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Foreword

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Version x.y.z

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- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- 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

In order to ensure efficient use and deployment of V2X applications on 3GPP networks an architecture for V2X application layer consisting of V2X application enabler is specified in this document.

The V2X application enabler capabilities takes into consideration the study in 3GPP TR 23.795 [9], the existing stage 1 and stage 2 work within 3GPP related to V2X in 3GPP TS 22.185 [2], 3GPP TS 22.186 [3] and 3GPP TS 23.285 [5], as well as V2X application standards defined outside 3GPP (e.g. ETSI, SAE).

1 Scope

The present document specifies the functional architecture, procedures and information flows for V2X application enabler layer. This specification includes the capabilities of the application layer support for V2X services that are necessary to ensure efficient use and deployment of V2X services over 3GPP systems. The VAE capabilities applies to EPS and 5GS.

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] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 22.185: "Service requirements for V2X services; Stage 1".
- [3] 3GPP TS 22.186: "Enhancement of 3GPP support for V2X scenarios; Stage 1".
- [4] 3GPP TS 23.280: "Common functional architecture to support mission critical services".
- [5] 3GPP TS 23.285: "Architecture enhancements for V2X services".
- [6] 3GPP TS 23.434: "Service enabler architecture layer for verticals; Functional architecture and information flows".
- [7] 3GPP TS 23.468: "Group Communication System Enablers for LTE (GCSE_LTE); Stage 2".
- [8] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".
- [9] 3GPP TR 23.795: "Study on application layer support for V2X services".
- [10] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".
- [11] 3GPP TS 26.348: "Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point".
- [12] 3GPP TS 29.214: "Policy and Charging Control over Rx reference point".
- [13] 3GPP TS 29.468: "Group Communication System Enablers for LTE (GCSE_LTE); MB2 Reference Point; Stage 3".
- [14] 3GPP TS 36.300: " Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".
- [15] ETSI EN 302 637-3 (V1.3.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".
- [16] ETSI TS 102 894-2 (V1.2.1): "Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionaryMultimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".

- [17] ETSI TS 102 965 (V1.4.1): "Intelligent Transport Systems (ITS); Application Object Identifier (ITS-AID); Registration".
- [18] ISO TS 17419: "Intelligent Transport Systems - Cooperative systems - Classification and management of ITS applications in a global context".
- [19] 3GPP TS 23.287: " Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services".
- [20] 3GPP TS 23.501: "System architecture for the 5G System (5GS)".
- [21] 3GPP TS 23.222: "Functional architecture and information flows to support Common API Framework for 3GPP Northbound APIs; Stage 2".
- [22] 3GPP TS 29.116: "Representational state transfer over xMB reference point between Content Provider and BM-SC".
- [23] 3GPP TS 23.003: "Numbering, Addressing and Identification".
- [24] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".
- [25] 3GPP TS 23.558: "Architecture for enabling Edge Applications".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP 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 3GPP TR 21.905 [1].

V2X group: A defined set of V2X UEs configured for specific purpose in V2X service.

V2X dynamic group: A V2X group where the V2X UEs are determined dynamically corresponding to a group criteria (e.g. proximity).

V2X service: A service offered by a V2X application which supports the related communications between two entities (e.g. V2X UE and V2X UE, V2X UE and V2X application server).

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

5GS	5G System
AS	Application Server
AID	Application Object Identifier
CAPIF	Common API Framework for northbound APIs
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
EPS	Evolved Packet System
ETSI	European Telecommunications Standards Institute
GPSI	Generic Public Subscription Identifier
LTE	Long-Term Evolution
MBMS	Multimedia Broadcast Multicast Service
PSID	Provider Service Identifier
SAE	Society of Automotive Engineers
SCEF	Service Capability Exposure Function
SCS	Services Capability Server

UE	User Equipment
USD	User Service Description
V2I	Vehicle-to-Infrastructure
V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VAE	V2X Application Enabler

4 Architectural requirements

4.1 General

4.1.1 Description

This subclause specifies the general requirements for V2X application layer functional architecture.

4.1.2 Requirements

[AR-4.1.2-a] The VAE client and the VAE server shall support one or more V2X applications.

[AR-4.1.2-b] The VAE capabilities should be offered as APIs to the V2X applications.

[AR-4.1.2-c] The VAE capabilities shall enable V2X UEs to obtain the address of available V2X application servers associated with served geographical area information.

[AR-4.1.2-d] The VAE capabilities shall enable V2X UEs to obtain the information of available V2X services (e.g. identified by V2X service ID).

[AR-4.1.2-e] The VAE capabilities shall support obtaining information of the available V2X services (e.g. identified by V2X service ID) from the V2X application.

[AR-4.1.2-f] The VAE capabilities shall support obtaining information of the associated geographical area from the V2X application.

[AR-4.1.2-g] The VAE client shall be able to communicate to multiple VAE servers.

4.2 V2X group communication

4.2.1 Description

This subclause specifies the V2X group communication related requirements.

4.2.2 Requirements

[AR-4.2.2-a] The VAE capabilities shall enable configuring ProSe group communication parameters to the VAE clients.

[AR-4.2.2-b] The VAE capabilities shall enable broadcast of the group communication parameters.

[AR-4.2.2-c] The VAE capabilities shall enable VAE clients to generate the group communication parameters.

[AR-4.2.2-d] The VAE capabilities shall enable to prevent overlapping of group communication.

4.3 V2X dynamic groups

4.3.1 Description

This subclause specifies the V2X dynamic groups related requirements.

4.3.2 Requirements

[AR-4.3.2-a] The VAE capabilities shall enable V2X dynamic groups formation.

[AR-4.3.2-b] The VAE capabilities shall enable configuring dynamic group communication parameters to the VAE client.

[AR-4.3.2-c] The VAE capabilities shall enable switching from Uu to PC5-based communication.

[AR-4.3.2-d] The VAE capabilities shall enable determining V2X UEs in the proximity.

[AR-4.3.2-e] The VAE capabilities shall enable V2X dynamic group management (e.g. joining, adding or removing V2X UEs, split or merge).

4.4 File distribution capability

4.4.1 Description

This subclause specifies the architectural requirements for file distribution.

4.4.2 Requirements

[AR-4.4.2-a] The VAE capabilities shall be able to support delivery of large files using unicast.

[AR-4.4.2-b] The VAE capabilities shall be able to support delivery of large files using MBMS.

[AR-4.4.2-c] The VAE server shall enable the re-use of MBMS capabilities for file distribution.

[AR-4.4.2-d] The VAE capabilities shall be able to support local MBMS based MBMS data delivery.

4.5 V2X application message distribution

4.5.1 Description

This subclause specifies the V2X (e.g. ETSI ITS, SAE) message distribution requirements.

4.5.2 Requirements

[AR-4.5.2-a] The VAE server shall provide a mechanism to distribute V2X messages to all registered receivers in targeted geographical areas.

[AR-4.5.2-b] The VAE server shall enable the delivery of several V2X messages over the same connection.

[AR-4.5.2-c] The VAE client shall have the capability to register to V2X messages within one or more geographical area.

[AR-4.5.2-d] The VAE server shall have the capability to only forward V2X messages to authorized V2X UEs in target geographical areas.

[AR-4.5.2-e] The VAE server shall provide a mechanism for priority support of different V2X messages (e.g. safety message).

[AR-4.5.2-f] The VAE capabilities shall support the transmission of V2X messages from the V2X UE to the V2X application server.

[AR-4.5.2-g] The VAE layer shall provide a mechanism to support session-oriented services.

[AR-4.5.2-h] The VAE layer shall support the delivery of V2X messages over pre-established sessions.

4.6 Service continuity

4.6.1 Description

This subclause specifies the V2X service continuity related requirements.

4.6.2 Requirements

[AR-4.6.2-a] The VAE capabilities shall enable V2X UEs to continue receiving V2X service when changing geographical area.

4.7 PC5 Provisioning in multi-operator V2X scenarios

4.7.1 Description

This subclause specifies the PC5 Provisioning for multi-operator V2X services related requirements.

4.7.2 Requirements

[AR-4.7.2-a] The VAE capabilities shall support PC5 policy/parameter provisioning for V2X services provided by a single V2X service provider; and offered by more than one MNO (aka multi-operator V2X services).

4.8 Support for VRU zone configuration and operation

4.8.1 Description

This subclause specifies the VRU zone configuration and operation related requirements.

4.8.2 Requirements

[AR-4.8.2-a] The VAE capabilities shall support VRU zone configurations (e.g. distribution of VRU zone related configuration information) to the relevant V2X UEs.

4.9 V2P communications requirements

4.9.1 Description

This subclause specifies the V2P communications related requirements.

4.9.2 Requirements

[AR-4.9.2-a] The VAE capabilities shall provide mechanisms (e.g. configurations) to support V2P communications.

5 Involved business relationships

Figure 5-1 shows the business relationships that exist and that are needed to support a single V2X user.

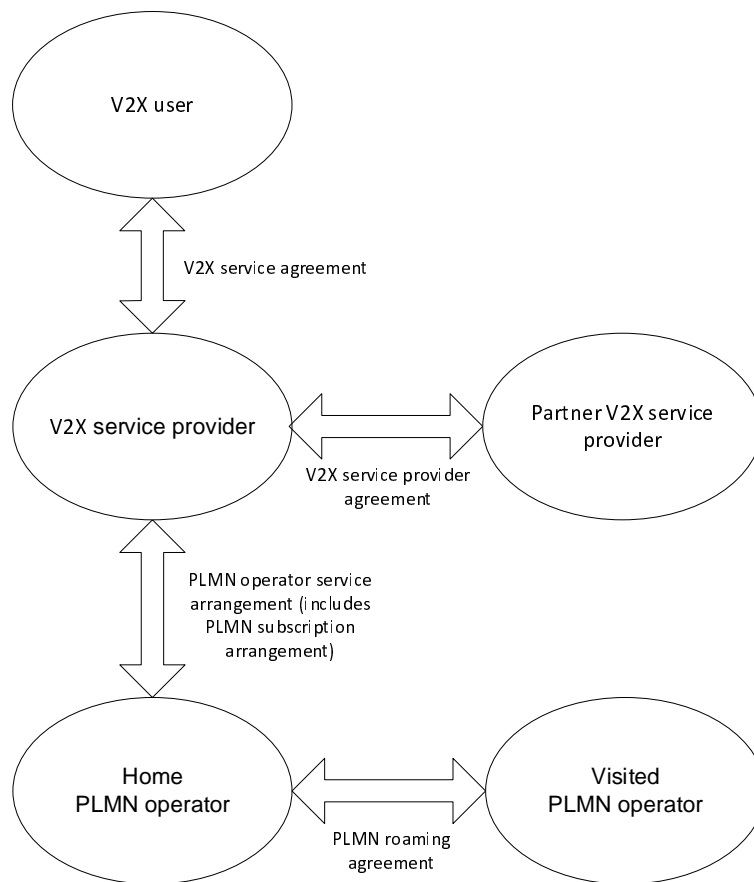


Figure 5-1: Business relationships for V2X services

The V2X user belongs to a V2X service provider based on a V2X service agreement between the V2X user and the V2X service provider. The V2X service provider can have V2X service agreements with several V2X users. The V2X user can have V2X service agreements with several V2X service providers. The V2X service provider can have V2X service provider agreements with several partner V2X service providers.

The V2X service provider and the home PLMN operator can be part of the same organization, in which case the business relationship between the two is internal to a single organization.

The home PLMN operator can have PLMN operator service arrangements with multiple V2X service providers and the V2X service provider can have PLMN operator service arrangements with multiple home PLMN operators. As part of the PLMN operator service arrangement between the V2X service provider and the home PLMN operator, PLMN subscription arrangements can be provided which allows the V2X UEs to register with home PLMN operator network.

The home PLMN operator can have PLMN roaming agreements with multiple visited PLMN operators and the visited PLMN operator can have PLMN roaming agreements with multiple home PLMN operators.

6 Functional model

6.1 General

The functional model for the V2X application layer is organized into functional entities to describe a functional architecture which addresses the application layer support aspects for V2X applications.

6.2 Functional model description

Figure 6.2-1 illustrates the simplified architectural model for the V2X application layer. It utilizes the architectural reference model specified in clause 4.2 in 3GPP TS 23.285 [5] and clause 4.2 in 3GPP TS 23.287 [19] which have impact on the application layer support aspects.

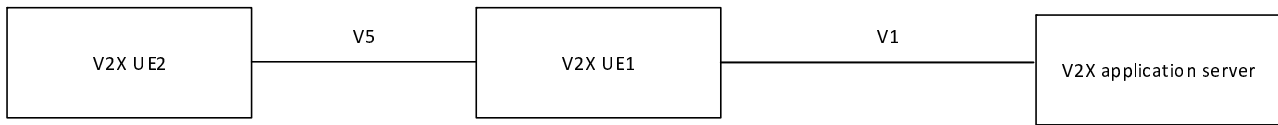


Figure 6.2-1: Simplified architectural model for the V2X application layer

The V2X UE1 communicates with V2X application server over V1 reference point. The V2X UE1 and V2X UE2 communicate over V5 reference point. V2X UE1 can also act as a UE-to-network relay, to enable V2X UE2 to access the V2X application server over V1 reference point.

The reference point V1 supports the V2X application related interactions between V2X UE and V2X AS and is specified in 3GPP TS 23.285 [5] and 3GPP TS 23.287 [19]. This reference point is supported for both unicast and multicast delivery modes. The reference point V5 supports the interactions between the V2X UEs and is specified in 3GPP TS 23.285 [5] and 3GPP TS 23.287 [19].

Figure 6.2-2 illustrates the detailed V2X application layer functional model. It enhances the simplified architectural model for the V2X application layer by specifying the functional entities at the V2X application layer.

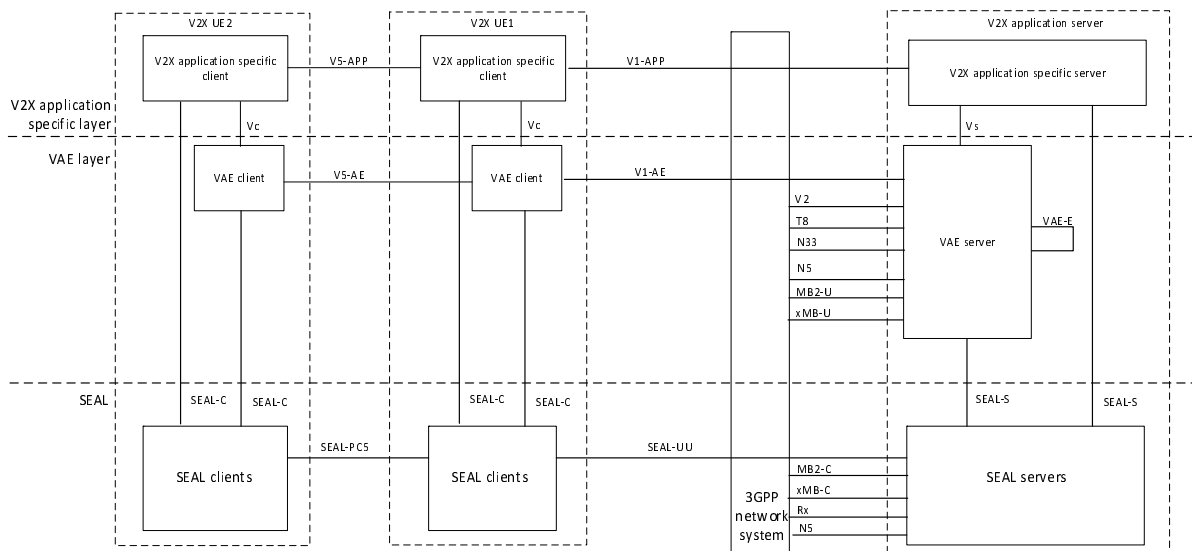


Figure 6.2-2: V2X application layer functional model

The V2X application layer functional entities for the V2X UE and the V2X application server are grouped into the V2X application specific layer and the VAE layer. The VAE layer offers the VAE capabilities to the V2X application specific layer. The V2X application layer functional model utilizes the SEAL services as specified in 3GPP TS 23.434 [6].

The VAE server is located in the VAE layer. The SEAL services utilized by VAE layer are location management, group management, configuration management, identity management, key management and network resource management. The V2X application specific layer consists of the V2X application specific functionalities.

NOTE 1: The functionalities of the V2X application specific layer are out of scope of the present document.

