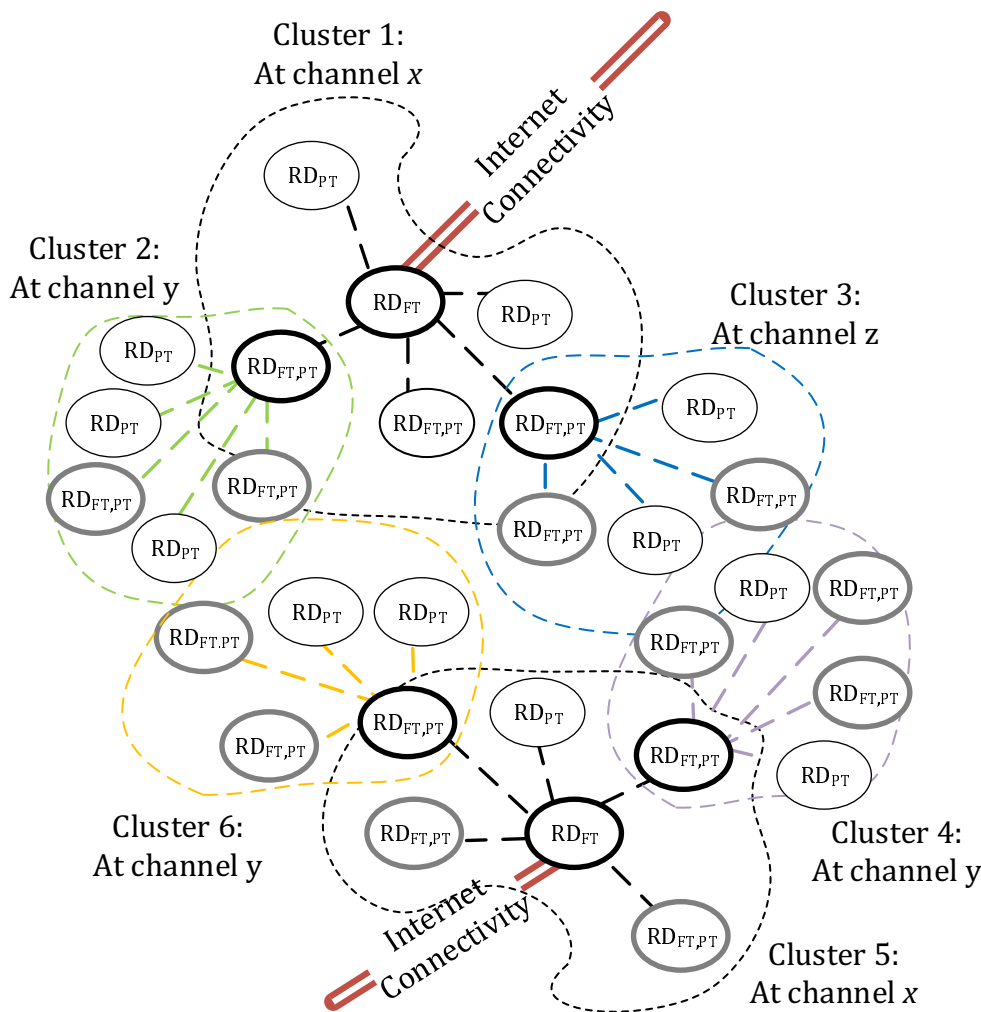


Figure 5.3.2-2: Example formation of the clusters in multiple RD_{FT} scenario

5.3.3 Uplink Routing

RD associates to the next hop RD based on received beacons quality attributes such as Received Signal Strength Indicator (RSSI) measurement from a beacon signal which assists it to determine the pathloss. If both DL pathloss and UL pathloss are such that connection can be established, the RD transmitting this beacon is considered as *potential next hop*. If RD detects multiple beacons from multiple RDs that meet the criteria of reliable connection, the RD considers the *route cost*. The *route cost* expresses the cost of the route to deliver data to the *sink*, i.e. to the RD_{FT} that has a backend connection to the internet. RD may select the RD_{FT} or RD_{FT,PT} for association which indicates the smallest *cost*.

The way the RD calculates the value for the *route cost* is left to implementation. Detailed calculations can be dependent on multiple factors, such as RD capabilities, data rate, interference and BLER, own load i.e. data amount to be delivered, available battery energy, etc. Route cost value will increase at least 1 in every hop. The maximum route cost value is 254, which is not seen as a limiting factor in real deployments.

Routing has also a *sink address*, which is the long RD ID (32 bits) of the RD_{FT} having the backend connection. When a system supports multiple RD_{FT}s, (the actual number of RD_{FT}s can be significantly large), the RD may send short packet to the backend so that that backend can update its knowledge of where different RDs are located in the mesh network and send DL traffic only to the correct RD_{FT}.

The third routing parameter, *application sequence number*, provides identification for network level application data that needs to be distributed in the DL direction to all members of the network. The application sequence number is used by the RD associated to the next hop to identify whether the application data has changed compared to the current application data. If the sequence number is increased the RD requests the application data from its next hop.

NOTE: The actual application data is outside of the scope of DECT-2020 NR but it can contain e.g. configuration data of the RD application such as measurement quantities and corresponding reporting frequencies, etc.

5.3.4 Downlink Routing

DECT-2020 NR standard defines three tools for downlink routing: Selective Flooding, Selective Source Routing and Cached Downlink Routing. Each downlink routing method is based on the cluster tree topology basis explained in clauses 5.3.1 to 5.3.4.

Selective Flooding is a basic mechanism to send downlink packets without maintaining routing tables. It uses the cluster tree topology to reach the RDs lower in the tree. Sink and each RD in FT mode forward the downlink unicast packets to each of their associated member RDs in FT mode. The mechanism provides robust delivery for downlink packets where packets towards the target RD travels the same route as any uplink packet with the cost that data packets are also received by RDs that are not the destination. However, the *Selective Flooding* defines that if one of the member-RDs is the actual destination RD of the packet, then the packet is only sent to that member. In addition to unicast downlink packets the *Selective Flooding* can be used for downlink broadcast and multicast packet.

Selective Source Routing is intended to minimize the need of flooding in downlink routing for unicast packets. Each RD registers itself and its parent RD to the Sink, which enables the Sink to maintain a routing table and create an exact downlink path to each RD to be appended in the downlink messages. The *Selective Source Routing* in DECT-2020 NR provides options to control and manage both registration messages and parts of the network where *Selective Source Routing* is in use. The Sink can define which branches of the cluster tree the DL source routing is applied, while others are flooded. Sink can also define how many hops are included in the DL source routing, while the remaining hops are flooded. Figure 5.3.4-1 depicts three examples how selective source routing can be applied to a branch (A), one hop (B) and two hops (C) in a cluster tree mesh network.

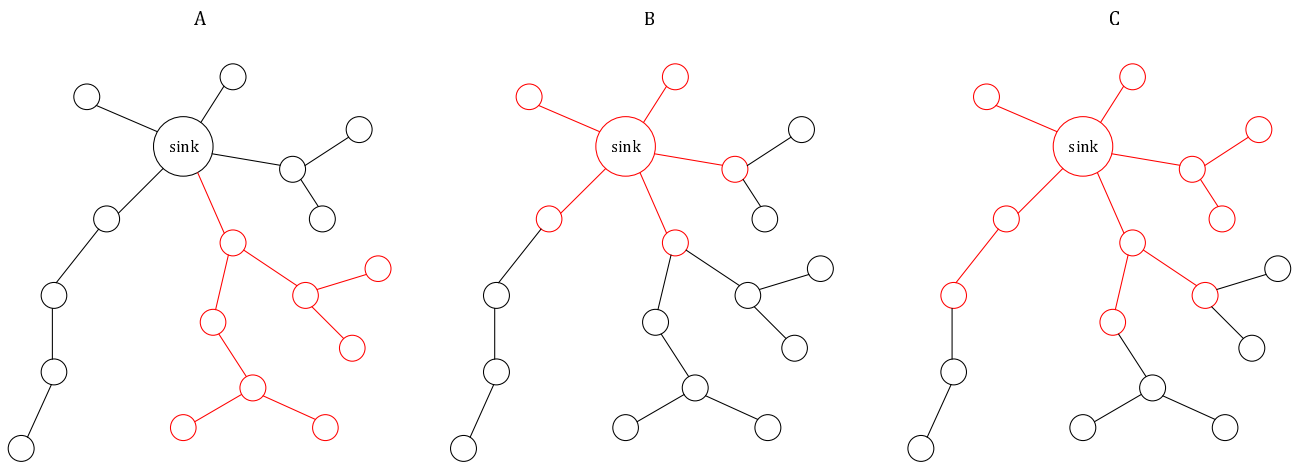


Figure 5.3.4-1: Examples of applying Selective Source Routing in cluster tree

The source routing information is disseminated using beacon or unicast messages. Each RD in FT mode forwards the given Sink originated source routing information, increasing the Hop-count by one at every hop. Also, the Source Routing ID is updated to the ID of the RD in FT mode at every hop, until is no more changed when the hop-limit is exceeded.