The V2X application server consists of the VAE server, the SEAL servers and the V2X application specific server. The VAE server provides the V2X application layer support functions to the V2X application specific server over Vs reference point. The SEAL server(s) provide the SEAL services to the V2X application specific server over SEAL-S reference point.

The V2X UEs consist of the VAE client, the SEAL clients and the V2X application specific client. The VAE client provides the V2X application layer support functions to the V2X application specific client over Vc reference point. The SEAL client(s) provide the SEAL services to the V2X application specific client over SEAL-C reference point.

NOTE 2: In some deployments, the client and server entities of SEAL can be part of VAE client and VAE server respectively.

The VAE client acts as a VAL client for its interaction with the SEAL clients as specified in 3GPP TS 23.434 [6]. The VAE server acts as a VAL server for its interaction with the SEAL servers as specified in 3GPP TS 23.434 [6].

In the VAE layer, the VAE client communicates with the VAE server over V1-AE reference point. In the V2X application specific layer, the V2X application specific client communicates with V2X application specific server over V1-APP reference point.

NOTE 3: The V1-APP reference point is out of scope of the present document.

In the VAE layer, the VAE client of V2X UE2 communicates with VAE client of V2X UE1 over V5-AE reference point. In the V2X application specific layer, the V2X application specific client of V2X UE2 communicates with VAE client of V2X UE1 over V5-APP reference point.

NOTE 4: The V5-APP reference point is out of scope of the present document.

The following SEAL services for V2X applications are supported:

- Location management as specified in 3GPP TS 23.434 [6];
- Group management as specified in 3GPP TS 23.434 [6];
- Configuration management as specified in 3GPP TS 23.434 [6];
- Identity management as specified in 3GPP TS 23.434 [6];
- Key management as specified in 3GPP TS 23.434 [6]; and
- Network resource management as specified in 3GPP TS 23.434 [6].

The VAE client interacts with SEAL clients over the SEAL-C reference point specified for each SEAL service. The VAE server interacts with SEAL servers over the SEAL-S reference point specified for each SEAL service. The interaction between the SEAL clients is supported by SEAL-PC5 reference point specified for each SEAL service. The interaction between a SEAL client and the corresponding SEAL server is supported by SEAL-UU reference point specified for each SEAL service.

NOTE 5: The SEAL-C, SEAL-S, SEAL-PC5, SEAL-UU reference points for each SEAL service is specified in 3GPP TS 23.434 [6].

To support distributed VAE server deployments, the VAE server interacts with another VAE server over VAE-E reference point.

V2X UE1 can also act as a UE-to-network relay,

- to enable VAE client on V2X UE2 to access VAE server over V1-AE reference point; and
- to enable V2X application specific client on V2X UE2 to access V2X application specific server over V1-APP reference point.

A V1-AE message can be sent over unicast, transparent multicast via xMB, transparent multicast via MB2. The non-transparent multicast via xMB (as specified in 3GPP TS 26.348 [11]) is triggered by a V1-AE message. Multicast distribution can be supported by both transparent and non-transparent multicast modes.

The VAE server interacts with the 3GPP network system over V2, MB2, xMB, Rx, T8, N5 and N33 reference points. The EPS and 5GS are considered as the 3GPP network system.

6.3 Functional entities description

6.3.1 General

Each subclause is a description of a functional entity corresponding to V2X application layer and does not imply a physical entity.

6.3.2 V2X application specific client

The V2X application specific client provides the client side functionalities corresponding to the V2X applications (e.g. platooning client). The V2X application specific client utilizes the VAE client for the V2X application layer support functions.

NOTE: The details of the V2X application specific client is out of scope of the present document.

6.3.3 V2X application specific server

The V2X application specific server provides the server side functionalities corresponding to the V2X applications (e.g. platooning server). The V2X application specific server utilizes the VAE server for the V2X application layer support functions. If CAPIF is supported, the V2X application specific server acts as CAPIF's API invoker as specified in 3GPP TS 23.222 [21].NOTE: The details of the V2X application specific server is out of scope of the present document.

6.3.4 VAE client

The VAE client provides the client side V2X application layer support functions as below:

- registration of VAE clients for receiving V2X messages;
- receiving V2X messages from the VAE server and the delivery to V2X application specific client(s) according to the V2X service ID;
- perform the role of the MBMS client for multicast file transfer using xMB APIs;
- receiving network monitoring reports from the VAE server;
- supports switching the modes of operations for V2V communications (e.g. between direct and in-direct V2V communications);
- providing application level locations to the VAE server (e.g. tile, geo-fence);
- receiving 3GPP system configuration information (e.g. V2X USD, PC5 parameters) from the VAE server; and
- supporting dynamic group management.

The VAE client supports interactions with the V2X application specific client(s).

6.3.5 VAE server

The VAE server acts as a GCS AS as described in 3GPP TS 23.468 [7] or acts as a content provider as described in 3GPP TS 26.346 [10]. If CAPIF is supported, the VAE server acts as CAPIF's API exposing function to provide service APIs to the V2X application specific server or another VAE server as specified in 3GPP TS 23.222 [21], or acts as CAPIF's API invoker to consume the service APIs provided by another VAE server.

The VAE server provides the server side V2X application layer support functions as below:

- communicating with the underlying 3GPP network systems (EPS, 5GS) for unicast and multicast network resource management;
- receiving monitoring reports/events from the underlying 3GPP network systems (EPS, 5GS) regarding network situation corresponding to RAN and core network;

- supporting registration of V2X UEs;
- tracking the application level geographic location of the V2X UEs;
- supporting V2X message distribution for the V2X applications;
- supporting provisioning of 3GPP system configuration information (e.g. V2X USD, PC5 parameters);
- perform the role of content provider for multicast file transfer using xMB APIs;
- providing network monitoring reports to the V2X UEs;
- communicating V2X service requirements to the underlying 3GPP network systems (EPS, 5GS);
- maintaining the mapping between the V2X user ID and the V2X UE ID;
- providing V2X service discovery;
- supporting V2X service continuity; and
- supporting V2X application resource adaptation.

6.3.6 SEAL client

The following SEAL clients for V2X applications are supported:

- Location management client as specified in 3GPP TS 23.434 [6];
- Group management client as specified in 3GPP TS 23.434 [6];
- Configuration management client as specified in 3GPP TS 23.434 [6];
- Identity management client as specified in 3GPP TS 23.434 [6];
- Key management client as specified in 3GPP TS 23.434 [6]; and
- Network resource management client as specified in 3GPP TS 23.434 [6].

6.3.7 SEAL server

The following SEAL servers for V2X applications are supported:

- Location management server as specified in 3GPP TS 23.434 [6];
- Group management server as specified in 3GPP TS 23.434 [6];
- Configuration management server as specified in 3GPP TS 23.434 [6];
- Identity management server as specified in 3GPP TS 23.434 [6];
- Key management server as specified in 3GPP TS 23.434 [6]; and
- Network resource management server as specified in 3GPP TS 23.434 [6].

6.4 Reference points description

6.4.1 General

The reference points for the V2X application layer are described in the following subclauses.

6.4.2 V1-AE

The interactions related to V2X application layer support functions between VAE client and VAE server are supported by V1-AE reference point. This reference point is an instance of V1 reference point as described in 3GPP TS 23.285 [5]. This reference point is supported for both unicast and multicast delivery modes.

6.4.3 V1-APP

The interactions related to V2X applications between V2X application specific client and V2X application specific server are supported by V1-APP reference point. This reference point is an instance of V1 reference point described in 3GPP TS 23.285 [5]. The details of V1-APP reference point is out of scope of the present document.

6.4.4 V5-AE

The interactions related to V2X application layer support functions between the VAE clients are supported by V5-AE reference point. This reference point is an instance of V5 reference point as described in 3GPP TS 23.285 [5].

6.4.5 V5-APP

The interactions related to V2X applications between V2X application specific clients are supported by V5-APP reference point. This reference point is an instance of V5 reference point described in 3GPP TS 23.285 [5]. The details of V5-APP reference point is out of scope of the present document.

6.4.6 Vs

The interactions related to V2X application layer support functions between the VAE server and the V2X application specific server are supported by Vs reference point. If CAPIF is supported, this reference point is an instance of CAPIF-2/2e reference point as specified in 3GPP TS 23.222 [21].

6.4.7 Vc

The interactions related to V2X application layer support functions between the VAE client and the V2X application specific client are supported by Vc reference point.

6.4.8 SEAL-C

The following SEAL-C reference points for V2X applications are supported:

- LM-C reference point for location management as specified in 3GPP TS 23.434 [6];
- GM-C reference point for group management as specified in 3GPP TS 23.434 [6];
- CM-C reference point for configuration management as specified in 3GPP TS 23.434 [6];
- IM-C reference point for identity management as specified in 3GPP TS 23.434 [6];
- KM-C reference point for key management as specified in 3GPP TS 23.434 [6]; and
- NRM-C reference point for network resource management as specified in 3GPP TS 23.434 [6].

6.4.9 SEAL-S

The following SEAL-S reference points for V2X applications are supported:

- LM-S reference point for location management as specified in 3GPP TS 23.434 [6];
- GM-S reference point for group management as specified in 3GPP TS 23.434 [6];
- CM-S reference point for configuration management as specified in 3GPP TS 23.434 [6];

- IM-S reference point for identity management as specified in 3GPP TS 23.434 [6];
- KM-S reference point for key management as specified in 3GPP TS 23.434 [6]; and
- NRM-S reference point for network resource management as specified in 3GPP TS 23.434 [6].

6.4.10 SEAL-PC5

The following SEAL-PC5 reference points for V2X applications are supported:

- LM-PC5 reference point for location management as specified in 3GPP TS 23.434 [6];
- GM-PC5 reference point for group management as specified in 3GPP TS 23.434 [6];
- CM-PC5 reference point for configuration management as specified in 3GPP TS 23.434 [6];
- IM-PC5 reference point for identity management as specified in 3GPP TS 23.434 [6];
- KM-PC5 reference point for key management as specified in 3GPP TS 23.434 [6]; and
- NRM-PC5 reference point for network resource management as specified in 3GPP TS 23.434 [6].

6.4.11 SEAL-UU

The following SEAL-UU reference points for V2X applications are supported:

- LM-UU reference point for location management as specified in 3GPP TS 23.434 [6];
- GM-UU reference point for group management as specified in 3GPP TS 23.434 [6];
- CM-UU reference point for configuration management as specified in 3GPP TS 23.434 [6];
- IM-UU reference point for identity management as specified in 3GPP TS 23.434 [6];
- KM-UU reference point for key management as specified in 3GPP TS 23.434 [6]; and
- NRM-UU reference point for network resource management as specified in 3GPP TS 23.434 [6].

6.4.12 VAE-E

The interactions related to V2X application supports functions between the VAE servers in a distributed deployment are supported by VAE-E reference point. If CAPIF is supported, this reference point is an instance of CAPIF-2/2e reference point as specified in 3GPP TS 23.222 [21].

6.5 External reference points

6.5.1 General

The reference points between the V2X application layer and the 3GPP network systems (EPS, 5GS) are described in the following clauses.

6.5.2 V2

The reference point V2 supports the interactions between V2X AS and the V2X control function of the EPS and is specified in 3GPP TS 23.285 [5].

6.5.3 Rx

The reference point Rx supports the interactions between the V2X AS and the PCRF and is specified in 3GPP TS 29.214 [12]. The functions for Rx reference point are supported by the network resource management server of the SEAL.

6.5.4 MB2-C

The reference point MB2-C supports the control plane interactions between the V2X AS and the BM-SC and is specified in 3GPP TS 29.468 [13]. The functions for MB2-C reference point are supported by the network resource management server of the SEAL.

6.5.5 MB2-U

The reference point MB2-U supports the user plane interactions between the V2X AS and the BM-SC and is specified in 3GPP TS 29.468 [13]. The functions for MB2-U reference point are supported by the VAE server.

6.5.6 xMB-C

The reference point xMB-C supports the control plane interactions between the V2X AS and the BM-SC and is specified in 3GPP TS 26.346 [10]. The functions for xMB reference point are supported by the network resource management server of the SEAL.

6.5.7 xMB-U

The reference point xMB-U supports the user plane interactions between the V2X AS and the BM-SC and is specified in 3GPP TS 26.346 [10]. The functions for xMB-U reference point are supported by the VAE server.

6.5.8 T8

The reference point T8 supports the interactions between the V2X AS and the SCEF and is specified in 3GPP TS 23.682 [8]. The functions of T8 interface are supported by VAE server and the functions related to location management of T8 are supported by the location management server.

6.5.9 N5

The reference point N5 supports the interactions between the V2X AS and the PCF and is specified in 3GPP TS 23.501 [20]. The functions of N5 interface are supported by VAE server.

6.5.10 N33

The reference point N33 supports the interactions between the V2X AS and the NEF and is specified in 3GPP TS 23.501 [20]. The functions of N33 interface are supported by VAE server and the functions related to location management of N33 are supported by the location management server.

7 Deployment models

7.1 General

This clause describes deployments of the functional model specified in clause 6. The reference points utilized from underlying 3GPP network as specified in clause 6.5 is represented as 3GPP interfaces in the deployment models.

NOTE: The representation of SEAL functionalities in the vertical deployment is specified in 3GPP TS 23.434 [6].

7.2 Deployment of VAE server

The VAE server deployments can be centralized and distributed.

7.2.1 Centralized deployments

A centralized deployment is where a single VAE server offers the VAE capabilities to one or more V2X application specific server. The VAE server and the V2X application specific server may be co-located in a single physical entity. The VAE server may be deployed either in the PLMN operator domain or deployed in the V2X service provider domain. The VAE server connects with the 3GPP network systems (EPS, 5GS) in one or more PLMN operator domain. When VAE server and V2X application specific server are co-located in a single physical entity, the Vs reference point between the VAE server and the V2X application enabler server may not be used.

Figure 7.2.1-1 illustrates a deployment of the VAE server and the V2X application specific server in a single physical entity and deployed in V2X service provider domain. The VAE server may be deployed in a separate physical entity from the V2X application specific server in the V2X service provider domain. In such deployments, the Vs reference point is used for the communication between the VAE server and the V2X application specific server.

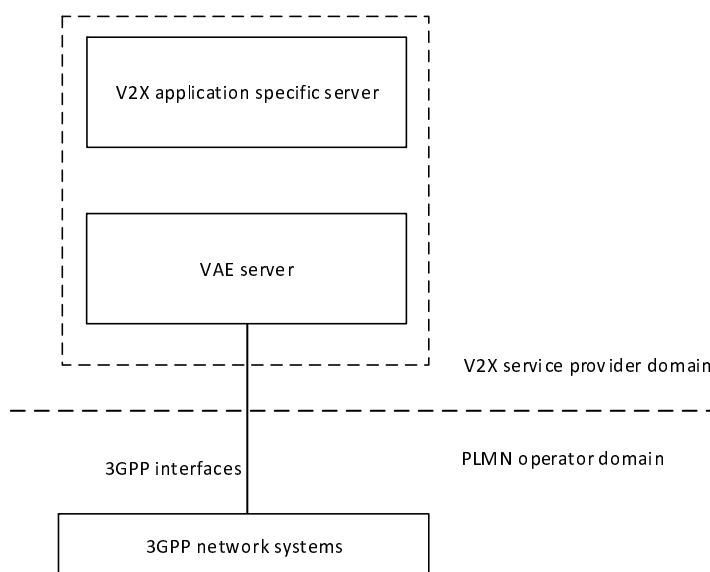


Figure 7.2.1-1: VAE server co-located with V2X application specific server in a single physical entity

Figure 7.2.1-2 illustrates a deployment of the VAE server in the PLMN operator domain and the V2X application specific server in the V2X service provider domain. The Vs reference point is used for the communication between V2X application specific server and the VAE server. The VAE server may support multiple V2X application specific servers.

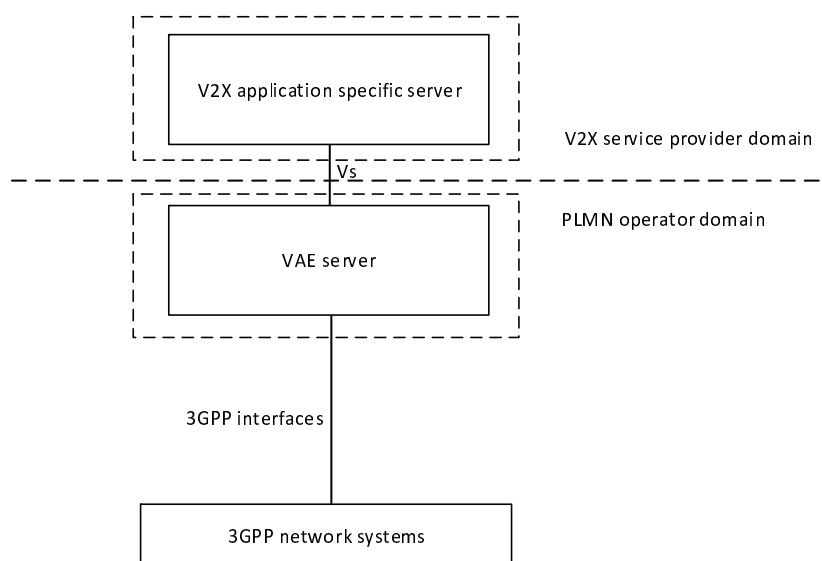


Figure 7.2.1-2: VAE server deployed in the PLMN operator domain

Figure 7.2.1-3 illustrates a deployment of the VAE server which connects to the 3GPP network systems (EPS, 5GS) in multiple PLMN operator domain. The VAE server may be co-located with the V2X application specific server in a single physical entity or deployed in different physical entities.

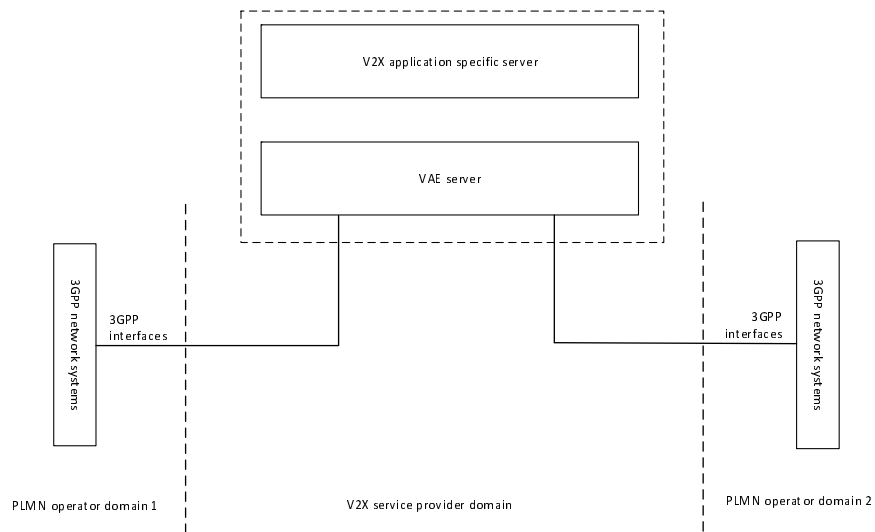


Figure 7.2.1-3: Deployment of VAE server with connections to 3GPP network systems in multiple PLMN operator domains

Figure 7.2.1-4 illustrates a deployment of the VAE server which provides VAE capabilities to multiple V2X application specific servers over Vs reference point and connects to the 3GPP network systems (EPS, 5GS) in multiple PLMN operator domain.

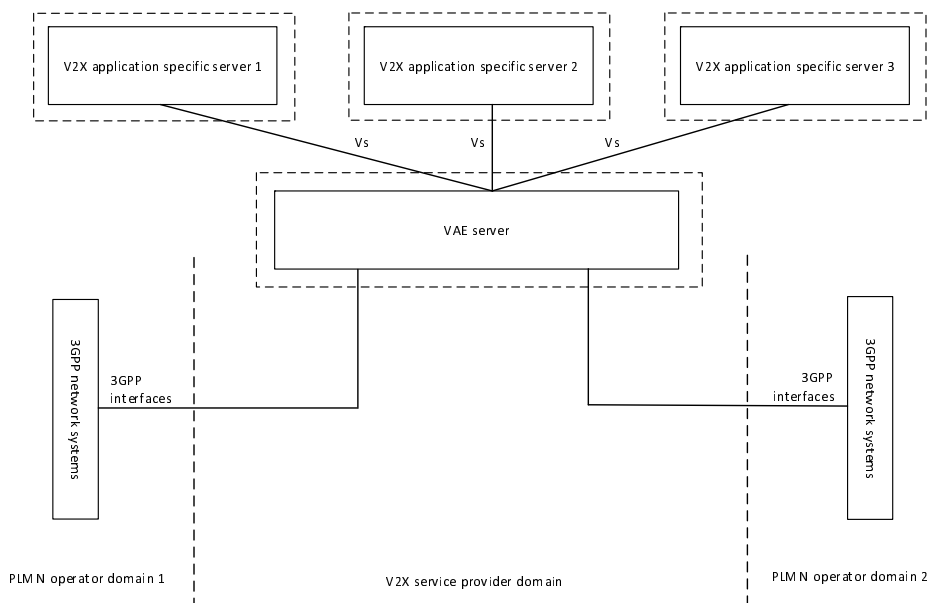


Figure 7.2.1-4: Deployment of VAE server with connections to multiple V2X application specific servers

7.2.2 Distributed deployment

The distributed deployment is where multiple VAE servers are deployed either in the V2X service provider domain or in the PLMN operator domain. The distributed deployment of the VAE servers provide geographical coverage or support multiple PLMN operator domains in a geographical location. The VAE servers interconnect via VAE-E and the Vs reference point is used for interaction between V2X application specific server and the VAE server.

Figure 7.2.2-1 illustrates the deployment of VAE servers in multiple PLMN operator domain and provides VAE capabilities to the V2X application specific server deployed in the V2X service provider domain. The V2X application specific server connects via Vs to the VAE servers.

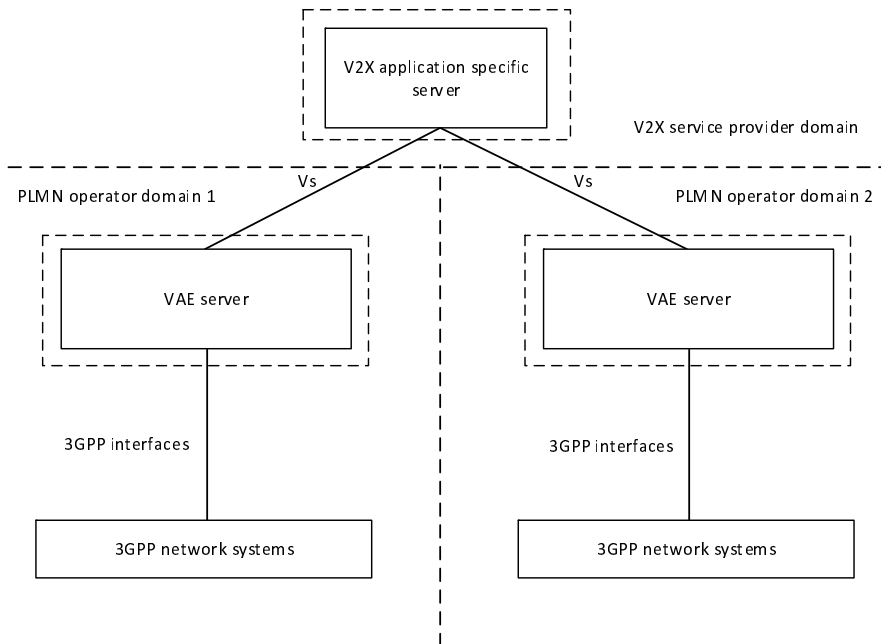


Figure 7.2.2-1: Distributed deployment of VAE servers in multiple PLMN operator domain without interconnection between VAE servers

Figure 7.2.2-2 illustrates the deployment of multiple VAE servers deployed in multiple PLMN operator domains. The V2X application specific server connects via Vs to the VAE server. The interconnection between VAE servers is via VAE-E and supports the V2X applications for the V2X UEs connected to the VAE servers in multiple PLMN operator domains.

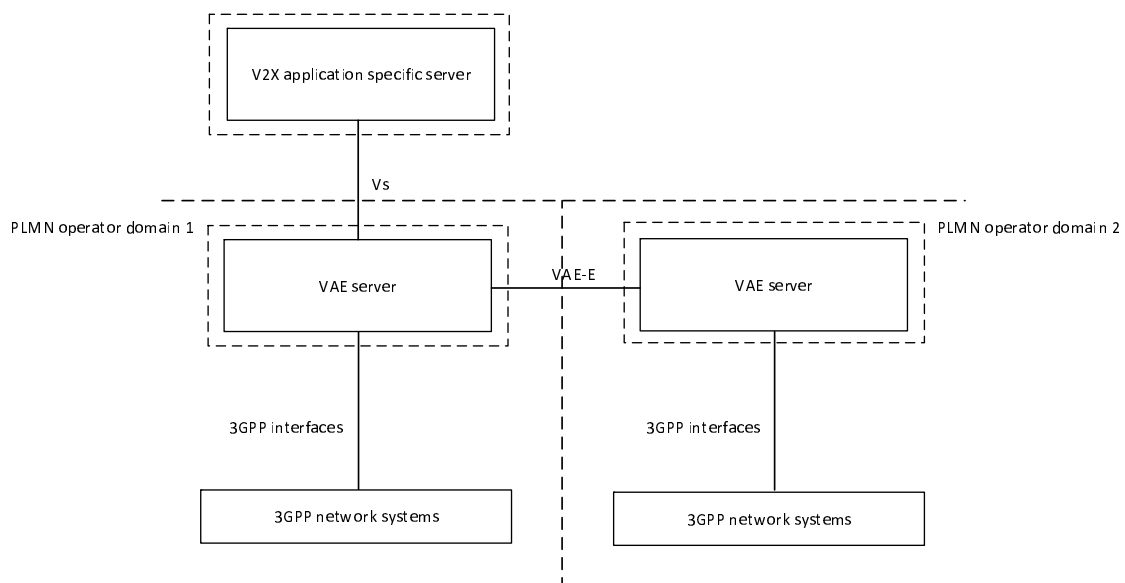


Figure 7.2.2-2: Distributed deployment of VAE servers in multiple PLMN operator domain with interconnection between VAE servers

Figure 7.2.2-3 illustrates the deployment of multiple VAE servers in PLMN operator domain based on geographical coverage. The V2X application specific server connects via Vs to the VAE server 1. The VAE servers interconnect via VAE-E and support the V2X communications to the V2X UEs connected to the VAE servers.

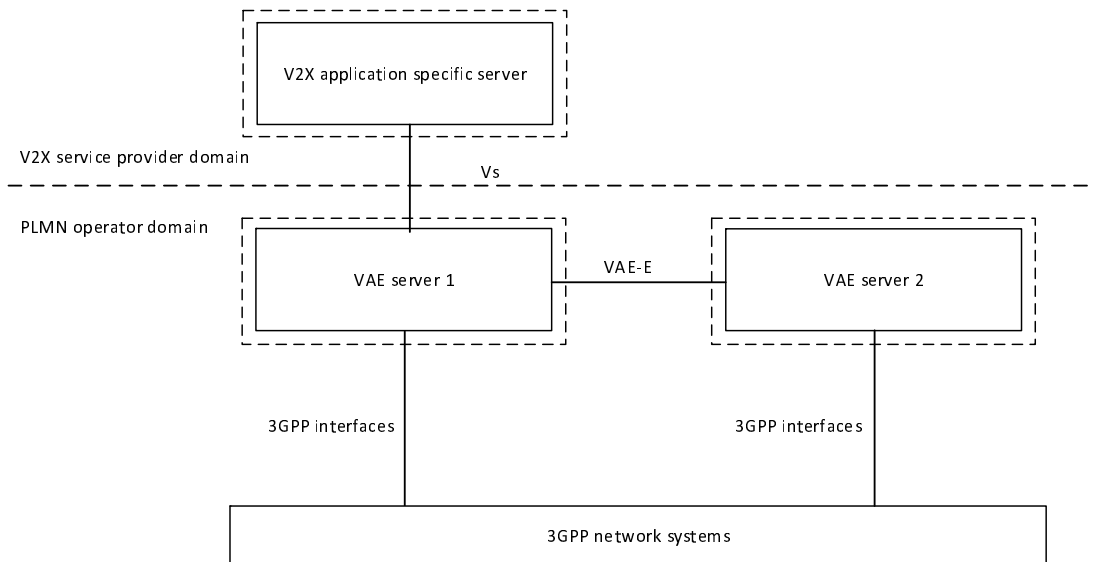


Figure 7.2.2-3: Distributed deployment of VAE servers in PLMN operator domain

Figure 7.2.2-4 illustrates the deployment of multiple VAE servers in the V2X service provider domain where VAE server 1 and VAE server 2 connect with 3GPP network system of PLMN operator domain 1 and PLMN operator domain 2 respectively. The PLMN operator domains provide coverage to different geographical areas. The V2X application specific server connects via Vs to the VAE server 1. The VAE servers interconnect via VAE-E and support the V2X applications for the V2X UEs connected via both the PLMN operator domains.

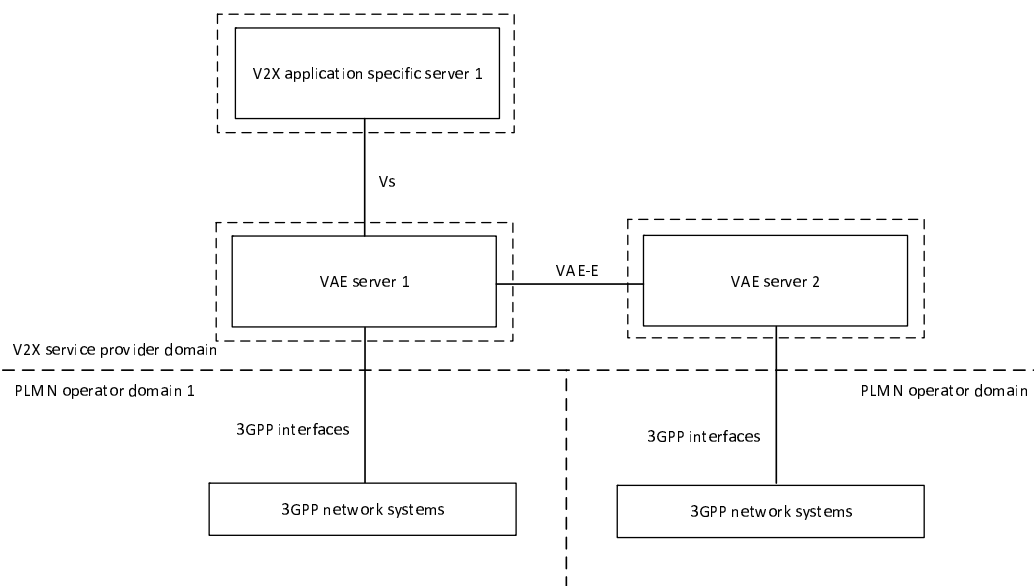


Figure 7.2.2-4: Distributed deployment of VAE servers in V2X service provider domain

8 Identities

8.1 V2X user identity (V2X user ID)

The V2X user ID can be an instance of the VAL user ID as specified in 3GPP TS 23.434 [6]. The V2X user ID is a globally unique identifier within the V2X service that represents the V2X user. The V2X user ID shall be a URI. The V2X user ID is used for authentication and authorization purposes for providing the V2X service towards the V2X user via the V2X UE. The V2X user ID also indicates the V2X service provider with whom the V2X user has a V2X service agreement. The V2X user may have V2X service agreement with several V2X service providers and thus will have obtained unique V2X user ID per V2X service provider.

Based on the service agreement, each V2X user ID is mapped to a V2X UE ID.

8.2 V2X UE identity (V2X UE ID)

The V2X UE ID can be an instance of the VAL UE ID as specified in 3GPP TS 23.434 [6]. The V2X UE ID is a unique identifier within the V2X service that represents the V2X UE. The V2X UE ID is mapped to an application specific UE identity (e.g. StationID as specified in ETSI TS 102 894-2 [16] or GPSI as specified in 3GPP TS 23.003 [23]). Due to privacy considerations, the V2X UE ID may be changed. The V2X UE ID is used to address the V2X UE in order to send V2X messages.