Each RD that associates to another RD, checks whether the Sink and/or Source Routing ID is changed compared to the previous association. If one or both have changed, the associating RD sends a new registration. If they both are the same as in the previous association, the associating RD does not send registration, i.e. it has changed its location in the cluster tree in a way that does not affect the downlink routing by the Sink.

The downlink packets are composed by the sink appended with the downlink path. Each RD in FT mode on the path forwards the packet only to the specified next hop RD until the destination RD is reached. If the next hop addresses are all consumed (edge of the source routing is reached) without yet reaching the destination RD, the packet is forwarded using Selected Flooding.

Cached Downlink Routing is based on a local capability of any RD in FT mode (Sink or any routing RD) to learn from which of its member RDs the packets of RDs further away in the cluster tree come from, an example topology is depicted in Figure 5.3.4-2. The RD in FT mode stores such linkage of the member RD address and the source address of the original RD sending an uplink packet. When a downlink packet with the destination address equal to that source address arrives the RD can, instead of flooding, send the downlink packet only the member RD that was linked.

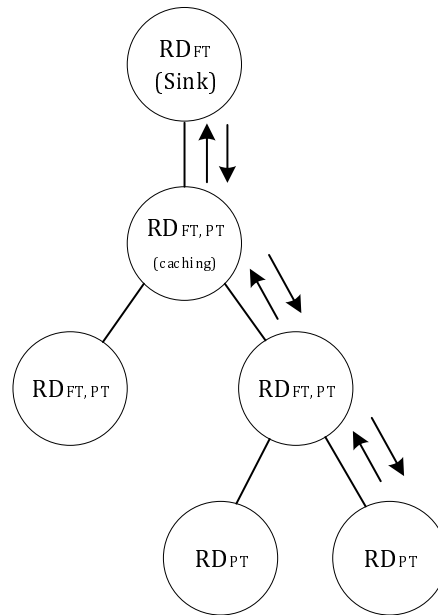


Figure 5.3.4-2: Example of Cached downlink routing in cluster tree

The validity of the route caching information is subject to the topology changes and therefore expected to be used primarily in case a downlink packet is expected soon after the uplink packet.

Cached downlink routing can be applied together with the *Selective Flooding* or *Selective Source Routing*. In case of *Selective Source Routing*, it is applied only outside of the hop limit, where *Selective Flooding* applies.

5.3.5 Routing between RDs

Packet routing between RDs in cluster tree topology uses selective hop-limited flooding, where RD transmits data to only destination if there is association between RD and RD that is the destination of the packet. Otherwise, data is flooded in radio neighbourhood with a limited hop count defined by the originating RD.

5.3.6 Configuration data distribution

The configuration data distribution mechanism is used to provide an efficient and reliable way of distributing the data to the RDs in the DECT-2020 network. Each RD operating in FT mode shall store the configuration data and transfer this data to associated RDs based on RD request. The *application sequence number* is advertised in beacon messages in the Route Info IE "application sequence number" -field to indicate the current version of the configuration data.

Figure 5.3.6-1 illustrates a configuration data distribution in the system with a local request procedure.

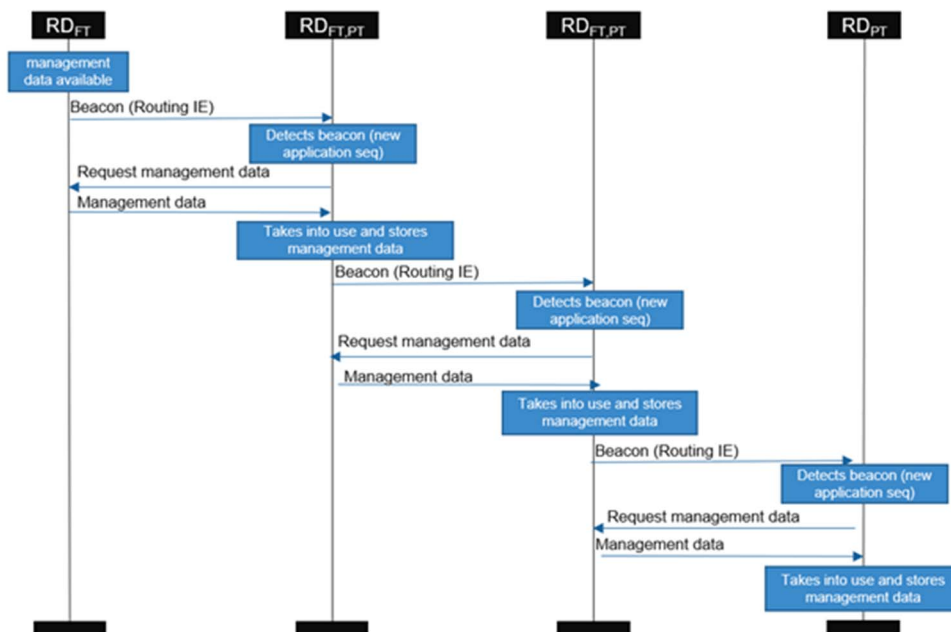


Figure 5.3.6-1: Logical presentation of the configuration/management data distribution

The configuration data distribution function is agnostic to the actual data content and usage and may be used by multiple different management entities with different data sets that may reside in the DECT-2020 NR protocol stack or higher layers.

Figure 5.3.6-2 illustrates the protocol architecture for the configuration data in the DECT-2020 NR system.

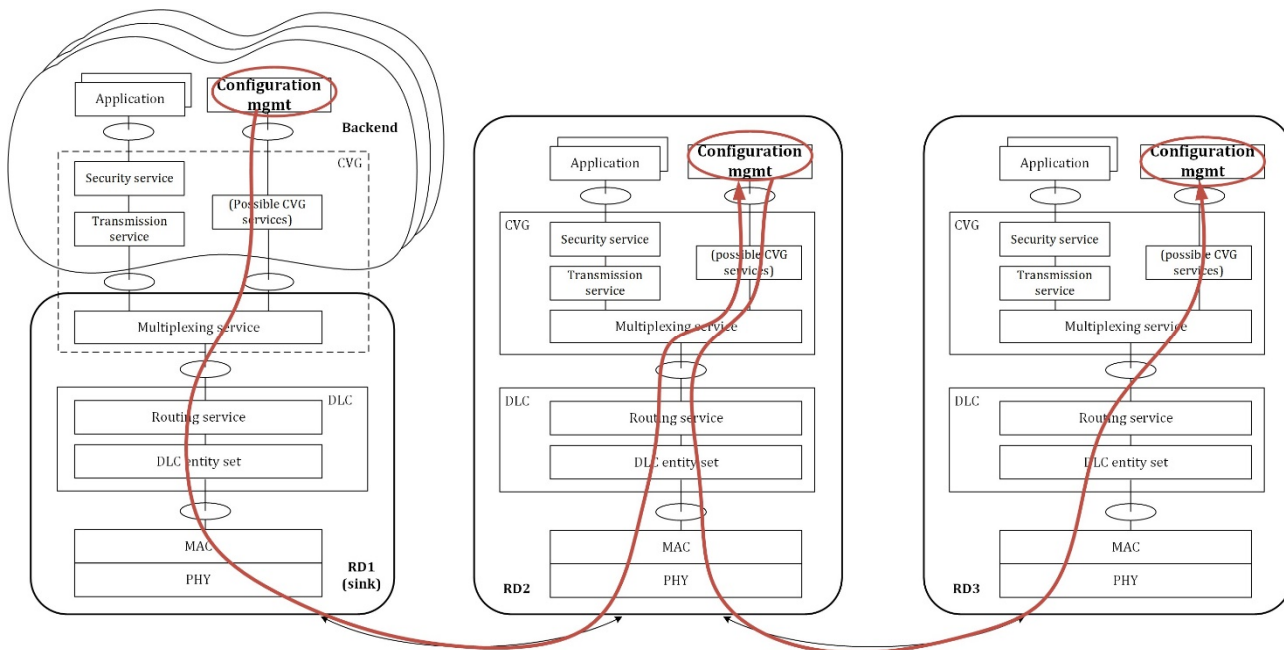


Figure 5.3.6-2: Configuration data management protocol architecture

The configuration data distribution flow is as follows:

- Each RD in FT-mode advertises the sequence number of its currently stored configuration data in its beacons using the Route Info IE.