8.3 V2X service identity (V2X service ID)

The V2X service ID can be an instance of the VAL service ID as specified in 3GPP TS 23.434 [6]. The V2X service ID is a globally unique identifier that represents the V2X service. A V2X application server provides a list of V2X services towards the V2X UE. Each V2X service is uniquely identified by a V2X service ID, which is an identifier of the V2X application. The V2X service ID can be used for policy mapping, QoS handling for V2X communication and V2X message distribution, as specified in 3GPP TS 23.285 [5]. An identifier of a V2X service, e.g. ITS-AID or PSID specified in ETSI TS 102 965 [17] and ISO TS 17419 [18], can be used as a V2X service ID.

8.4 V2X group identity (V2X group ID)

The V2X group ID is a globally unique identifier within the V2X service that represents a set of V2X users and the corresponding V2X UE. The set of V2X users may belong to the same or different V2X service provider. It indicates the V2X application server where the group is defined.

8.5 Geographical area identity (GEO ID)

The V2X service provider defined identity of a geographical area. The GEO ID supports different representations of geographical area (e.g. geo-fence, tile identifiers). The VAE server maintains the mapping of the GEO ID with the location corresponding to one or more V2X UE IDs.

The GEO ID may support the format of a URI.

9 Procedures and information flows

9.1 Usage of SEAL services

9.1.1 Group management service

9.1.1.1 General

The VAE capabilities (VAE client and VAE server) utilize the group management service procedures (e.g. creation, join, leave) of SEAL based on the group configuration information (e.g. group join policy, group leader) provided by the V2X application specific layer. The decisions and corresponding triggers (e.g. group creation, join, leave) for group management are responsibility of the V2X application specific layer and the details of the group management are abstracted by the VAE capabilities. The group management service of SEAL provides support for platooning groups and pre-arranged groups for V2X communications.

9.1.1.2 Information flows

The following information flows of group management service of SEAL as specified in 3GPP TS 23.434 [6] are applicable for the V2X applications:

- Group creation request specified in subclause 10.3.2.1;

- Group creation response specified in subclause 10.3.2.2;
- Group creation notification specified in subclause 10.3.2.3;
- Group information query request specified in subclause 10.3.2.4;
- Group information query response specified in subclause 10.3.2.5;
- Group membership update request specified in subclause 10.3.2.6;
- Group membership update response specified in subclause 10.3.2.7;
- Group membership notification specified in subclause 10.3.2.8;
- Group deletion request specified in subclause 10.3.2.9;
- Group deletion response specified in subclause 10.3.2.10;
- Group deletion notification specified in subclause 10.3.2.11;
- Group information request specified in subclause 10.3.2.12;
- Group information response specified in subclause 10.3.2.13;
- Group information subscribe request specified in subclause 10.3.2.14;
- Group information subscribe response specified in subclause 10.3.2.15;
- Group information notify request specified in subclause 10.3.2.16;
- Group information notify response specified in subclause 10.3.2.17;
- Store group configuration request specified in subclause 10.3.2.18;
- Store group configuration response specified in subclause 10.3.2.19;
- Get group configuration request specified in subclause 10.3.2.20;
- Get group configuration response specified in subclause 10.3.2.21;
- Subscribe group configuration request specified in subclause 10.3.2.22;
- Subscribe group configuration response specified in subclause 10.3.2.23;
- Notify group configuration request specified in subclause 10.3.2.24;
- Notify group configuration response specified in subclause 10.3.2.25;
- Configure VAL group request specified in subclause 10.3.2.26;
- Configure VAL group response specified in subclause 10.3.2.27;
- Group announcement specified in subclause 10.3.2.28;
- Group registration request specified in subclause 10.3.2.29;
- Group registration response specified in subclause 10.3.2.30;
- Identity list notification specified in subclause 10.3.2.31;
- Group de-registration request specified in subclause 10.3.2.32;
- Group de-registration response specified in subclause 10.3.2.33;
- Location-based group creation request specified in clause 10.3.2.34;

The usage of the above information flows are clarified as below:

- The identity list is the list of V2X UE IDs.

- During group creation the identity list contains the list of V2X UE IDs that are part of the group to be created. If the group member list is empty, an empty group is created; and
- The VAL service ID list is the list of V2X service IDs whose service communications are to be enabled on the group.
- Table 9.1.1.2.1-1 describes the VAL service specific information corresponding to the V2X applications.

Table 9.1.1.2.1-1: V2X service specific information for group creation request

Information element	Status	Description
V2X group ID	O	The group ID to be used for the V2X group. If group ID is not provided then the group ID should be allocated by group management server.
Group join policy	O (NOTE)	The policy information to be enforced by the group management server for members joining the group.
Group leader ID	O (NOTE)	The identity information of the V2X user to be used for user controlled group join.
NOTE: If the information elements, identity list specified in 3GPP TS 23.434 [6] is empty and group leader ID is not included, then group join policy information element must be included.		

- The VAL group ID is the V2X group ID.
- The identity is the V2X UE ID;
- The VAL server is the VAE server;
- The VAL group configuration information is the V2X group configuration information;
- The VAL group configuration data is the V2X group configuration information;
- The VAL group information reference is the V2X group information reference; and
- The VAL services requested is the V2X service IDs.

9.1.1.3 Procedures

The following procedures of group management service of SEAL as specified in 3GPP TS 23.434 [6] are applicable for the V2X applications:

- Group creation specified in subclause 10.3.3;
 - Group creation support is provided for the V2X applications (e.g. platooning and cooperative short distance grouping) to provide a dedicated group for the V2X UEs to communicate with each other. The group creation supports group without any group members to enable group member joining.
- Group information query specified in subclause 10.3.4;
- Group membership specified in subclause 10.3.5;
- Group configuration management specified in subclause 10.3.6;
- Location-based group creation specified in clause 10.3.7;
- Group announcement and join specified in subclause 10.3.8;
- Group member leave specified in clause 10.3.9;
- Temporary groups specified in clause 10.3.10;

9.1.2 Configuration management service

9.1.2.1 General

The VAE capabilities (VAE client and VAE server) utilize configuration management service procedures of SEAL to support V2X services for unicast and multicast delivery over LTE-Uu. The configuration management service of SEAL is utilized for offline configuration (before the V2X UE is receiving the V2X service from the V2X application specific server) and online configuration (during the V2X UE is receiving the V2X service from the V2X application specific server).

9.1.2.2 Information flows

The following information flows of configuration management service are applicable for the V2X applications:

- Get VAL UE configuration request specified in subclause 11.3.2.1 of 3GPP TS 23.434 [6];
- Get VAL UE configuration response specified in subclause 11.3.2.2 of 3GPP TS 23.434 [6];

The usage of the above information flows are clarified as below:

- The VAL UE ID is the V2X UE ID;
- VAL service ID is the V2X service ID; and
- VAL UE configuration data is the V2X UE configuration data. The V2X UE configuration data includes:
 - V2X server USD information as specified in 3GPP TS 23.285 [5]; and
 - V2X application server address information as specified in 3GPP TS 23.285 [5] and transport port for unicast.

9.1.2.3 Procedures

The following procedures of configuration management service are applicable for the V2X applications:

- VAL UE configuration data specified in subclause 11.3.3 of 3GPP TS 23.434 [6].
 - Once the V2X UEs are connected to the serving PLMN, the V2X UE is configured with configuration data (e.g. local service information) for receiving V2X services.

9.1.3 Location management service

9.1.3.1 General

The VAE capabilities (VAE client and VAE server) utilize location management (e.g. network location of UEs) service procedures of SEAL to support V2X services.

9.1.3.2 Information flows

The following information flows of location management service of SEAL as specified in 3GPP TS 23.434 [6] are applicable for the V2X applications:

- Location reporting configuration request specified in subclause 9.3.2.0;
- Location reporting configuration response specified in subclause 9.3.2.1;
- Location information report specified in subclause 9.3.2.2;
- Location information request specified in subclause 9.3.2.3;
- Location reporting trigger specified in subclause 9.3.2.4;
- Location information subscription request specified in subclause 9.3.2.5;

- Location information subscription response specified in subclause 9.3.2.6;
- Location information notification specified in subclause 9.3.2.7;
- Location reporting configuration cancel request specified in clause 9.3.2.8;
- Get UE(s) information request specified in clause 9.3.2.9;
- Get UE(s) information response specified in clause 9.3.2.10;

The usage of the above information flows are clarified as below:

- The identity is the V2X UE ID or V2X group ID;
- The set of identities is the V2X UE ID;
- The identity list or identities list is the list of V2X UE IDs; and
- The VAL server is the VAE server.

9.1.3.3 Procedures

The following procedures of location management service of SEAL as specified in 3GPP TS 23.434 [6] are applicable for the V2X applications:

- Event-triggered location reporting procedure specified in subclause 9.3.3;
- On-demand location reporting procedure specified in subclause 9.3.4;
- Client-triggered or VAL server-triggered location reporting procedure specified in clause 9.3.5;
- Location reporting event triggers configuration cancel specified in subclause 9.3.6;
- Location information subscription procedure specified in subclause 9.3.7;
- Event-trigger location information notification procedure specified in subclause 9.3.8;
- On-demand usage of location information procedure specified in subclause 9.3.9;
- Obtaining UE(s) information at a location specified in clause 9.3.10;

9.1.4 Identity management service

9.1.4.1 General

The VAE capabilities (VAE client and VAE server) utilizes identity management service procedures (e.g. authentication and authorization of UEs) of SEAL to support V2X services.

9.1.4.2 Information flows

The information flows of identity management service are specified in subclause 12.3.2 of 3GPP TS 23.434 [6] and are applicable for the V2X applications.

9.1.4.3 Procedures

The following procedures of identity management service are applicable for the V2X applications:

- General user authentication and authorization for VAL services specified in subclause 12.3.3 of 3GPP TS 23.434 [6].

9.1.5 Key management service

9.1.5.1 General

The VAE capabilities (VAE client and VAE server) utilizes key management service procedures of SEAL to support V2X services.

9.1.5.2 Information flows

The information flows of key management service are specified in subclause 13.3 of 3GPP TS 23.434 [6] and are applicable for the V2X applications.

9.1.5.3 Procedures

The procedures of key management service are specified in subclause 13.3 of 3GPP TS 23.434 [6] and are applicable for the V2X applications.

9.1.6 Network resource management service

9.1.6.1 General

The VAE capabilities (VAE client and VAE server) utilizes network resource management service procedures of SEAL to support V2X services.

9.1.6.2 Information flows

The following information flows of network resource management service of SEAL specified in 3GPP TS 23.434 [6] are applicable for the V2X applications:

- Network resource adaptation request specified in subclause 14.3.2.1;
- Network resource adaptation response specified in subclause 14.3.2.2;
- MBMS bearer announcement specified in subclause 14.3.2.3;
- MBMS listening status report specified in subclause 14.3.2.4;
- MBMS suspension reporting instruction specified in subclause 14.3.2.5;
- Resource request specified in subclause 14.3.2.6;
- Resource response specified in subclause 14.3.2.7;
- Resource modification request specified in subclause 14.3.2.8;
- Resource modification response specified in subclause 14.3.2.9;
- MBMS bearers request specified in subclause 14.3.2.10;
- MBMS bearers response specified in subclause 14.3.2.11; and
- User plane delivery mode specified in subclause 14.3.2.12;

9.1.6.3 Procedures

The following procedures of network resource management service of SEAL specified 3GPP TS 23.434 [6] are applicable for the V2X applications:

- Request for unicast resources at VAL service communication establishment specified in subclause 14.3.3.2.1;
- Request for modification of unicast resources specified in subclause 14.3.3.2.2;

- Network resource adaptation specified in subclause 14.3.3.3.1;
- Request for unicast resources at VAL service communication establishment specified in subclause 14.3.3.3.2;
- Request for modification of unicast resources specified in subclause 14.3.3.3.3;
- Use of pre-established MBMS bearers specified in subclause 14.3.4.2;
- Use of dynamic MBMS bearer establishment specified in subclause 14.3.4.3;
- MBMS bearer announcement over MBMS bearer specified in subclause 14.3.4.4;
- MBMS bearer quality detection specified in subclause 14.3.4.5;
- Service continuity in MBMS scenarios specified in subclause 14.3.4.6;
- MBMS suspension notification specified in subclause 14.3.4.7;
- MBMS bearer event notification specified in subclause 14.3.4.8; and
- Switching between MBMS bearer and unicast bearer specified in subclause 14.3.4.9.

9.2 V2X UE registration

9.2.1 General

The VAE capabilities provide support for registering V2X UEs at the VAE server. The VAE server uses the registration information to distribute V2X messages to the appropriate V2X UEs.

9.2.2 Information flows

9.2.2.1 Registration request

Table 9.2.2.1-1 describes the information flow for a VAE client to register for specific V2X messages at the VAE server.

Table 9.2.2.1-1: Registration request

Information element	Status	Description
V2X UE ID	M	Identifier of the V2X UE (e.g. StationID specified in ETSI TS 102 894-2 [16])
V2X service ID	M	V2X service ID, the V2X UE is interested in receiving (e.g. PSID or ITS AID of ETSI ITS DENM, ETSI ITS CAM)
Supported RAT types	O	RAT types (e.g. NR, E-UTRA) supported by the V2X UE

9.2.2.2 Registration response

Table 9.2.2.2-1 describes the information flow for VAE server to respond for registration request from the VAE client.

Table 9.2.2.2-1: Registration response

Information element	Status	Description
Result	M	Result from the VAE server in response to registration request indicating success or failure

9.2.2.3 Deregistration request

Table 9.2.2.3-1 describes the information flow for a VAE client to deregister from receiving specific V2X messages from the VAE server.

Table 9.2.2.3-1: Deregistration request

Information element	Status	Description
V2X UE ID	M	Identifier of the V2X UE
V2X service ID	M	V2X service ID the V2X UE is no longer interested in receiving (e.g. PSID or ITS AID of ETSI ITS DENM, ETSI ITS CAM)

9.2.2.4 Deregistration response

Table 9.2.2.4-1 describes the information flow for VAE server to respond for deregistration request from the VAE client.

Table 9.2.2.4-1: Deregistration response

Information element	Status	Description
Result	M	Result from the VAE server in response to the deregistration request

9.2.3 V2X UE registration for receiving V2X messages

9.2.3.1 General

This subclause describes the procedures for V2X UE to register for receiving V2X messages from the V2X AS. The process is triggered by the V2X UE who is interested in receiving certain V2X messages.

9.2.3.2 Procedure

Pre-condition:

- The VAE client has discovered the VAE server and is aware of the address of the VAE server (e.g. FDQN).

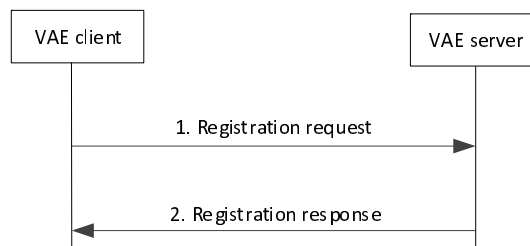


Figure 9.2.3.2-1: Procedure for registering the VAE client at the VAE server

1. The VAE client sends a registration request to the VAE server.
2. The VAE server sends an acknowledgement to the VAE client.

9.2.4 V2X UE deregistration from receiving V2X messages

9.2.4.1 General

This subclause describes the procedures for V2X UE to deregister from receiving V2X messages from the V2X AS. The process is triggered by the V2X UE who is no longer interested in receiving certain V2X messages.

9.2.4.2 Procedure

Pre-condition:

- The VAE client has already registered with the VAE server as described in subclause 9.2.3.

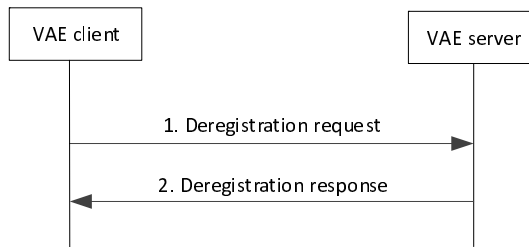


Figure 9.2.4.2-1: Procedure for deregistering the VAE client at the VAE server

1. The VAE client sends a deregistration request to the VAE server.
2. The VAE server sends a deregistration response to the VAE client.

9.3 Application level location tracking

9.3.1 General

The VAE capabilities provide support for location tracking of the VAE client(s) as per the geographical information provided by the V2X application specific layer.

9.3.2 Information flows

9.3.2.1 Subscription request

Table 9.3.2.1-1 describes the information flow for a VAE client to subscribe to a geographical area at the VAE server.