- When an RD in PT mode receives a Route Info IE "application sequence number" -field with higher sequence number from in RD FT in mode that it is associated, it sends a configuration data request message to the RD FT in mode. If an RD uses data transmission without association, as defined in clause 5.5.1 it may transmit configuration data request without association.
- The configuration data request message is identified from endpoint address reserved for this purpose as defined in Annex A in ETSI TS 103 636-5 [4].
- The RD in FT mode responds with a configuration data response message with the configuration data as payload. The configuration data is identified from endpoint address reserved for this purpose as defined in Annex A in ETSI TS 103 636-5 [4]. The configuration data may comprise multiple configuration response messages.

An RD in PT mode shall initiate a configuration data request in the following cases:

- The RD does not have any valid configuration data.
- The RD identifies a sequence in the received beacon message that is higher from its own stored sequence.
- The RD identifies a sink address in the Route Info IE received in the beacon message that differs from the previous sink address.

5.4 Interworking

The interworking with 3GPP 5G networks is supported by DECT-2020 NR via interworking profiles.

DECT-2020 can be connected as untrusted non-3GPP access network to the 5G Core Network via a Non-3GPP Inter-Working-Function (N3IWF) or as a trusted non-3GPP access network via a Trusted Non-3GPP Gateway Function (TNGF).

Figures 5.4-1 and 5.4-2 provide an overview on the network architecture restricted to the relevant entities. For details refer to ETSI TS 123 501 [i.1].

A DECT-2020 FT can, for example, act as an intelligent gateway to the 3GPP network. In the case of untrusted Non-3GPP access the DECT-2020 FP is connected via N3IWF, while in case of trusted Non-3GPP access the DECT-2020 FT connects via TNGF.

A DECT-2020 PT if it supports both technologies can act as well as UE of the 3GPP network. Depending on capabilities of the DECT-2020, a PT can be part of both networks in parallel or on demand.

DECT-2020 provides "standalone" non-3GPP accesses to the 5G Core Network, so a DECT-2020 network is operated fully independent and outside of the 3GPP NG-RAN.

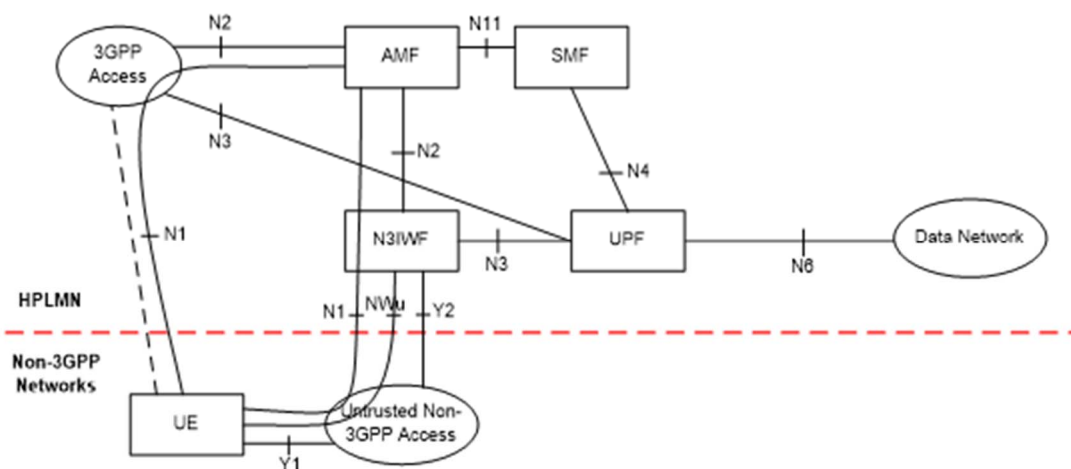


Figure 5.4-1: Non-roaming architecture for 5G Core Network with untrusted non-3GPP access [i.1]

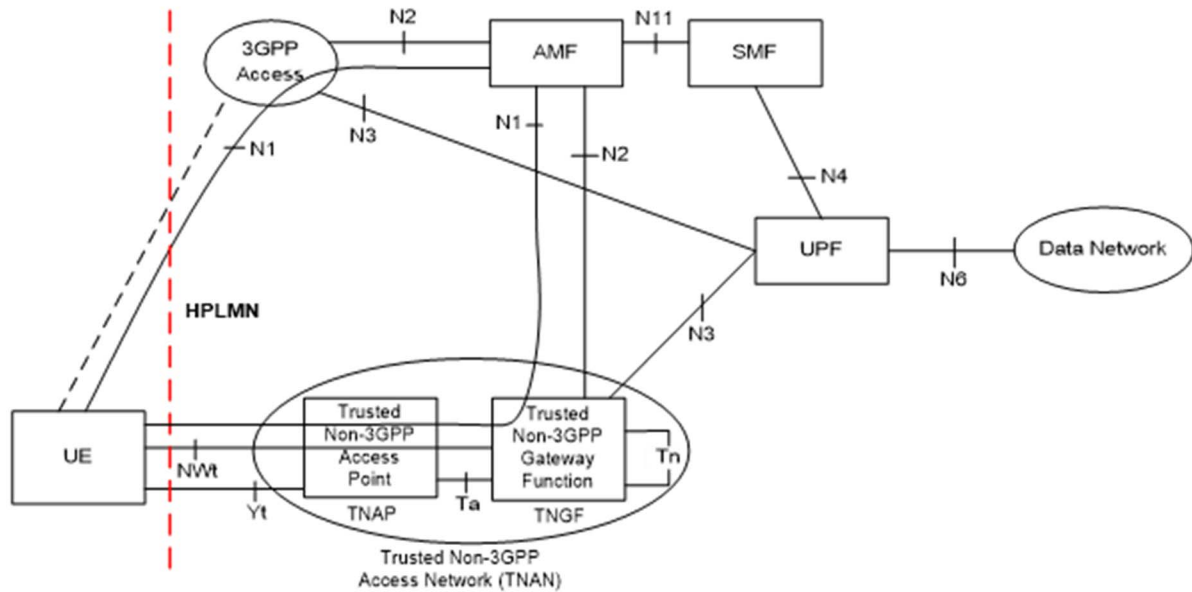


Figure 5.4-2: Non-roaming architecture for 5G Core Network with trusted non-3GPP access [i.1]

5.5 Energy optimization features

5.5.1 Data without association

The data transmission without association enables a radio device to transmit data to an FT without performing association with it. Based on the target address in routing PDU, the data can be routed to the backend as depicted in Figure 5.5.1-1 or to other RD in the network.

The RD in FT mode enables this operation by indicating support of this feature in Network and Cluster beacon messages. Additionally, an RD performing such transmission, has been authenticated and RD has obtained the necessary MAC and CVG end-to-end security keys, and other system configuration parameters in advance. This can be achieved by an external configuration method or by using normal data transfer in the associated mode.

Before initiating the transmission, the RD searches the network and cluster beacons to detect at least one RD operating in FT mode. If multiple RDs in FT mode are found select RD for uplink data as selecting RD in for association as defined in clause 5.1.4 of ETSI TS 103 636-3 [2]. RD applies the configuration received from the beacon messages including RACH resources.

The RD sends data from the application-specific Endpoint and in mesh system operation sets the target address in routing IE set to "any sink" or RD ID that is the final target of the data as defined in clause 5.2.8 of ETSI TS 103 636-5 [4]. It uses the Unicast header option in MAC PDU as defined in clause 6.3.3 of ETSI TS 103 636-4 [3].

When RD in FT-mode receives the data, it can recognize from the Unicast header that it does not have an association with the sending RD. RD in FT-mode sends an acknowledgement to the data transmission. RD may include MAC IEs containing application data in the MAC PDU sent as response. FT may also use an Association Request message to enable the RD in PT to move normal associated state for obtaining normal connectivity. The RD in FT mode makes routing decisions based on routing IE as defined in clause 5.2.8 of ETSI TS 103 636-5 [4].

After receiving acknowledgement to all transmitted data and performing all MAC protocol actions, the RD sending data without association may sleep until new data is to be sent.

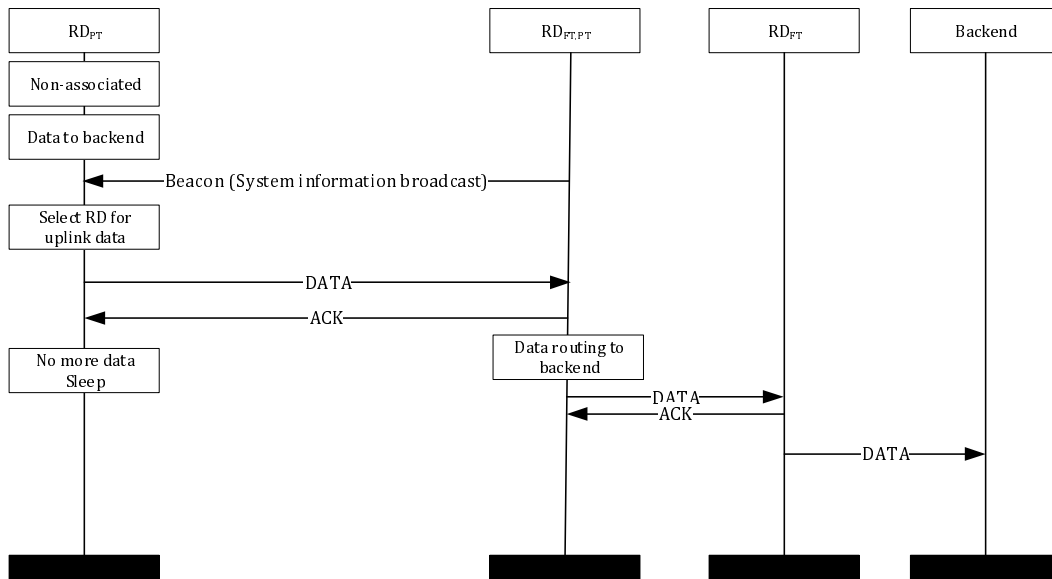


Figure 5.5.1-1: Data transmission without association

6 Overview on Radio technology

6.1 Radio interface protocol architecture

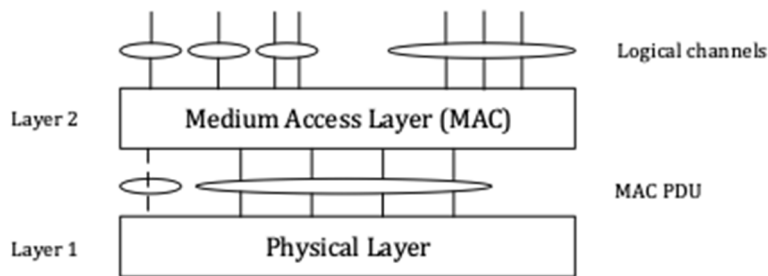


Figure 6.1-1: Radio interface protocol architecture

Figure 6.1-1 shows the DECT-2020 radio interface protocol architecture around the Physical layer (PHY). The physical layer interfaces the Medium Access Control (MAC) layer. The circles between different layer/sub-layers indicate Service Access Points (SAPs). The physical layer offers Physical Control Channel (PCC) and Physical Data Channel (PDC) to transmit MAC PDU(s). Different physical channels are characterized by how the information is transferred over the radio interface within a single transmission packet.

The DLC protocol and Convergence layers support flexible system architecture, where DLC layer provides necessary functions for the MAC layer at each radio link including packet routing, whereas the convergence layer provides adaptation functions between application layer protocols and DECT-2020 NR radio interface. Figure 6.1-2 depicts an example of protocol architecture exploiting mesh topology and routing with IPv6 and non-IPv6 applications.

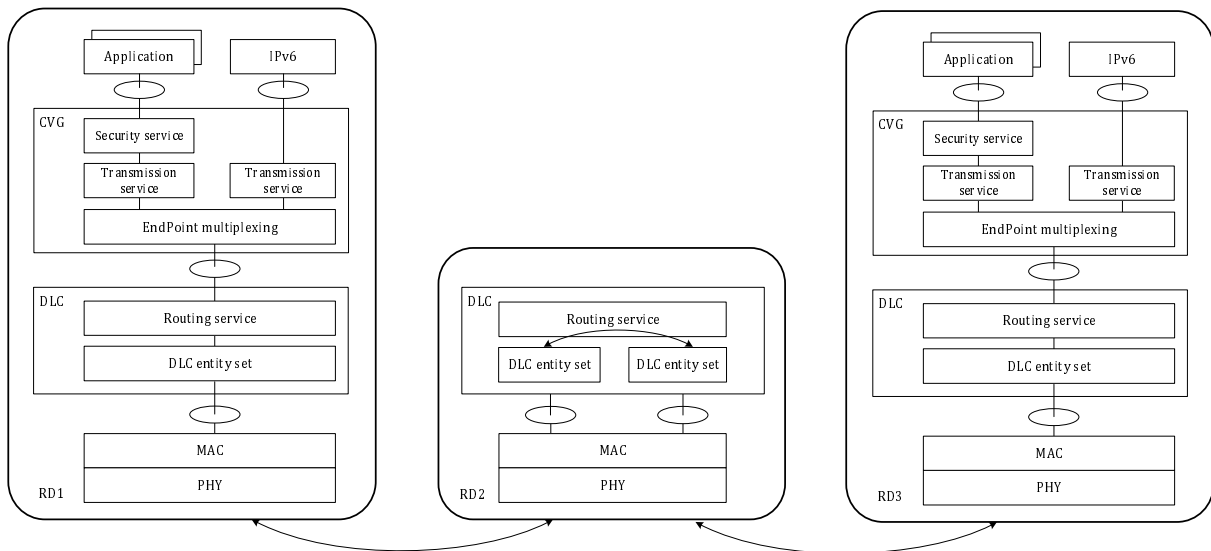


Figure 6.1-2: Illustration of overall protocol architecture

6.2 Physical Layer

6.2.1 Physical Layer functions and capabilities

The DECT-2020 NR physical layer is in principle suitable to address frequency bands below 6 GHz. The physical layer employs Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) combined with Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) in a Time Division Duplex (TDD) communication manner.

Subcarrier spacing is defined by the subcarrier scaling factor μ , resulting either in 27 kHz, 54 kHz, 108 kHz or 216 kHz OFDM subcarriers spacing. In addition, the Fourier transform scaling factor β can be set to allow different transmission bandwidths for each configuration of the subcarrier spacing. This results in the support of nominal RF bandwidth from 1,728 MHz up to 221,184 MHz.

The physical layer can perform the following functions in order to provide the data transport service:

- Error detection on the physical channel and indication to higher layers.
- FEC encoding/decoding of the physical channel.
- Hybrid ARQ soft-combining.
- Rate matching of the coded physical channel data to physical channels.
- Mapping of the coded physical channel data onto physical channels.
- Modulation and demodulation of physical channels.
- Frequency and time synchronization.
- Radio characteristics measurements and indication to higher layers.
- Multiple Input Multiple Output (MIMO) antenna processing.
- Transmit Diversity (TX diversity).
- Beamforming.

The physical channels defined are:

- the Physical Control Channel (PCC);
- the Physical Data Channel (PDC).

The modulation schemes supported are:

- BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM and 1024-QAM.

The channel coding scheme for transport blocks in all physical channels is Turbo Coding with a coding rate of $R = 1/3$, two 8-state constituent encoders and a turbo code internal interleaver. Trellis termination is used for the turbo coding. Before the turbo coding, transport blocks are segmented into byte aligned segments with a maximum information block size. Error detection is supported by the use of 16 or 24 bit CRC as specified for a given physical channel.

6.2.2 Radio characteristics

Radio characteristics of DECT-2020 NR combined with the physical layer support nominal RF bandwidth from 1,728 MHz up to 221,184 MHz. The current release focuses on URLLC and mMTC use cases.

The radio channel numbering scheme enables to assign channels from 450 MHz up to 5 875 MHz organized into 17 different operating bands.

The transmitter output power can be adapted to different types of application requirements and support use cases like battery powered industrial applications, which enables the support for high equipment density use cases. The RX-TX transition time is defined to operate within the Guard Interval (GI), which enables a very competitive low latency operation with hybrid ARQ operation.