Table 9.3.2.1-1: Subscription request

Information element	Status	Description
V2X UE ID	M	Identifier of the V2X UE
GEO ID	M	Geographical area identifier (e.g. URI, tile identifier, geo-fence tile identifier)

9.3.2.2 Subscription response

Table 9.3.2.2-1 describes the information flow for VAE server to respond for geographical area subscription request from the VAE client.

Table 9.3.2.2-1: Subscription response

Information element	Status	Description
Result	M	Result from the VAE server in response to subscription request indicating success or failure

9.3.2.3 Unsubscription request

Table 9.3.2.3-1 describes the information flow for a VAE client to unsubscribe from a geographical area at the VAE server.

Table 9.3.2.3-1: Unsubscription request

Information element	Status	Description
V2X UE ID	M	Identifier of the V2X UE
GEO ID	M	Geographical area identifier (e.g. URI, tile identifier, geo-fence tile identifier)

9.3.2.4 Unsubscription response

Table 9.3.2.4-1 describes the information flow for VAE server to respond for geographical area unsubscription request from the VAE client.

Table 9.3.2.4-1: Unsubscription response

Information element	Status	Description
Result	M	Result from the VAE server in response to unsubscription request

9.3.3 Tracking geographical location at the VAE server

9.3.3.1 General

This subclause describes the procedures for tracking V2X UEs geographical location at the VAE server. The V2X UE provides geographical area information to the VAE server upon moving to a new geographical area. This information is used by the VAE server to create and update the mapping between the geographical location and the identification of the V2X UE.

9.3.3.2 Procedure

Pre-conditions:

1. The VAE client is provisioned with GEO ID information;
2. The VAE client has registered with the VAE server as described in subclause 9.2.3; and
3. The VAE client has subscribed to a certain geographical area identifier (GEO ID A) in order to receive V2X messages for this area.

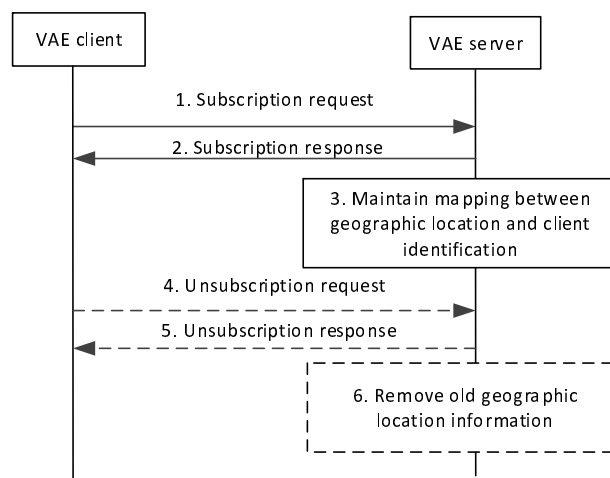


Figure 9.3.3.2-1: Procedure for tracking the client geographical area at the VAE server

1. Upon entering a new geographical area, the client subscribes to the geographic area Geo ID B.
2. The VAE server sends a subscription response to the VAE client.

3. The VAE server stores the new geographical area information GEO ID B with the client identification information V2X UE ID.
4. The client unsubscribes from the old geographical area GEO ID A.
5. The VAE server sends an unsubscription response to the VAE client.
6. The VAE server removes the old geographical area information GEO ID A associated with the client identification information V2X UE ID.

9.4 V2X message delivery

9.4.1 General

The VAE capabilities provide support for V2X message distribution originated from the V2X application specific layer. The message communication corresponding V2X applications and services are the responsibility of the V2X application specific layer entities. The VAE capabilities abstract the message distribution aspects from the V2X application specific layer.

9.4.2 Information flows

9.4.2.1 V2X message

Table 9.4.2.1-1 describes the information flow for a VAE server to deliver a V2X message to the VAE client.

Table 9.4.2.1-1: V2X message

Information element	Status	Description
V2X UE ID	M	Identifier of the destination V2X UE
V2X message payload (see NOTE)	M	V2X message payload carried by the V2X message (e.g. ETSI ITS DENM [15])
V2X service ID	M	The V2X service ID to which the V2X message belongs to
GEO ID	O	Geographical area identifier
Reception report required	O	Indicates whether a reception report is required for the V2X message
NOTE: The V2X message is V2X application/service specific and is not specified in this specification.		

9.4.2.2 V2X message reception report

Table 9.4.2.2-1 describes the information flow for VAE client to respond to reception of a V2X message from the VAE server.

Table 9.4.2.2-1: V2X message reception report

Information element	Status	Description
Result	M	Result from the VAE client in response to V2X message reception indicating success or failure

9.4.2.3 V2X group message

Table 9.4.2.3-1 describes the information flow for a VAE server to deliver a V2X message to a group of VAE clients.

Table 9.4.2.3-1: V2X group message

Information element	Status	Description
V2X group ID	M	The group ID for which the V2X message is addressed.
V2X message payload (see NOTE)	M	V2X message payload carried by the V2X message (e.g. ETSI ITS DENM [15]).
V2X service ID	M	The V2X service ID to which the V2X group message belongs to.
Geo ID	O	Geographical area identifier
Reception report required	O	Indicates whether a reception report is required for the V2X group message
NOTE: The V2X message is V2X application/service specific and is not specified in this specification.		

9.4.2.4 V2X uplink message

Table 9.4.2.4-1 describes the information flow for a VAE client to transmit a V2X message to the VAE server.

Table 9.4.2.4-1: V2X uplink message

Information element	Status	Description
V2X UE ID	M	Identifier of the sender V2X UE
V2X message payload (see NOTE)	M	V2X message payload carried by the V2X uplink message (e.g. ETSI ITS DENM [15])
V2X service ID	M	V2X service ID, the V2X UE is sending to the V2X AS
GEO ID (s)	O	Geographical area identifier of the originating V2X message from the V2X UE
Reception report required	O	Indicates whether a reception report is required for the uplink V2X message
NOTE: The V2X message payload is V2X application/service specific and is not specified in this specification.		

9.4.2.5 V2X uplink message reception report

Table 9.4.2.5-1 describes the information flow for a VAE server in response to a received V2X message from the VAE client.

Table 9.4.2.5-1: V2X uplink message reception report

Information element	Status	Description
Result	M	Result from the VAE server in response to V2X message indicating success or failure

9.4.2.6 Subscribe V2X message delivery request

Table 9.4.2.6-1 describes the information flow for a V2X application specific server to subscribe with VAE server for V2X messages.

Table 9.4.2.6-1: Subscribe V2X message delivery request

Information element	Status	Description
V2X application specific server identity information	M	Identity information of the V2X application specific server.
V2X service ID	M	The V2X service ID to which the V2X application-specific server registers to
GEO ID	O	The geographical area identifier to which the V2X application-specific server registers to
Endpoint information	M	Information of the endpoint of the V2X application specific server to which the uplink messages have to be sent.

9.4.2.7 Subscribe V2X message delivery response

Table 9.4.2.7-1 describes the information flow for a VAE server to provide a response to the V2X application specific server for subscription request for V2X uplink message delivery.

Table 9.4.2.7-1: Subscribe V2X uplink message delivery response

Information element	Status	Description
Subscription identifier (NOTE)	M	The subscription identifier corresponding to the request
Result	M	Result from the VAE server indicating subscription success or failure.
NOTE: If Result indicates failure, the value of the subscription identifier in the response is ignored.		

9.4.2.8 Unsubscribe V2X message delivery request

Table 9.4.2.8-1 describes the information flow for a V2X application specific server to unsubscribe with VAE server for V2X messages.

Table 9.4.2.8-1: Unsubscribe V2X message delivery request

Information element	Status	Description
Subscription identifier	M	The subscription identifier provided by the VAE server.

9.4.2.9 Unsubscribe V2X message delivery response

Table 9.4.2.9-1 describes the information flow for a VAE server to provide a response to the V2X application specific server for unsubscription request for V2X uplink message delivery.

Table 9.4.2.9-1: Unsubscribe V2X uplink message delivery response

Information element	Status	Description
Result	M	Result from the VAE server indicating unsubscription success or failure.

9.4.3 Message delivery to target geographical areas from the VAE server

9.4.3.1 General

This subclause describes the procedures for delivering V2X messages to registered V2X UEs at the VAE server in targeted geographical areas.

9.4.3.2 Procedure

Pre-conditions:

1. One or more VAE clients have registered with the VAE server as described in subclause 9.2.3;
2. One or more VAE clients have subscribed to geographical area GEO ID;
3. The VAE server has created a mapping between geographical area information and client identification as described in subclause 9.3.3; and
4. The V2X application-specific server has subscribed with the VAE server as described in subclause 9.4.6.

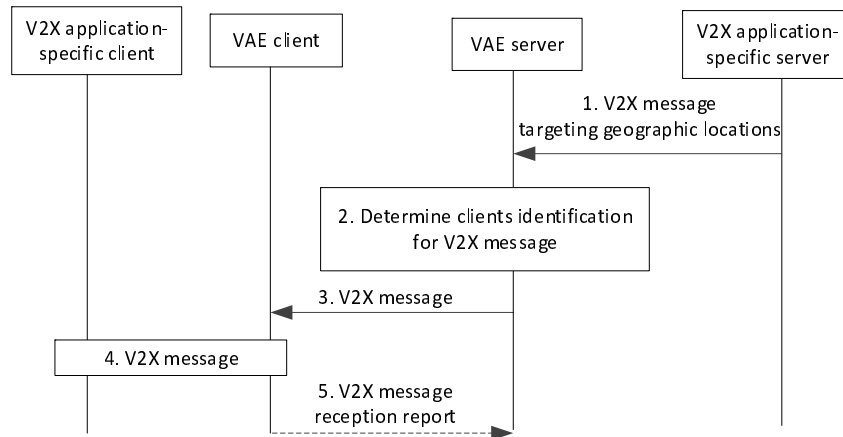


Figure 9.4.3.2-1: Procedure for delivering messages to target geographical areas from the VAE server

1. The application-specific server sends a V2X message of a service with V2X Service ID (e.g. ETSI ITS DENM, ETSI ITS CAM) with target geographical area GEO ID.
2. The VAE server retrieves the list of registered and subscribed clients for the V2X message targeting geographical area GEO ID and determines the clients' identification V2X UE ID.
3. The VAE server transmits the message to each VAE client using the client identification.
4. The VAE client provides the V2X message to the application-specific client.
5. The VAE client provides a V2X message reception report to the VAE server if indicated in the V2X message.

9.4.4 V2X group message distribution

9.4.4.1 General

This subclause describes the procedures for V2X group delivery from the VAE server to the VAE clients.

9.4.4.2 Procedure

Pre-conditions:

1. The VAE client has registered for receiving V2X group messages as described in in subclause 10.3.8 of 3GPP TS 23.434 [6].
2. The V2X application-specific server has subscribed with the VAE server as described in subclause 9.4.6.

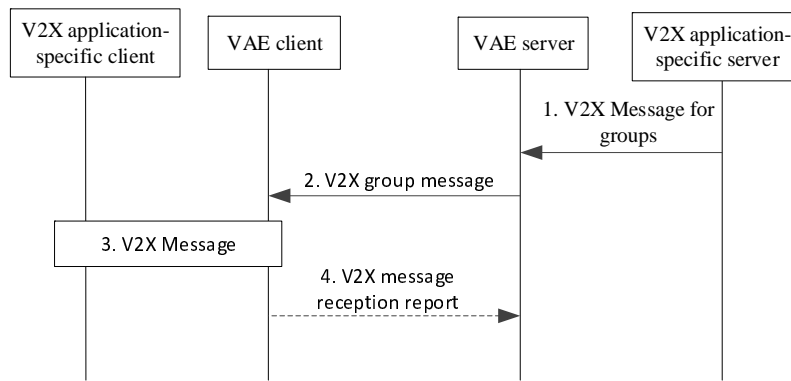


Figure 9.4.4.2-1: Procedure for delivering V2X group messages to VAE clients

1. The V2X application-specific server provides a V2X message for distribution to V2X group with V2X Group ID.
2. The VAE server delivers the V2X message to all registered VAE clients with V2X Group ID.
3. The VAE client provides the V2X message to the V2X application-specific client.
4. The VAE client may provide a V2X message reception report to the VAE server.

9.4.5 Uplink V2X message delivery

9.4.5.1 General

This subclause describes the procedures for delivering V2X messages from the V2X UE to the V2X application server.

9.4.5.2 Procedure for uplink message delivery

Pre-conditions:

1. The VAE client has discovered the VAE server as described in subclause 9.1.2.
2. The VAE client has registered to a V2X service identified by a V2X Service ID as described in subclause 9.2.
3. The V2X application specific server has performed the subscription as specified in clause 9.4.6.

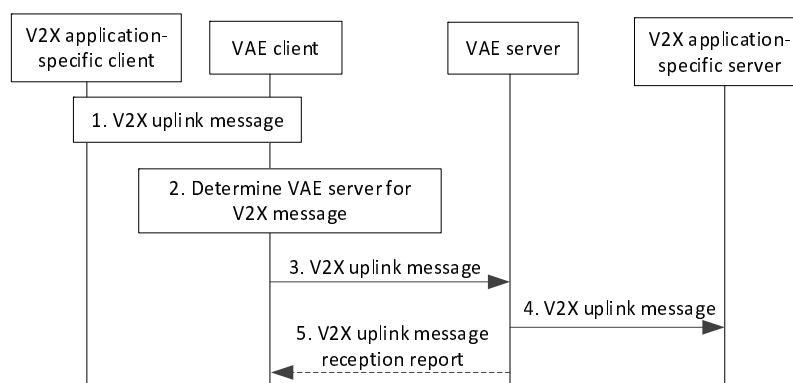


Figure 9.4.5.2-1: Procedure for delivering messages from V2X UE to the V2X application server

1. The V2X application-specific client sends a V2X uplink message to the VAE client.
2. The VAE client determines the VAE server for receiving the V2X uplink message with V2X Service ID.
3. The VAE client transmits the V2X uplink message to the VAE server.
4. The VAE server provides the V2X uplink message to the endpoint of V2X application-specific server(s).

5. The VAE server may provide a V2X uplink message reception report to the VAE client if indicated in the V2X uplink message.

9.4.6 Procedure for subscription to message delivery

Pre-condition:

- The V2X application specific server is configured with the VAE server information.

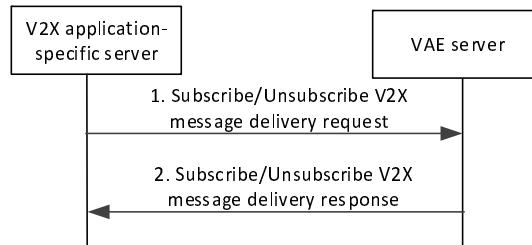


Figure 9.4.6-1: Procedure for subscription to message delivery

1. The V2X application-specific server sends a subscribe V2X message delivery request to the VAE server including the information of V2X service ID, GEO ID and the end point address at which the uplink messages from the V2X UE to the V2X application specific server are to be delivered.
2. The VAE server stores the subscription information and provides an acknowledgement via a subscribe V2X message delivery response message to the V2X application specific server.

9.5 File Distribution

9.5.1 General

The VAE capabilities provide support for file distribution to the V2X application specific layer. The VAE capabilities abstract the aspects like file chunking, QoE management, file delivery from the V2X application specific layer.

9.5.2 Use of MBMS "files" session type

The VAE server acts as a content provider and the VAE client acts as an MBMS client in the xMB reference model (subclause 4.1 in 3GPP TS 26.348 [11]).

The VAE server makes use of the xMB procedures from 3GPP TS 26.348 [11] to create MBMS sessions whose type is set to "files" and to request the delivery of files over these sessions. Before provisioning files to the BM-SC, the VAE server prepares the file for distribution, which may include partition of large files into smaller files or encryption.

The VAE server is responsible for translating the parameters related to the V2X application triggering the file delivery into corresponding xMB parameters. Table 9.5.2-1 describes the mapping between the V2X parameters and the xMB API properties specified in 3GPP TS 26.348 [11].

Table 9.5.2-1: Mapping between V2X parameters and xMB APIs

V2X parameter	Corresponding xMB API property
File transfer session indicator	Session Type: Files
List of files to be sent by the VAE server and their locations	File List
Target geographical area for the V2X Ues	Geographical Area
Information about the V2X application (e.g., software update, HD map download)	Service Class
Maximum bitrate for the V2X application	Max Bitrate
Maximum delay for the V2X application	Max Delay
QoE metrics the VAE server is interested in receiving about the V2X application	QoE Reporting
Local MBMS information or local MBMS activation indication	Local MBMS information (NOTE)
NOTE: The local MBMS information as the xMB API property is defined in 3GPP TS 29.116 [22].	