Receiver requirement defines the minimum performance for the radio device with hybrid ARQ support. The reference sensitivity levels scale depending on the operating bandwidths.

Measurement requirements are defined for channel access purposes and to support radio environment quality reporting for mobility and mesh routing purposes.

The requirements are defined keeping in mind the state of art in performance, low power consumption and competitive implementation cost.

6.3 Medium Access Control Layer

6.3.1 Introduction

The objective of this clause is to provide an overview on the MAC protocol layer architecture, the used identities, the used transport channels and the mapping of the MAC PDU into the physical layer packet.

The descriptions provided are a model of the MAC layer i.e. it does not specify or restrict implementations.

6.3.2 MAC Structure

The overall MAC structure is depicted in Figure 6.3.2-1. The MAC layer provides DTCH and MTCH logical channels for transferring higher layer data. The flow of the higher layer data and MAC internal messages to physical channels is depicted with black solid lines. The grey dashed line corresponds to MAC internal control interfaces between the MAC function and the MAC control entity.

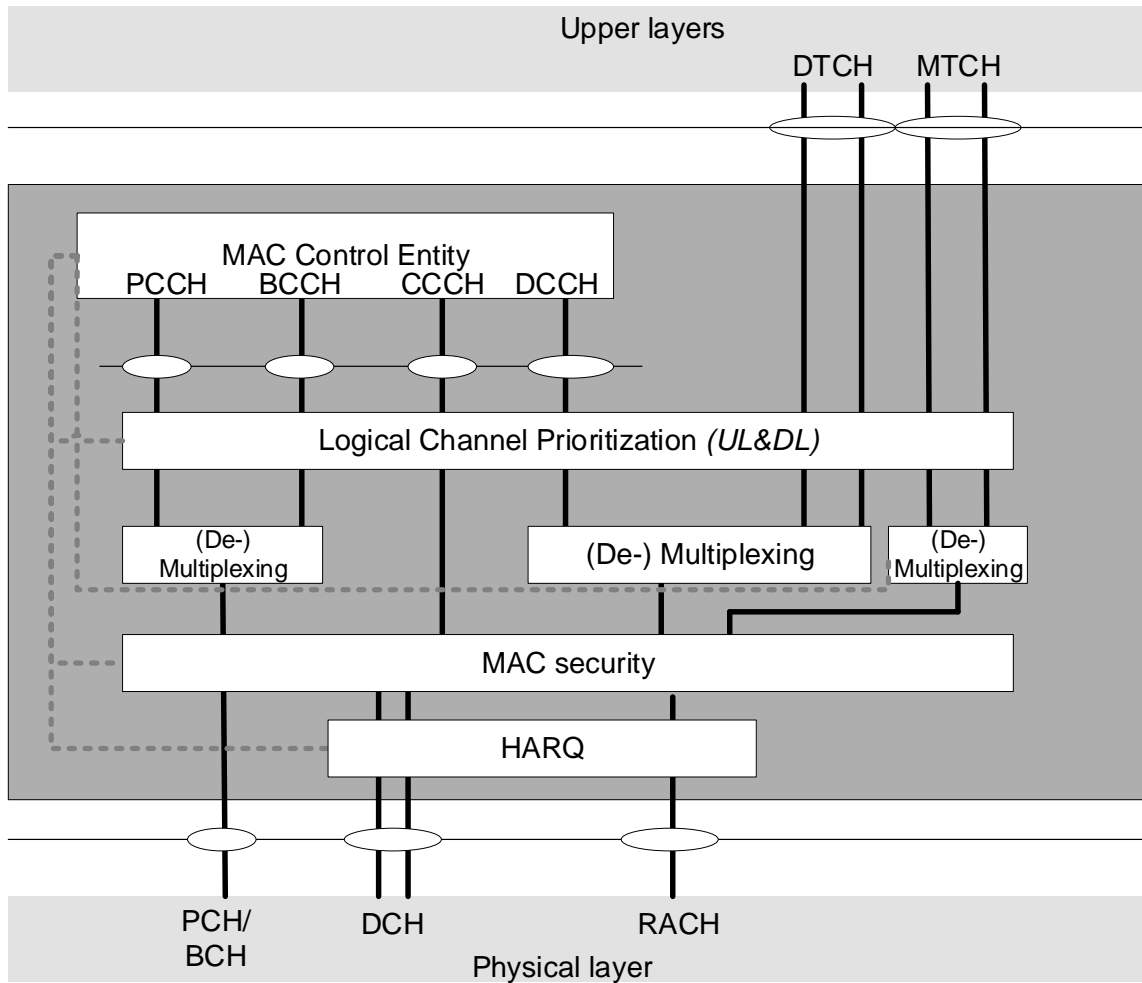


Figure 6.3.2-1: MAC structure overview

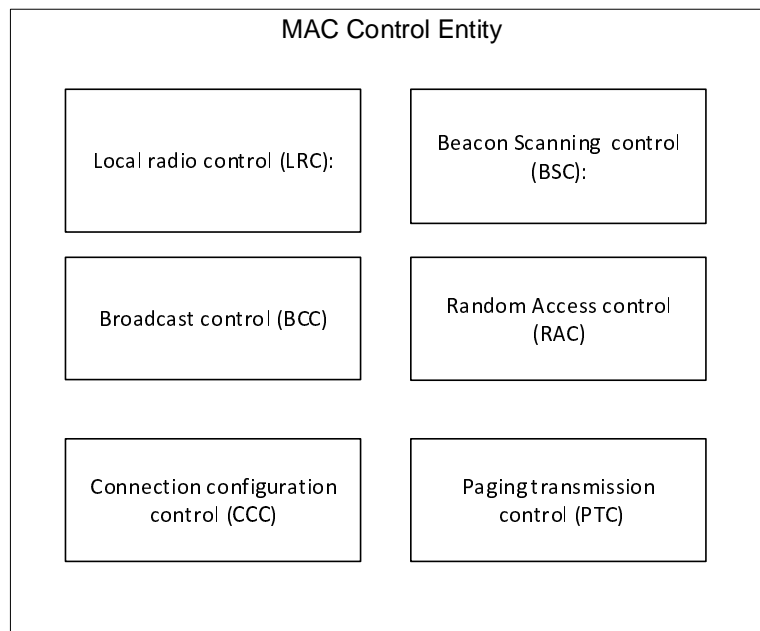


Figure 6.3.2-2: MAC control Entity

The MAC layer of the Radio Device (RD) handles transmission and reception of the following transport channels:

- Paging and Broadcast Channel (PCH/BCH);
- Dedicated Channel (DCH);
- Random Access Channel (RACH).

The MAC control entity is depicted in Figure 6.3.2-2.

6.3.3 Identities

Network ID

The Network ID has a length of 32 bits, and first 24 MSB bits are used to identify a DECT-2020 network uniquely from other DECT-2020 networks. The 8 LSB bits of the network ID are selected locally to minimize collision with other networks.

The network ID is transmitted periodically in a beacon frame as plain text enabling other RDs to detect which network the transmitted beacon belongs to.

Long Radio Device ID (Long RD ID)

The long radio device ID has a length of 32 bits, and it identifies a radio device uniquely in a single DECT-2020 network. An RD obtains the long RD ID as part of the authentication process over the DECT-2020 system or via manual provision or by using another communication channel.

The long RD ID is used:

- in association procedure to recognize associating RDs uniquely;
- in MAC layer security procedures;
- in packet routing in mesh system operation to identify original source and final target receiver of the routed data packet.

The long RD ID is transmitted in the MAC PDU to:

- identify the receiver and the transmitter of the packet in the association procedure for exchanging short RD IDs; or
- when transmitter of the frame considers that there is potential confusion on short RD IDs.

Short Radio Device ID (Short RD ID)

The short radio device ID has length of 16 bits, and it identifies a radio device locally in DECT-2020 network.

The short RD ID is used in the transmitter or receiver fields of the PHY control field to identify transmitter and receiver of the packet.

The short RD ID is exchanged during association procedure between RDs performing association so that linkage between short RD ID and long RD ID is obtained by both associating RDs. Each radio device randomly selects short RD ID value that it uses in association.

6.3.4 Services

The MAC layer provides the following services to upper layers:

- data transfer;
- radio resource allocation.

The MAC layer expects the following services from the physical layer:

- data transfer services in physical layer packets;
- measurements.