NOTE: The list of V2X parameters needed for file delivery is not exhaustive and can be updated based on the specific V2X application requirements.

9.6 Provisioning 3GPP system information by VAE server

9.6.1 General

The VAE server can provision network related information like multicast (e.g. V2X USD) to the V2X UE to further enable V2X UE to consume V2X service based on the location and connection with the VAE server.

9.6.2 Information flows

9.6.2.1 V2X USD announcement

Table 9.6.2.1-1 describes the information flow V2X USD announcement from the VAE server to the VAE client.

Table 9.6.2.1-1: V2X USD announcement

Information element	Status	Description
V2X UE ID	O	Identity of the V2X UE to which the configuration is required
V2X USD configuration data	M	The V2X USD configuration data as specified in 3GPP TS 23.285 [5]

9.6.2.2 Set PC5 parameters request

Table 9.6.2.2-1 describes the information flow set PC5 parameters request from the VAE server to the VAE client.

Table 9.6.2.2-1: Set PC5 parameters request

Information element	Status	Description
V2X UE ID	O	Identity of the V2X UE to which the configuration is required
PC5 parameters configuration data	M	The PC5 parameters configuration data as specified in 3GPP TS 23.285 [5] and 3GPP TS 23.287 [8]. For PC5 provisioning in multi-operator V2X services (as specified in clause 9.15), these parameters may be the joint provisioning policies/parameters to be used by the V2X-UEs within the V2X service.

9.6.2.3 Set PC5 parameters response

Table 9.6.2.3-1 describes the information flow set PC5 parameters response from the VAE client to the VAE server.

Table 9.6.2.3-1: Set PC5 parameters response

Information element	Status	Description
Result	M	The result whether setting the PC5 parameters received by the VAE server was successful or not.

9.6.3 V2X USD provisioning

9.6.3.1 General

This subclause describes the procedure for VAE server provisioning the V2X USD information to V2X UE via V1-AE reference point for V2X communication using MBMS.

9.6.3.2 Procedure

Figure 9.6.3.2-1 illustrates the procedure for provisioning V2X USD to the V2X UE via V1-AE reference point.

Pre-conditions:

1. The V2X UE has connected to the VAE server.
2. If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.

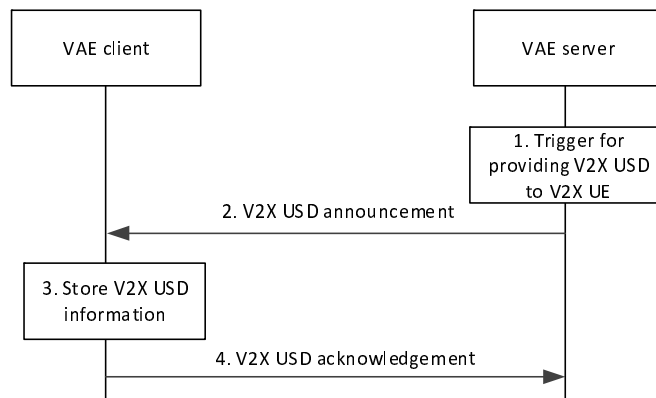


Figure 9.6.3.2-1: V2X USD provisioning

1. The VAE server is triggered for providing V2X USD to V2X UE.
2. The VAE server sends the V2X USD announcement to the VAE client in the V2X UE with the information of the V2X USDs corresponding to the V2X applications. The V2X USD information consists of TMGI, list of SAIs, frequency and SDP information for V2X applications' communication using MBMS. The details of V2X USD are specified in subclause 4.4.7.2 in 3GPP TS 23.285 [5]. This message can be sent via unicast or multicast.
3. Upon receiving the V2X USD announcement, the VAE client of the V2X UE stores the received V2X USDs.

NOTE: The principles for storing and applying precedence when V2X USD is configured via different mechanisms (e.g. MBMS service announcement or pre-configuration or by VAE server via V1-AE reference point) is as per V2X service provider's policy.

4. The VAE client of the V2X UE provides an acknowledgement to the VAE server of the V2X AS. This step is optional when the announcement is sent via multicast.

9.6.4 PC5 parameters provisioning

9.6.4.1 General

This subclause describes the procedure for the VAE server provisioning the PC5 parameter provisioning information to the V2X UE via V1-AE reference point for V2X communication on PC5. The configuration information includes the configuration parameters specified in 3GPP TS 23.285 [5], 3GPP TS 23.287 [8] and additional application related configuration parameters.

9.6.4.2 Procedure

Figure 9.6.4.2-1 illustrates the procedure for provisioning PC5 parameters to the V2X UE via V1 reference point.

Pre-conditions:

1. The V2X UE has discovered and connected to the VAE server.
2. If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.

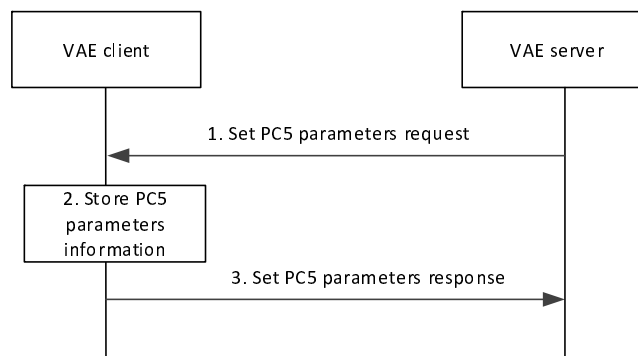


Figure 9.6.4.2-1: PC5 parameters provisioning

1. The VAE server sends the set PC5 parameters request to the VAE client with the information of the PC5 parameters. The PC5 parameters information are specified in subclause 4.4.1.1.2 in 3GPP TS 23.285 [5] and in subclause 5.1.2.1 in 3GPP TS 23.287 [8]. This message can be sent via unicast or multicast.
2. Upon receiving the set PC5 parameters request, the VAE client stores the received PC5 parameters in the V2X UE.
3. The VAE client provides an acknowledgement by sending the set PC5 parameters response to the VAE server.

9.7 Network monitoring by the V2X UE

9.7.1 General

The V2X UE subscribes for network monitoring information from the VAE server. Such network monitoring information may be used by the V2X UE for network connectivity adaptations (e.g. switching between different modes of operations for V2V communications).

9.7.2 Information flows

9.7.2.1 Network monitoring information subscription request

Table 9.7.2.1-1 describes the information flow network monitoring information subscription request from the VAE client to the VAE server.

Table 9.7.2.1-1: Network monitoring information subscription request

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE subscribing for the network monitoring information
Subscription event	M	Identify one or multiple network monitoring events (e.g. uplink degradation, congestion, overload, coverage)
Triggering criteria	M	Identify when the VAE server will send the monitoring reports to the VAE client.
Area information	O	Identify the area where the event is subscribed.
V2X UE ID(s)	O	Identify the V2X UE(s) to be monitored.
V2X service ID(s)	O	Identify the V2X service which is related with the event.

9.7.2.2 Network monitoring information subscription response

Table 9.7.2.2-1 describes the information flow network monitoring information subscription response from the VAE server to the VAE client.

Table 9.7.2.2-1: Network monitoring information subscription response

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE
Result	M	Indicates success or failure

9.7.2.3 Network monitoring information notification

Table 9.7.2.3-1 describes the information flow network monitoring information notification from the VAE server to the VAE client.

Table 9.7.2.3-1: Network monitoring information notification

Information element	Status	Description
V2X UE ID	M	Identity of the subscribed V2X UE
Network monitoring information (NOTE 2)	M	This includes information on network status for the triggering criteria, and may include the following parameters: <ul style="list-style-type: none"> - Uplink quality level - Congestion information (NOTE 1) - Geographical Area (cell area or TA for which the monitoring applies) - Time Validity (the period for which the monitoring applies) - Coverage level and bearer level events (optionally, for MBMS) - QoS Sustainability
V2X UE ID (NOTE 2)	O	Identify the V2X UE that the network monitoring information is related.
NOTE 1: With respect to the congestion information acquired from 5GC, it may be exact values for congestion status reported by NWDAF to NEF or abstracted values e.g. (High, Medium, Low) which can be reported by the NEF.		
NOTE 2: If subscription is for multiple V2X UE IDs, then multiple Network monitoring information IEs corresponding to V2X UE ID(s) can be present.		

9.7.3 V2X UE subscription for network monitoring information

9.7.3.1 General

This subclause describes the procedure for V2X UE subscription for network monitoring information.

9.7.3.2 Procedure

Figure 9.7.3.2-1 illustrates the procedure where the V2X UE subscribes for the network monitoring information from the VAE server.

Pre-condition:

- The VAE client of the V2X UE is connected to the VAE server and is authorized to access the network monitoring information.

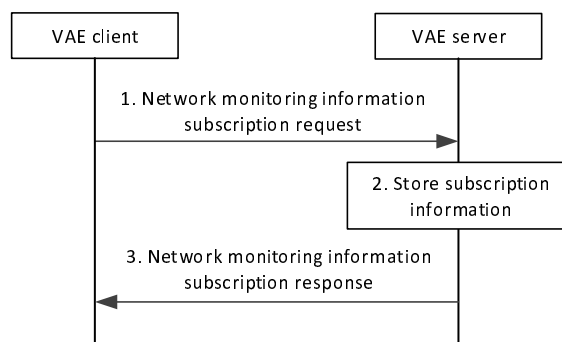


Figure 9.7.3.2-1: V2X UE subscription for network monitoring information

1. The VAE client sends a network monitoring information subscription request to the VAE server. The area information and/or the V2X UE ID(s) (e.g., the initiating V2X UE ID, the V2X UE ID(s)) is included to indicate whether per area or per UE(s) networking monitoring information is subscribed.
2. The VAE server checks for the authorization of the VAE client to access the network monitoring information and if allowed, stores the subscription information corresponding to the V2X UE.
3. The VAE server sends a network monitoring information subscription response to the VAE client including the result of the subscription (i.e. success or failure).

9.7.4 Notifications for network monitoring information

9.7.4.1 General

This subclause describes the procedure for notification of network monitoring information from the VAE server.

9.7.4.2 Procedure

Figure 9.7.4.2-1 illustrates the procedure where the VAE server sends notification of the network monitoring information to the V2X UEs.

Pre-conditions:

1. The VAE server acting as a SCS/AS is configured with the SCEF information and is authorized to exchange information with the SCEF as specified in subclause 4.9 in 3GPP TS 23.682 [8]. The VAE server has subscribed to QoS notification service from 5GS (e.g. PCF/NWDAF). The notification may either include the request for QoS sustainability events as specified in 3GPP TS 23.288 [24] or can include a QoS change notification requests as provided by SMF and specified in 3GPP TS 23.287 [8];

2. The V2X UE1 and V2X UE2 have subscribed for the network monitoring information at the VAE server.
3. The VAE server may be aware of the RAT type the V2X UE supports from the registration of VAE client.

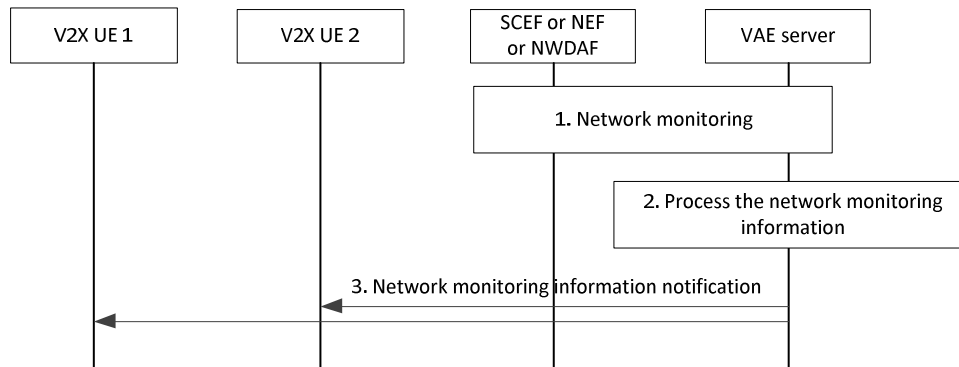


Figure 9.7.4.2-1: Notifications for network monitoring information

1. The VAE server communicates with the SCEF to receive network monitoring information as per the procedure in subclause 4.9 of 3GPP TS 23.682 [8], and/or communicates with NEF or NWDAF to receive QoS monitoring information and/or data analytics information of 5GS as defined in 3GPP TS 23.288 [24] for the requesting area and/or the V2X UE(s). The VAE server may determine to receive network monitoring information from EPC or 5GC or both considering the RAT type provided by the UE. The VAE server subscription to QoS monitoring service from 5GS (e.g. PCF/NWDAF) may be active for a certain period of time or a given geographical area and/or the V2X UE(s). The monitoring may either include the request for QoS sustainability events as specified in 3GPP TS 23.288 [24], or can include a QoS change notification requests as provided by SMF and specified in 3GPP TS 23.287 [8]. The reporting may be configured by the application enabler layer for a given area, V2X UE(s), time, periodicity etc taking into account the service requirement and other parameters (e.g. expected congestion in certain area, time of the day, road conditions). Based on the subscription, as specified in 3GPP TS 23.287 [8], 5GS provides the extended QoS monitoring report, over N33 interface. This report may come either from NWDAF or SMF via PCF/NEF.
2. The network monitoring information (e.g. uplink or downlink link degradations, congestions, etc.) available at the VAE server about the on-going V2V session(s) and the network status is based on the original network monitoring information provided by the SCEF in step 1, and/or based on QoS monitoring report or data analytics from 5GS as specified in step 1. The VAE server determines the network monitoring information to send to the UE.
3. The monitoring information is sent to the subscribed V2X UEs via network monitoring information notification.

9.8 Switching modes of operations for V2V communications

9.8.1 General

The V2X services need to support different modes of operation for V2V (PC5 and Uu) communications. The V2X UE makes the decision to switch between different modes of operation for V2V communications considering the V2V service KPIs as specified in 3GPP TS 22.186 [3]. The V2X application layer may provide the network monitoring information or recommendation for the communication mode to assist the V2X UE in making the switching decision for the operation modes selection.

The V2X UE determines switching of the mode of operation for V2V sessions based on several factors including the received network monitoring information as specified in subclause 9.7 and the PC5 communication quality information and assistance information received from the VAE server. The V2X UE switches the mode of operation and engages in either direct (PC5) or indirect (Uu) session as specified in subclause 23.14 of 3GPP TS 36.300 [14].

9.8.2 Information flows

9.8.2.1 Communication status request

Table 9.8.2.1-1 describes the information flow of communication status request from the VAE server to the VAE client.

Table 9.8.2.1-1: Communication status request

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE requested for communication status
V2X service ID	O	Identity of the V2X service being requested

9.8.2.2 Communication status response

Table 9.8.2.2-1 describes the information flow of communication status response from the VAE client to the VAE server.

Table 9.8.2.2-1: Communication status response

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE
V2V communication mode	M	V2V communication mode supported by the V2X UE (e.g. LTE PC5, NR PC5)
V2X service ID	O	Identify of the V2X service corresponding to the communication status
Cell information	O	Cell information (e.g. NR cell, E-UTRA cell) of which the V2X UE is located
Communication link status information	O	Communication status of the V2X UE (e.g. uplink/downlink data rates, packet loss and etc.)

9.8.2.3 V2V communication assistance info

Table 9.8.2.3-1 describes the information flow of V2V communication assistance info from the VAE server to the VAE client.

Table 9.8.2.3-1: V2V communication assistance info

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE
V2X service ID	O	Identify of the V2X service corresponding to the recommendation information
V2V communication assistance information	M	Assistance information for V2V communication mode switching to the V2X UE (e.g. recommended V2V communication mode, location, V2X service type, time validity, V2X service status, V2X application requirement, etc.)

9.8.3 Assistance for V2V communication mode switching

9.8.3.1 General

The VAE server provides assistance information for V2V communication mode switching to the V2X UE. To provide the assistance the VAE server may acquire the application requirements, the communication status of the V2X UEs and the network monitoring information from the 3GPP network.

9.8.3.2 Procedure

Figure 9.8.3.2-1 illustrates the procedure of assistance for V2V communication mode switching.

Pre-conditions:

1. The VAE server is aware of the RAT type the V2X UE supports.

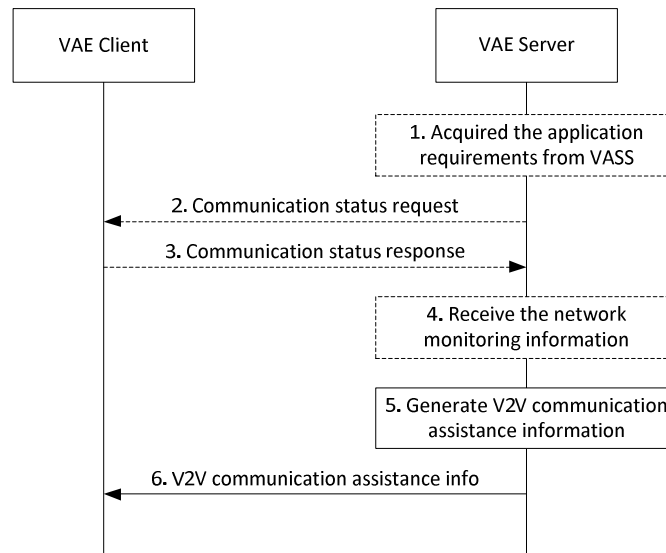


Figure 9.8.3.2-1: Assistance for V2V communication mode switching

1. The VAE server may have acquired the application requirement from the V2X application specific server. The application requirements may include the conditions corresponding to the V2V communication modes (e.g. network status, UE's location, QoS, V2X service type, and other influential parameters for V2V communication mode).
2. The VAE server may send the communication status request to the VAE client to acquire the current communication status of the UE.
3. The VAE client responds to the VAE server with the communication status information (e.g. the current V2V communication mode, communication link quality and etc.)
4. The VAE server may have received the network monitoring information from the 3GPP network.
5. Based on information acquired above the VAE server generates assistance information (configuration or recommendation) for V2V communication mode switching.
6. The VAE server sends the V2V communication assistance information to the VAE client.

9.9 V2X service discovery

9.9.1 General

The VAE server provides service information (e.g. available V2X services) to the V2X UE to enable the V2X UE to register and receive V2X services over LTE-Uu. The V2X services are identified by V2X service IDs.

9.9.2 Information flows

9.9.2.1 Get V2X UE service discovery request

Table 9.9.2.1-1 describes the information flow get V2X UE service discovery request from the VAE client to the VAE server and between VAE servers.

Table 9.9.2.1-1: Get V2X UE service discovery request

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE requesting the service discovery information.
V2X UE location information	O	Location information of the V2X UE

9.9.2.2 Get V2X UE service discovery response

Table 9.9.2.2-1 describes the information flow get V2X UE service discovery response from the VAE server to the VAE client and between VAE servers.

Table 9.9.2.2-1: Get V2X UE service discovery response

Information element	Status	Description
Result	M	Indicates the success or failure of getting the service discovery information
V2X UE service discovery information	O (NOTE)	The V2X UE service discovery data includes: <ul style="list-style-type: none"> - List of available V2X services identified by V2X service IDs - Mapping of the V2X services to V2X application server address as specified in 3GPP TS 23.285 [5]
NOTE: If the Result information element indicates failure then V2X UE service discovery information element is not included.		

9.9.3 V2X UE service discovery

9.9.3.1 General

This subclause describes the procedure for providing V2X service information to the V2X UE via V1-AE reference point for unicast V2X communication over LTE-Uu.

9.9.3.2 Procedure

The procedure for V2X UE obtaining the V2X UE service discovery information is illustrated in figure 9.9.3.2-1.

Pre-conditions:

1. The V2X UE has connected to the VAE server.
2. The VAE server has received information about available V2X services from the V2X application-specific server.

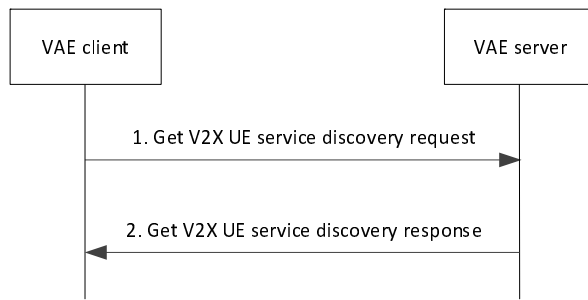


Figure 9.9.3.2-1: V2X UE obtains the service discovery information

1. The VAE client sends a get V2X UE service discovery request to the VAE server for obtaining V2X UE service discovery information.
2. The VAE server sends get V2X UE service discovery response to the VAE client. This message carries the V2X UE service discovery information.

9.9.4 V2X service discovery across multiple V2X service providers

9.9.4.1 General

This clause describes the procedure for V2X UE (having V2X application subscription with V2X service provider A) obtaining the V2X UE service discovery information (offered by V2X service provider B) while in the service area of V2X service provider B.

9.9.4.2 Procedure

The procedure for V2X UE obtaining the V2X UE service discovery across multiple V2X service providers is illustrated in figure 9.9.4.2-1.

Pre-conditions:

1. The V2X UE has connected to the VAE server 1 of V2X service provider A with whom the V2X UE has a V2X application subscription with.
2. The V2X UE is in the service area of the VAE server 2 operated by V2X service provider B.
3. The service area and VAE server 2 mapping information of V2X service provider B is available at VAE server 1 of V2X service provider A.

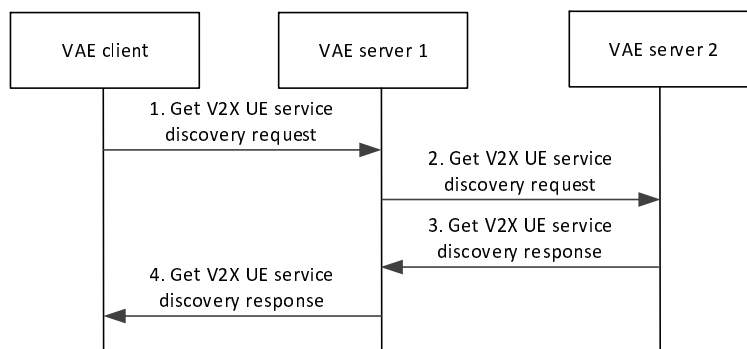


Figure 9.9.4.2-1: V2X service discovery across multiple V2X service providers

1. The VAE client sends a get V2X UE service discovery request to the VAE server 1 for obtaining V2X UE service discovery information with V2X UE ID and current V2X UE location.
2. The VAE server 1 determines, based on the V2X UE location that the V2X UE is in the service area operated by the VAE server 2 of the V2X service provider B. The VAE server 1 sends the get V2X UE service discovery

request to the VAE server 2 to get the V2X application server information for the V2X UE. The V2X UE location is included in the request.

3. The VAE server 2 determines the local V2X application server information based on UE location, and sends get V2X UE service discovery response to the VAE server 1. This message carries the local V2X application server information.
4. The VAE server 1 forwards the get V2X UE service discovery response to the VAE client.

Editor's note: Whether and how to resolve user privacy issue for this procedure is FFS.

9.10 V2X service continuity

9.10.1 General

The VAE server supports V2X service continuity by making available the local service information based on geographical areas to the V2X UEs.

9.10.2 Information flows

9.10.2.1 Service continuity request

Table 9.10.2.1-1 describes the information flow from a VAE server to issue a service continuity request to other VAE servers.

Table 9.10.2.1-1: Service continuity request

Information element	Status	Description
GEO ID	M	Geographical area identifier (e.g. URI, tile identifier, geo-fence tile identifier)
V2X service ID	M	PSID or ITS-AID the V2X UE is interested in receiving (e.g. ETSI ITS DENM, ETSI ITS CAM)

9.10.2.2 Service continuity response

Table 9.10.2.2-1 describes the information flow for a VAE server to respond to a service continuity request from other VAE server.

Table 9.10.2.2-1: Service continuity response

Information element	Status	Description
VAE server ID	M	Identifier of the VAE server (e.g., FQDN)
Result	M	The result whether the VAE server can serve the requested GEO ID and V2X Service ID

9.10.2.3 Local service information request (VAE client to VAE server)

Table 9.10.2.3-1 describes the information flow local service information request from the VAE client to the VAE server.

Table 9.10.2.3-1: Local service information request (VAE client to VAE server)

Information element	Status	Description
V2X UE ID	M	Identity of the V2X UE requesting the service discovery information.
GEO ID	M	Geographical area identifier for which the local service information is requested

9.10.2.3a Local service information request (between VAE servers)

Table 9.10.2.3a-1 describes the information flow local service information request between VAE servers.

Table 9.10.2.3a-1: Local service information request (between VAE servers)

Information element	Status	Description
V2X UE ID	O	Identity of the V2X UE requesting the service discovery information.
V2X UE location	M	The V2X UE location information for which the location service information is requested.
GEO ID	M	Geographical area identifier for which the local service information is requested

9.10.2.4 Local service information response

Table 9.10.2.4-1 describes the information flow local service information response from the VAE server to the VAE client and between VAE servers.

Table 9.10.2.4-1: Local service information response

Information element	Status	Description
Result	M	Indicates the success or failure of getting the local service information
Local service information	O (NOTE)	The local service information: <ul style="list-style-type: none"> - V2X server USD information as specified in 3GPP TS 23.285 [5] - V2X application server address information as specified in 3GPP TS 23.285 [5] and transport port for unicast - V2X USD information as specified in 3GPP TS 23.285 [5]
NOTE: If the Result information element indicates failure then local service information IE is not included.		

9.10.3 V2X service continuity management

9.10.3.1 General

This subclause describes the procedure to determine the VAE server for serving a VAE client when moving to a new geographical area.

9.10.3.2 Procedure

Pre-conditions:

1. The VAE servers have been configured with the information of the other VAE servers.
2. The VAE servers have obtained information of the available V2X services (e.g. identified by PSID or ITS-AIDs) and their corresponding geographical area association from the V2X application.
3. The VAE server 1 has received a geographic location update for a geographic area outside its coverage, with GEO ID, from a VAE client as described in subclause 9.3.

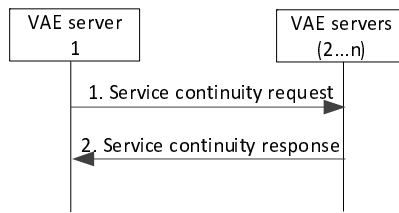


Figure 9.10.3.2-1: Procedure for V2X service continuity management

1. VAE server 1 sends a service continuity request to other VAE servers (2 ... n).

NOTE: The VAE server may send the service continuity request to all VAE servers it is connected to or to a subset of VAE servers, e.g. within the same PLMN.

2. The VAE servers provide a service continuity response to VAE server 1.

9.10.4 Dynamic local service information

9.10.4.1 General

For the V2X scenarios like extended sensors, platooning, the V2X UEs may be connected to the serving PLMN, but the V2X application server information may change as per the geographical location. Also it is not practically feasible to provide all the V2X server USDs to the V2X UE via the initial V2X UE configuration by the PLMN. It is hence required that the V2X server USDs may be provided considering the mobility of the V2X UE. This subclause describes the procedure for obtaining the local service information by the V2X UE via V1-AE.

9.10.4.2 Procedure

Figure 9.10.4.2-1 illustrates the procedure for obtaining the dynamic local service information by the V2X UE via V1-AE.

Pre-conditions:

1. The V2X UE is connected to the VAE server in geographical area A.
2. The V2X UE has no local service information for geographical area B.
3. If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.

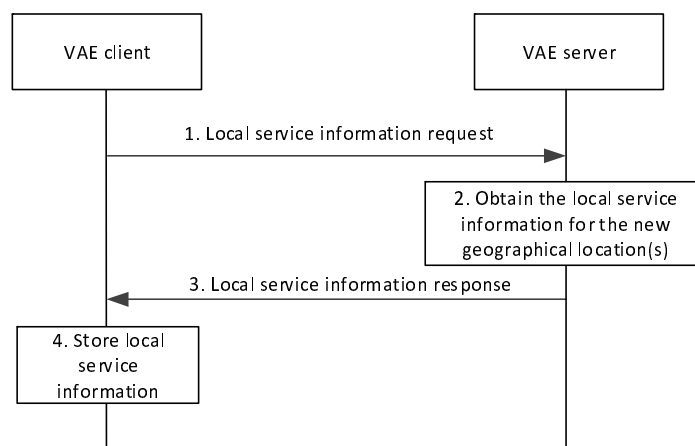


Figure 9.10.4.2-1: Obtaining dynamic local service information by V2X UE via V1-AE

1. The VAE client sends a local service information request to the VAE server (responsible for geographic location A) which may include mobility information like the geographic locations (geographic location B).

2. The VAE server determines the local service information (e.g. V2X server USD(s), V2X USD) corresponding to the geographic locations information received in step 1.
3. The VAE server provides the local service information (e.g. V2X server USD(s), V2X USD) with the corresponding geographic locations information to the VAE client via a local service information response. The V2X USD information consists of TMGI, list of SAIs, frequency and SDP information with the local service information for local V2X application server discovery. The details of V2X server USD are specified in subclause 4.4.7.3 in 3GPP TS 23.285 [5]. This message can be sent via unicast or multicast.
4. Upon receiving the local service information in step 3, the VAE client stores the received information.

Editor's note: The impact of edge application enabler study (FS_EDGEAPP) on this procedure is FFS.

9.10.5 Procedure for dynamic local service information in multiple V2X service provider scenario

The procedure for V2X UE (having V2X application subscription with V2X service provider A) obtaining the dynamic local service information (offered by V2X service provider B) while in the service area of V2X service provider B is illustrated in figure 9.10.5-1.

Pre-conditions:

1. The V2X UE has connected to the VAE server of V2X service provider A with whom the V2X UE has V2X application subscription with.
2. The V2X UE is in the service area of the VAE server 2 operated by V2X service provider B.
3. The service area and VAE server 2 information of V2X service provider B mapping is available at VAE server 1 of V2X service provider A.

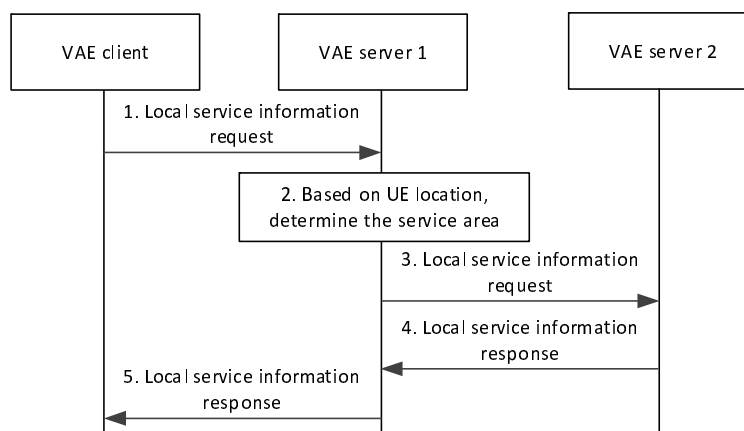


Figure 9.10.5-1: Dynamic local service information in multiple V2X service provider scenario

1. The VAE client sends a local service information request to the VAE server 1 (responsible for geographic location A) with V2X UE ID and current V2X UE location.
2. The VAE server 1 determines the V2X UE is in the service area of VAE server 2 of V2X service provider B, and the local service information corresponding to the service area of VAE server 2 is not available at VAE server 1. If the local service information corresponding to the service area of VAE server 2 is available, then go to step 5.
3. The VAE server 1 sends the local service information request to the VAE server 2 to get the local service information information for the V2X UE. The V2X UE location is included in the request.
4. The VAE server 2 determines the local service information (e.g. V2X server USD(s), V2X USD) with the corresponding geographic locations information based on UE location, and sends local service information response to the VAE server 1. This message carries the local service information. Upon receiving the local service information corresponding to the service area of VAE server 2, the VAE server 1 stores the received information.

5. The VAE server 1 provides the local service information to the VAE client. Upon receiving the local service information, the VAE client stores the received information.

9.11 V2X application resource management

9.11.1 General

The VAE server utilizes the NRM server of the SEAL to support the network resource management aspects towards the V2X applications. The VAE server supports the V2X UEs connected to EPS networks of different PLMN operators.

9.11.2 Information flows

9.11.2.1 V2X application requirement request

Table 9.11.2.1-1 describes the information flow V2X application requirement request from the V2X application specific server to the VAE server.