6.3.5 Functions

The MAC layer supports the following control functions in the MAC control entity:

- Local Radio Control (LRC): This function is overall in charge of the radio resource in the local coordination area, when RD coordinates local radio resources, i.e. operates as FT.
- Paging Transmission Control (PTC): This function controls paging message transmission when RD coordinates local radio resources, i.e. operates as FT.
- Broadcast Control (BCC): This functionality controls Beacon and other broadcast/multicast transmissions.
- Random Access Control (RAC): This functionality is in charge of random access transmissions.
- Beacon Scanning Control (BSC): This function controls scanning operations.
- Connection Configuration Control (CCC): This functionality controls multiplexing, mapping data to transport channel, MCS, HARQ configuration, MAC security and handovers with LRC.

The MAC layer supports the following transmission functions:

- paging and broadcast signalling;
- control signalling;
- RD device capability signalling;
- radio resource management by channel selection and channel access procedures;
- logical channel prioritization;
- mapping between logical channels and transport channels;
- multiplexing of MAC SDUs from one or different logical channels onto MAC PDU to be delivered to the physical layer on transport channels;
- demultiplexing of MAC SDUs to one or different logical channels from transport blocks MAC PDU delivered from the physical layer via transport channels;
- error correction through HARQ;
- MAC layer security by providing integrity protection and ciphering.

6.3.6 Channel Structure

The MAC layer provides data transfer services on logical channels. To accommodate different kinds of data transfer services, multiple types of logical channels are defined i.e. each supporting transfer of a particular type of information.

Each logical channel type is defined by what type of information is transferred. MAC has a set of internal logical channels and logical channels to higher layers.

The MAC layer has the control and traffic channels listed in Table 6.3.6-1.

Table 6.3.6-1: Logical channels provided by MAC

Logical channel name	Acronym	Available for higher layers	Control channel	Traffic channel
Broadcast Control Channel	BCCH		X	
Paging Control Channel	PCCH		X	
Common Control Channel	CCCH		X	
Dedicated Control Channel	DCCH		X	
Dedicated Traffic Channel	DTCH	X		X
Multicast Traffic Channel	MTCH	X		X

The MAC sublayer uses the transport channels listed in Table 6.3.6-2.

Table 6.3.6-2: Transport channels used by MAC

Transport channel name	Acronym	Downlink	Uplink
Paging and Broadcast Channel	PCH/BCH	X	
Dedicated Channel	DCH	X	X
Random Access Channel	RACH	X	X

Logical channels can be mapped as described in Table 6.3.6-3.

Table 6.3.6-3: Channel mapping

Transport channel \ Logical channel	PCH/BCH	DCH	RACH
BCCH	X		
PCCH	X		
CCCH			X
DCCH	X	X	X
DTCH		X	X
MTCH	X		X

In packet transmission transport channels are mapped to Physical Data Channel (PDC) carried in the physical layer packet. Additionally, MAC provides the number of used spatial streams, and content of the Physical Layer Control Field to the physical layer. The Physical Layer Control Field is mapped to the Physical Control Channel (PCC) of the physical layer packet.

6.4 Mobility and State Transitions

6.4.1 Overview

The RD_{PT} operates in the following states: non-associated and associated. The mobility support, i.e. handover, is applicable for an RD which is associated to one or more RD_{FT} or RD_{FT,PT}. The different handover procedures are introduced in clause 6.4.2, wherein the handover functionality is the same in both star and mesh topologies.

6.4.2 Intra DECT-2020 Mobility

The involved handover procedures may be intra-cell or inter cell. The intra-cell handover means RD_{PT} or RD_{FT,PT} changes its association from an instance (e.g. sector) of an RD_{FT} or RD_{FT,PT} into another instance of the same RD_{FT} or RD_{FT,PT}. The inter-cell handovers consider changing association from an RD_{FT} or RD_{FT,PT} into another RD_{FT} or RD_{FT,PT}.

Intra-cell handover may be controlled by either the radio devices acting as RD_{FT} or RD_{PT} and triggered when the quality on allocated resources becomes poor and other free resources exist. Detection of free resources is based on a spectrum sensing and beacon measurements and takes into account the activity of other uncoordinated systems. Seamless handover is supported, by allocating new resource before releasing old ones.

The radio device sends a handover-request (part of association request process) to the detected RD_{FT} on the selected random-access channel indicated in beacon message. If the RD_{FT} accepts the request, it indicates the position of the new resources and the connection is established, and data delivery can be switched over. After that the old resources will be released.

Inter-cell handover is generally controlled by the RD_{PT} and triggered when quality on allocated resources becomes poor and/or another suitable RD_{FT} is detected. Seamless handover with 0 ms interruption time is supported. The RD_{PT} sends a handover-request as indicated in intra-cell case to the new RD_{FT} on the selected random access channel. If the RD_{FT} accepts the request, then it indicates the position of the new resource allocation and the data will be switched over. After that the old resource will be released.

Handover between two DECT-2020 systems is performed in the same way as inter-cell handover. Both systems should be interconnected by the proper network infrastructure.

6.5 Data Link Control

6.5.1 DLC Entities and Architecture

The DLC architecture is depicted in Figure 6.5.1-2. There is single routing service entity in each RD.

There is a single DLC entity set for each radio link between an RD in PT mode and an RD in FT mode. For an RD operating in both FT and PT mode in mesh clustered three, the RD has:

- One DLC entity set for the RD that it has performed association with as defined in ETSI TS 103 636-4 [3].
- One DLC entity set for each RD that has performed association with it as ETSI TS 103 636-4 [3], as depicted in Figure 6.5.1-1.

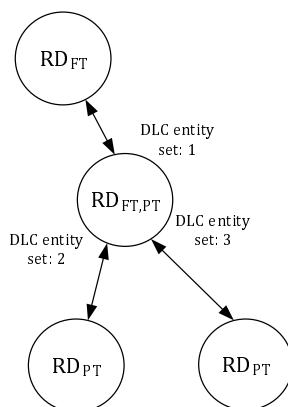


Figure 6.5.1-1: DLC entity sets for RD operating in both FT and PT mode

Additionally, an RD has a DLC entity set for Broadcast and RD to RD communication.

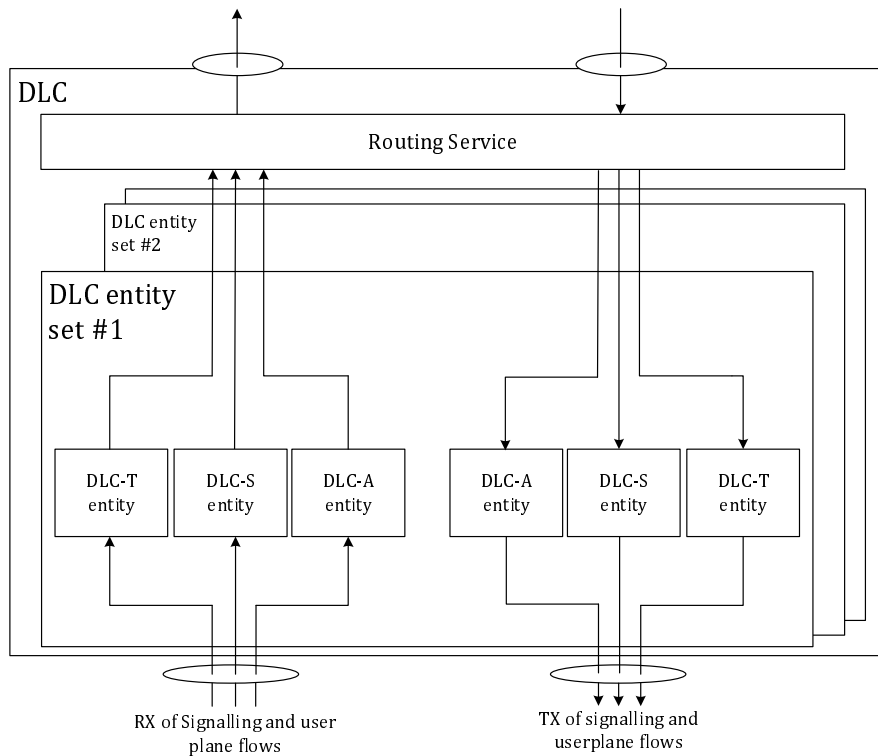


Figure 6.5.1-2: DLC architecture

DLC entity set comprises one DLC entity for a DCH/MTCH seen by the MAC layer, as identified a MAC flow in MAC multiplexing header in clause 6.3.4 in ETSI TS 103 636-4 [3].

A DLC entity can be operating in following service modes based on QoS and application data format requirements:

- Service type 0: Transparent mode (DLC-T).
- Service type 1: Segmentation mode (DLC-S).
- Service type 2: DLC ARQ mode (DLC-A).
- Service type 3: Segmentation and ARQ mode (DLC-SA).

6.5.2 Routing services

Routing services support the following:

- Packet Routing from RD to backend (uplink) with special unicast address reserved for backend.
- Packet routing from backend (downlink) to RDs with unicast, multicast or broadcast address.
- Packet Routing between RDs, with unicast, multicast or broadcast address with hop-limited flooding.

6.6 Convergence Layer

6.6.1 General

The CVG layer operates end-to-end between the terminal entities. Intermediate nodes in a mesh network do not process the CVG layer payload.

The convergence layer provides the following services:

- Multiplexing service:
 - Identification and multiplexing of higher layer data (see clause 6.6.3).
- Transmission service:
 - Segmentation and reassembly, retransmission, flow control, lifetime control, duplicate removal, and delivery order of SDUs routed over the DECT-2020 network.
 - A set of Tx service types are defined to implement practical combinations of the transmission procedures (see clause 6.6.2).
- Security service:
 - Cipherring and integrity protection of messages.

The use of the services is optional, but they follow the hierarchy depicted in the layer architecture as in Figure 6.6.1-1.

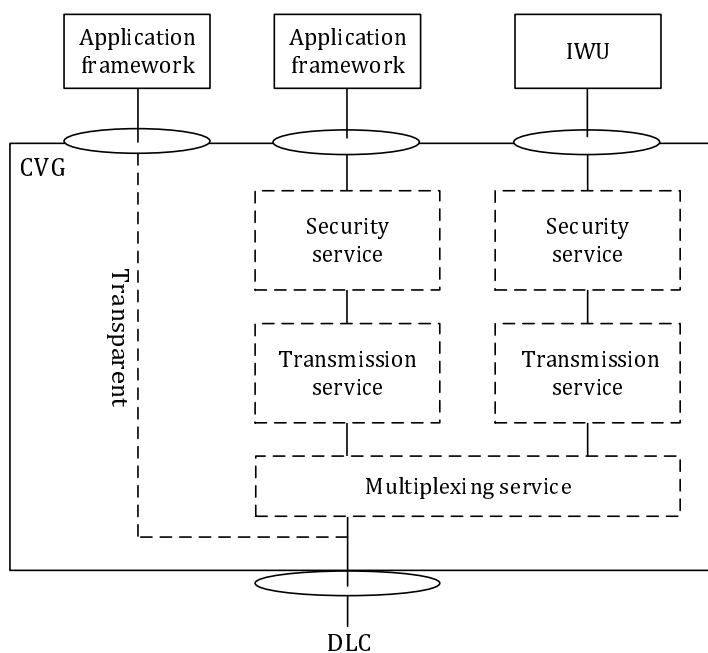


Figure 6.6.1-1: CVG architecture

6.6.2 CVG Service types

The CVG layer's service types are related to the CVG procedures as defined in Table 6.6.2-1. However, the use of CVG Security, Multiplexing, Duplicate removal and Delivery order procedures are independent of the CVG service type.

Table 6.6.2-1: CVG Service types & features

	Transparent	Sequence numbering	Segmentation & reassembly	Lifetime	Flow control	ARQ
Service type 0	X	-	-	-	-	-
Service type 1	-	X	-	-	-	-
Service type 2	-	X	X	-	-	-
Service type 3	-	X	X	X	X	X(*)
Service type 4	-	X	X	X	X	X

NOTE: (*) = uses ARQ in a limited manner.

6.6.3 Data identification and multiplexing

Convergence layer provides identification and multiplexing of higher layer data using different CVG level multiplexing procedures: Endpoint (EP) multiplexing and Mux tag multiplexing.

Endpoint multiplexing is based on using a 2-octet EP mux field. The EP mux address space is divided into different purposes, for free use, for Public specifications and for Company specific use. Other than free use values are allocated by ETSI on request. This makes it possible to identify data globally, for example, a public specification value is allocated to IPv6 datagrams.

Mux tag enables multiplexing of higher layer data using a short, 3-bit identifier, by enumerating the values locally.

6.7 Co-existence

6.7.1 General

DECT-2020 NR supports several features enabling the co-existence of different DECT technologies in the 1 880 MHz to 1 900 MHz band and in other frequency bands DECT technologies can employ.

In the design of DECT-2020 NR special attention has been given to enable co-existence between multiple DECT-2020 NR systems and systems employing other DECT technologies (e.g. DECT, DECT evolution, DECT ULE).

Certain features ease DECT-2020 NR use also in co-existence with other technologies outside of the 1 880 MHz to 1 900 MHz band.

6.7.2 Technical Features for Supporting Co-existence

For enabling co-existence between DECT-2020 NR systems and systems employing other DECT technologies (e.g. DECT, DECT evolution, DECT ULE) the following design choices were specifically made in DECT-2020 NR:

- The smallest nominal channel bandwidth is the same as the nominal channel bandwidth in DECT systems, i.e. 1,728 MHz.
- Wider nominal channel bandwidths are multiples of 1,728 MHz.
- Operating channel centre frequencies are aligned with DECT when operating on nominal channel bandwidth 1,728 MHz.
- If operating on wider nominal channel bandwidths the centre frequency of the operating channel can be aligned so that transmissions respect the existing DECT channel raster and minimize overlapping.
- DECT-2020 NR frame, slot and subslot lengths are aligned with frame and slot lengths of DECT.
- Transmission lengths are multiples of subslot and slot lengths.

- Capability to allocate scheduled resources.
- Last minute scan for detecting periodic DECT transmissions.

DECT-2020 NR supports the following advanced spectrum management functions that further assist co-existence of DECT-2020 NR systems with DECT technologies and also with other technologies in additional frequency bands:

- Operating channel and subslots clause, so that RD in FT mode system initiates operation at the available spectrum resources that has lowest interference levels.
- Selecting the RD for association, enabling an RD in PT mode to initiate association to the optimum RD in FT mode to minimize spectrum utilization.
- Transmission power control to minimize the TX power use and interference caused to other systems.
- Capability to detect and measure (RSSI-2 measurement) transmissions occurring from other DECT-2020 NR systems.
- Capability to identify other DECT-2020 NR systems.
- Capability to measure (RSSI-1 measurement) any transmission from any other system occurring on operating frequency band of the DECT-2020 NR RD.
- Time synchronization over the air between different parts of the DECT-2020 NR system and even between different DECT-2020 NR systems.
- Listen Before Talk (LBT) with exponential back-off operation for transmitting random access resources.
- Set operating channel centre frequency and nominal channel bandwidth according to regulation of a given band.

7 Security Architecture

7.1 General

DECT-2020 NR security architecture relies on two independent security layers operating at MAC and CVG protocol layers. The MAC security is a radio link specific operating between two RDs transmitting and receiving MAC PDUs, whereas the CVG layer security is end-to-end between two CVG endpoints entities sending and receiving CVG PDUs. The different security layers are illustrated in Figure 7.1-1.

Both security layers provide ciphering and integrity protection with AES-128 and CMAC respectively with separate ciphering and integrity keys.

When DECT-2020 NR network has MAC security activated, it is applied at the link level for all data transmissions including also network beacon and cluster beacon messages. MAC security provides both ciphering and integrity protection. Further, the CVG layer may utilize an additional security layer with ciphering and integrity protection providing end-to-end security between the data source's CVG layer to data target's CVG layer as illustrated in Figure 7.1-1.

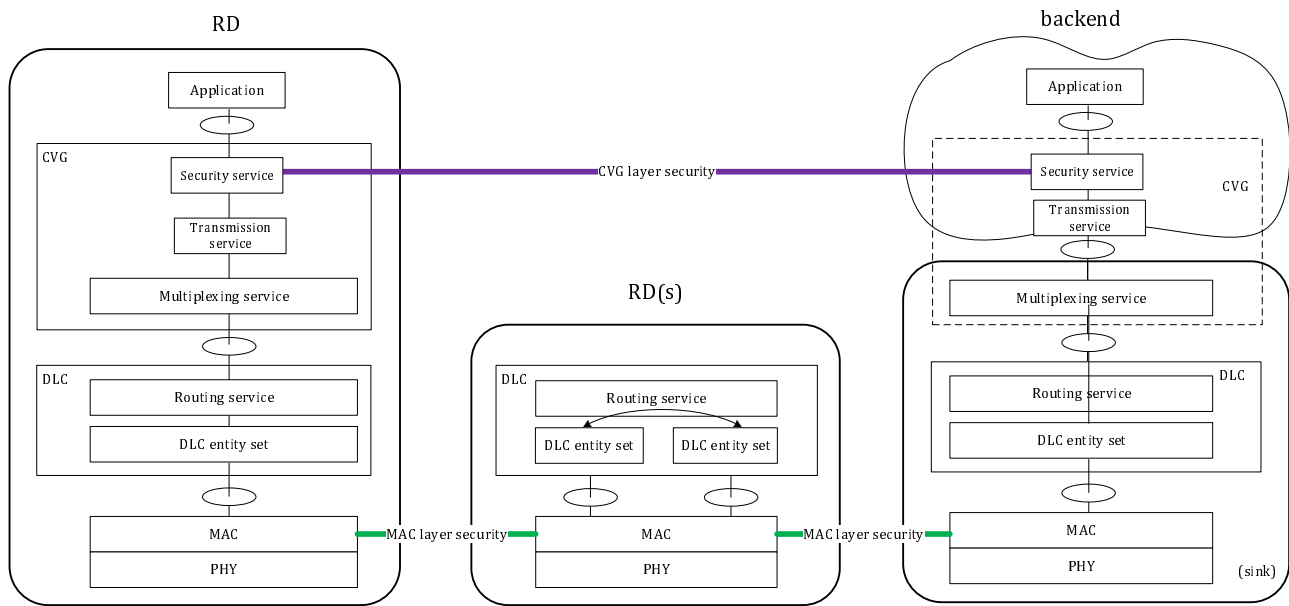


Figure 7.1-1: DECT-2020 NR Security architecture

7.2 Secure Joining

Secure Joining enables communication for authentication and provisioning process including security key distribution between RD and the Provisioning Server for an RD that does not have valid MAC and/or CVG security credentials of the network.

Secure Joining is enabled when needed by the network owner. It can be enabled system-wide or only at a certain location of the network. The Secure Joining operation provides a communication framework to support multiple authentication and provisioning protocols as it is agnostic on the actual authentication and provisioning protocols and the location of the Provisioning Server.

Figures 7.2-1 and 7.2-2 illustrate the communication path and the functional blocks of DECT-2020 NR participating in Secure Joining in the star network and mesh network architecture. Provisioning entities controlling the communication are involved in three parts of the system which are:

- Provisioning Client.
- Provisioning Proxy.
- Provisioning Server.

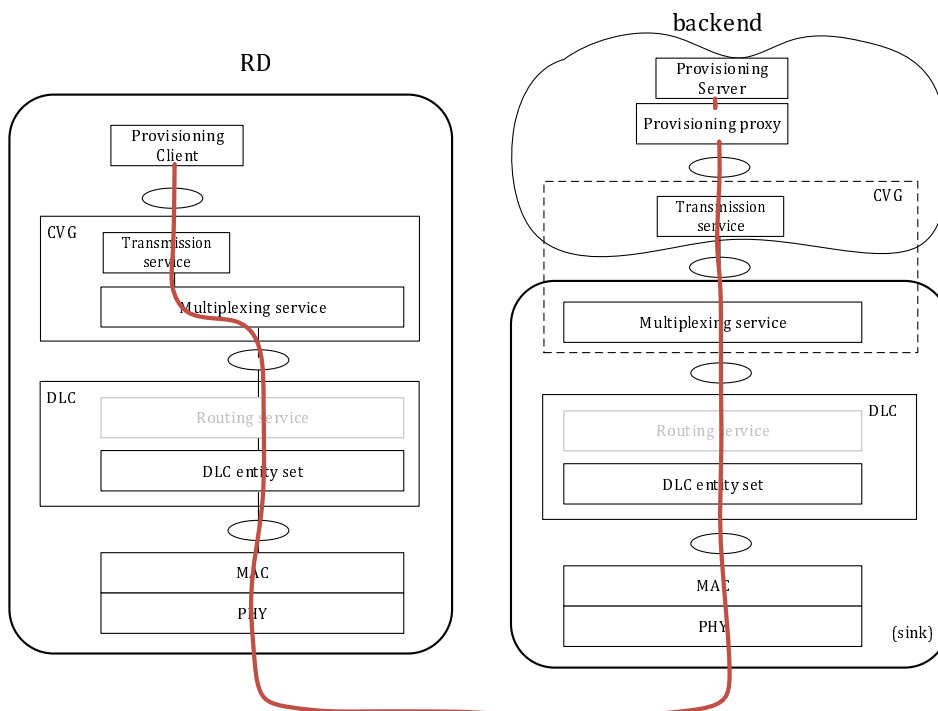


Figure 7.2-1: Secure Joining protocol architecture in star system operation, where redline presents communication path

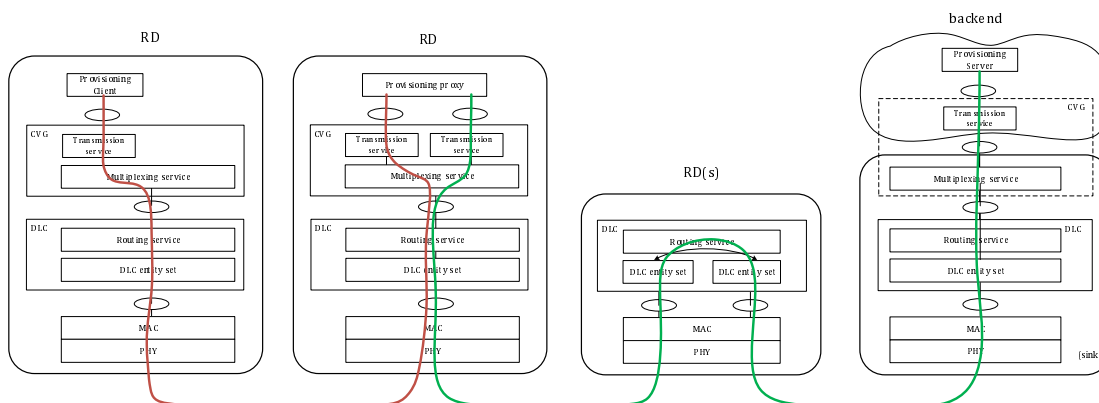


Figure 7.2-2: Secure Joining protocol architecture in mesh system operation with the communication path, where green path presents a normal DECT-2020 NR mesh communication path

The Provisioning Client is part of RD's management entity of the RD, operating in PT mode, which enables authentication and joining to a specific network. The Provisioning Client has the following functions:

- controls selecting the network and RD for unencrypted association;
- communicates with the authentication server to perform authentication;
- performs authentication functions according to the supported authentication algorithm;
- communicates, after successful authentication, to obtain configuration parameters and security credentials according to supported provisioning protocol from the Provisioning Server via Provisioning Proxy;
- provides obtained configuration parameters and security credentials to DECT-2020 NR protocol.

The Provisioning Proxy is part of RD's management entity of the RD, operating in FT mode, which enables secure joining. The Provisioning Proxy has the following functions:

- controls transmission of joining beacon messages and/or joining information IE;

- controls transmission of unencrypted network and cluster beacon messages;
- forwarding messages between the Provisioning Client and the Provisioning Server.

The Provisioning Server is part of the DECT-2020 NR control and management functionality. The Provisioning Server has the following functions:

- communicates with the RD being authenticated;
- performs authentication functions according to the supported authentication algorithm;
- communicates, after successful authentication, to provide configuration and security credentials according to supported provisioning protocol to the Provisioning Client via Provisioning Proxy.

In mesh system operation, the RD in PT mode shall use the address of the RD in FT mode as the target address of all communication. The RD in FT mode shall only provide CVG data identified with Endpoint value indicated in the Joining Information IE of the Provisioning Proxy, filtering any other routing PDU from the RD in PT mode. The EndPoint value identifies the supported authentication protocol as defined in Annex A of ETSI TS 103 636-5 [4].

The Provisioning Proxy shall forward messages from the Provisioning Client to the Provisioning Server by using normal DECT-2020 NR routing mechanisms. The Provisioning Server shall send all communications using normal DECT-2020 NR routing mechanisms to the Provisioning Proxy located in the RD in FT mode. The Provisioning Proxy forwards messages from the Provisioning Server to RD being authenticated.

History

Document history		
V2.1.1	October 2024	Publication