Table 9.11.2.1-1: V2X application requirement request

Information element	Status	Description
V2X UE ID	M (NOTE)	Identity of the V2X UE for which V2X application requirement is initiated.
V2X group ID	M (NOTE)	Identity of the V2X group for which the V2X application requirement is initiated.
V2X service ID	M	The V2X service ID for which application requirement corresponds to.
V2X application requirement	M	The requirement for application change. E.g. service levels for application service.
End point information	M	The end point information to which the notification shall be sent.
NOTE: Either of the information element should be present.		

9.11.2.2 V2X application requirement response

Table 9.11.2.2-1 describes the information flow V2X application requirement response from the VAE server to the V2X application specific server.

Table 9.11.2.2-1: V2X application requirement response

Information element	Status	Description
Result	M	The result of the V2X application requirement request.

9.11.2.3 V2X application requirement notification

Table 9.11.2.3-1 describes the information flow V2X application requirement notification from the VAE server to the V2X application specific server.

Table 9.11.2.3-1: V2X application requirement notification

Information element	Status	Description
Result	M	The result of the network resource adaptation corresponding to the V2X application requirement.

9.11.3 V2X application resource adaptation

9.11.3.1 General

This subclause describes the procedure for V2X application resource adaptation where the VAE server maps the V2X application requirement to network resource request for single or groups of V2X UEs.

9.11.3.2 Procedure

Figure 9.11.3.2-1 illustrates the procedure where the VAE server supports V2X application resource adaptation.

Pre-conditions:

1. The VAE server has the KPI information for the V2X services.
2. The VAE server is provided with the network monitoring information as per the subclause A.3.
3. The VAE server is configured with the NRM server information.

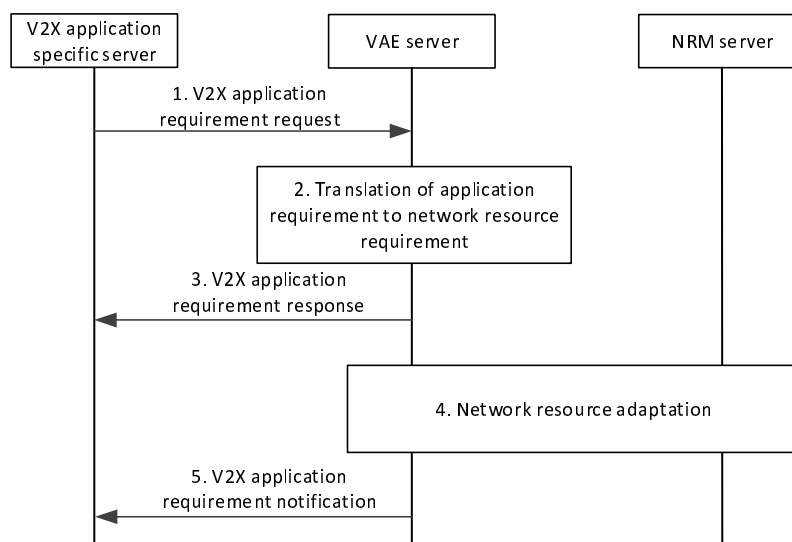


Figure 9.11.3.2-1: V2X application resource adaptation

1. The V2X application specific server sends a V2X application requirement request to the VAE server for an adaptation of the V2X service operation per V2X UE or per group of UEs.
2. The VAE server translates the V2X application requirement to different network resource requirement for group of users, which may be a subset of V2X UEs within the V2X group that will be affected by application adaptation.
3. If the V2X application requirement is successfully translated to the network resource requirement, the VAE server sends a V2X application requirement response to the V2X application specific server.
4. The VAE server performs network resource adaptation by interacting with the NRM server as specified in the 3GPP TS 23.434 [6] for the V2X application requirement received in step 1.
5. Based on the result of the network resource adaptation in step 4 corresponding to step 1, the VAE server sends a V2X application requirement notification to the V2X application specific server.

9.12 Dynamic group management

9.12.1 General

Some of the V2X scenarios require group-based communication (e.g. platooning). Unlike V2X communication for safety scenarios where all V2X UEs in the communication range receive broadcasted communication, the group-based communication is expected to be received only by the V2X UEs of the members of that group. However in some scenarios the V2X UEs are required to be determined dynamically (with the assistance of the V2X application server or independently by the V2X UEs when they are not connected to the network) during the operation. Also each V2X application group has to be mapped to a ProSe Layer-2 group ID in order to avoid any interference during PC5 communications for the V2X application groups. The ProSe Layer-2 Group ID is only used in PC5 V2X group communication (without the involvement of the V2X application server).

9.12.2 Information flows

9.12.2.1 Push Layer-2 group ID mapping

Table 9.12.2.1-1 describes the information flow push layer-2 group ID mapping from the VAE server to the VAE client and between the VAE clients.

Editor's note: Whether the procedures and information flows for dynamic group management are to be moved to SEAL is FFS.

Table 9.12.2.1-1: Push Layer-2 group ID mapping

Information element	Status	Description
Dynamic group information	M	Group information including dynamic group ID, group definition, group leader ID
ProSe Layer-2 Group ID	M	ProSe Layer-2 Group ID corresponding to the dynamic group information

9.12.2.2 Configure dynamic group request

Table 9.12.2.2-1 describes the information flow for configure dynamic group request from the V2X application specific sever to the VAE server.

Table 9.12.2.2-1: Configure dynamic group request

Information element	Status	Description
Dynamic group information	M	Group information including dynamic group ID, group definition, group leader ID
Endpoint information	M	End point information to which the configure dynamic group notification has to be sent

9.12.2.3 Configure dynamic group response

Table 9.12.2.3-1 describes the information flow for configure dynamic group response from the VAE server to the V2X application specific sever.

Table 9.12.2.3-1: Configure dynamic group response

Information element	Status	Description
Result	M	Result from the VAE server in response to the configure dynamic group request.

9.12.2.4 Configure dynamic group notification

Table 9.12.2.4-1 describes the information flow for configure dynamic group notification from the VAE server to the V2X application specific sever.

Table 9.12.2.4-1: Configure dynamic group notification

Information element	Status	Description
Dynamic group information	M	Group information including dynamic group ID, UE ID (joined or left UE(s))

9.12.2.5 Identity list notification

Table 9.12.2.5-1 describes the information flow identity list notification from the VAE client to the VAE server.

Table 9.12.2.5-1: Identity list notification

Information element	Status	Description
Dynamic group information	M	Group information including dynamic group ID, UE ID (joined or left UE(s))

9.12.2.6 Dynamic group information update request

Table 9.12.2.6-1 describes the information flow for dynamic group information update request from the VAE Client to the VAE server.

Table 9.12.2.6-1: Dynamic group information update request

Information element	Status	Description
Dynamic group information to update	M	Dynamic group information to update, e.g. group leader ID
Endpoint information	M	End point information to which response has to be sent

9.12.2.7 Dynamic group information update response

Table 9.12.2.7-1 describes the information flow for dynamic group information update response from the VAE server to the VAE client.

Table 9.12.2.7-1: Dynamic group information update consent response

Information element	Status	Description
Result	M	Result from the VAE server in response to the Dynamic group information update request.

9.12.2.8 Dynamic group information update consent request

Table 9.12.2.8-1 describes the information flow for dynamic group information update consent request from the VAE Server to the VAE client from whom consent is required.

Table 9.12.2.8-1: Dynamic group information update consent request

Information element	Status	Description
Information for consent	M	Dynamic group information for consent, e.g. group leader ID

9.12.2.9 Dynamic group information update consent response

Table 9.12.2.9-1 describes the information flow for dynamic group information update consent response from the VAE client to the VAE server.

Table 9.12.2.9-1: Dynamic group information update consent response

Information element	Status	Description
Result	M	Result from the VAE server in response to the Dynamic group information update consent request.

9.12.2.10 Dynamic group information update notification

Table 9.12.2.10-1 describes the information flow for dynamic group information update notification from the VAE server to the V2X application specific sever.

Table 9.12.2.10-1: Dynamic group information update notification

Information element	Status	Description
Dynamic group information	M	Dynamic group information which has been updated, e.g. group leader ID

9.12.2.11 Dynamic group information update indication

Table 9.12.2.11-1 describes the information flow for group information update indication from the VAE server to the VAE client.

Table 9.12.2.11-1: Dynamic group information update notification

Information element	Status	Description
Dynamic group information	M	Dynamic group information for which update request has been received, e.g. group leader ID

9.12.2.12 Dynamic group information update consent request (Off network)

Table 9.12.2.12-1 describes the information flow for group information update request from the VAE client to the VAE client.

Table 9.12.2.12-1: Group information update request

Information element	Status	Description
Information for consent	M	Dynamic group information for consent, e.g. group leader ID

9.12.2.13 Dynamic group information update consent response (Off network)

Table 9.12.2.13-1 describes the information flow for group information update consent response from the VAE client to the VAE server.

Table 9.12.2.13-1: Dynamic group information update consent response

Information element	Status	Description
Result	M	Result from the VAE server in response to the Dynamic group information update consent request.

9.12.3 On-network dynamic group creation

9.12.3.1 General

The V2X application specific server is responsible for V2X dynamic group formation (including information like group ID assignment, group definition), membership management (e.g. user authorization). VAE layer supports V2X UEs in the Uu communication range assigning a ProSe Layer-2 Group ID for application layer V2X dynamic group formation.

9.12.3.2 Procedure

The procedure for on-network dynamic group creation is illustrated in figure 9.12.3.2-1.

Pre-condition:

1. V2X application dynamic group is defined at the V2X application specific server with V2X UE assigned as dynamic group leader.
2. VAE server has a pool of the ProSe Layer-2 Group IDs that can be assigned to dynamic groups

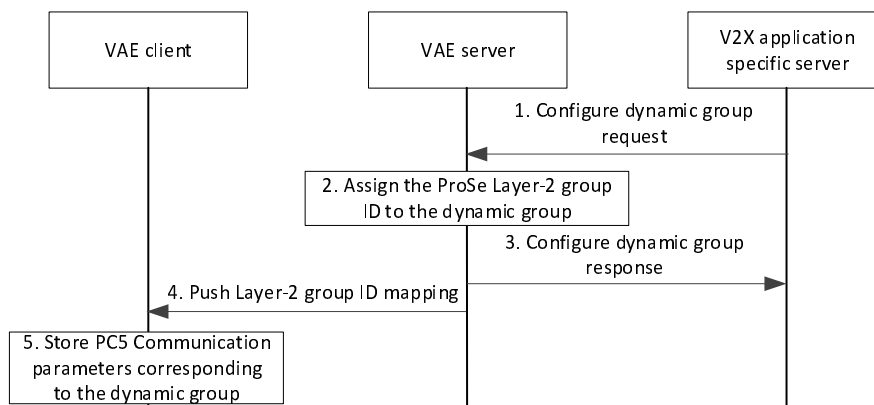


Figure 9.12.3.2-1: On-network dynamic group creation

1. The V2X application specific server requests the VAE server to configure dynamic group corresponding to the dynamic group information (e.g. dynamic group ID, group definition, group leader).
2. To enable PC5 communication, the VAE server assigns ProSe Layer-2 Group ID to the received dynamic group information from the available ProSe Layer-2 Group ID pool.
3. The VAE server responds to the V2X application specific server for the request to configure dynamic group.
4. The VAE server triggers a push request including ProSe Layer-2 Group ID corresponding to the dynamic group information to the VAE client.
5. The VAE client stores the received PC5 communication parameters corresponding to the dynamic group information received from the VAE server.

NOTE 1: The VAE client may further announce the dynamic group information including the corresponding ProSe Layer-2 Group ID to the other VAE clients within the PC5 communication proximity on a PC5 channel dedicated for V5-AE communications, enabling more V2X UEs to join the dynamic group.

NOTE 2: When there is loss of connectivity with the network by the V2X UEs, service continuity is ensured by the V2X UEs switching to PC5 communication using the VAE server assigned ProSe Layer-2 Group ID corresponding to the dynamic group formation.

9.12.4 Off-network dynamic group creation

9.12.4.1 General

The V2X application specific client is responsible for V2X dynamic group information (including information like group ID assignment, group definition). VAE layer on the client supports assigning a ProSe Layer-2 Group ID for application layer V2X dynamic group formation.

9.12.4.2 Procedure

The procedure for off-network dynamic group creation is illustrated in figure 9.12.4.2-1.

Pre-condition:

1. VAE clients are provisioned ProSe Layer-2 Group ID(s) generation rules corresponding to the group information or
2. VAE client(s) are configured with the unique pool of ProSe Layer-2 Group IDs, when they are in coverage area of the VAE server.

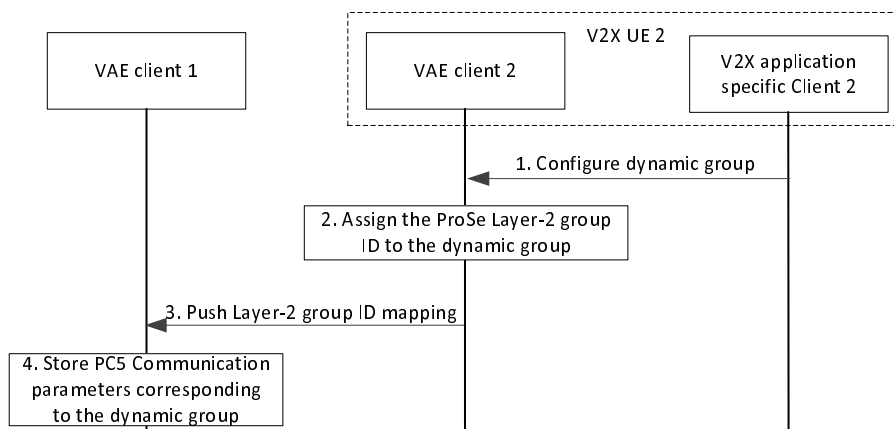


Figure 9.12.4.2-1: Off-network dynamic group creation

1. The V2X application specific client 2 requests the VAE client 2 to configure dynamic group corresponding to the dynamic group information (e.g. dynamic group ID, group definition, group leader).
2. Each VAE client generates ProSe Layer-2 Group ID independently based on the provisioned ProSe Layer-2 Group ID(s) generation rules for its group information or the VAE client 2 assigns ProSe Layer-2 Group ID from the pool of configured ProSe Layer-2 Group IDs.
3. VAE client may further announce the dynamic group information including the corresponding ProSe Layer-2 Group ID to the other VAE clients within the PC5 communication proximity on a PC5 channel dedicated for V5-AE communications, enabling more V2X UEs to join the dynamic group.
4. The VAE client stores the PC5 communication parameters corresponding to the dynamic group information received from another VAE client.

9.12.5 On-network dynamic group notification

9.12.5.1 General

Once the on-network dynamic group is created as defined in subclause 9.12.3, the VAE client notifies the VAE server about changes in the group (i.e. UE joins or leaves the group) and finally the V2X application specific server is notified with such information.

9.12.5.2 Procedure

The procedure for on-network dynamic group notification is illustrated in figure 9.12.5.2-1.

Pre-condition:

1. V2X application dynamic group is created as defined in subclause 9.12.3.

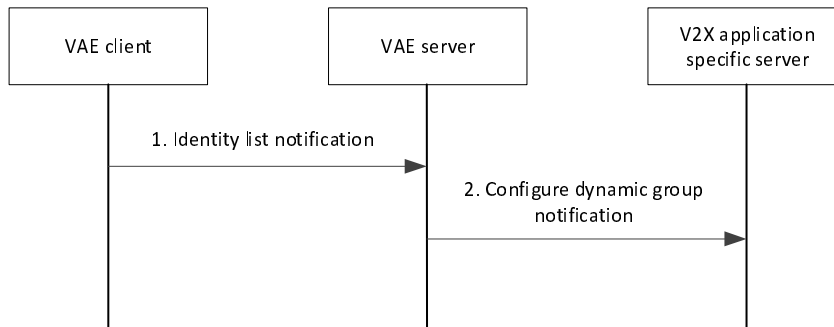


Figure 9.12.5.2-1: On-network dynamic group notification

1. The VAE client sends identity list notification to the VAE server about group member changes.
2. Upon receipt of the identity list notification from the VAE client, the VAE server further notifies the V2X application specific server about the newly joined or left group member(s).

9.12.6 On network dynamic group information update procedure

9.12.6.1 General

This subclause provides procedures to update dynamic group information of an on-network V2X dynamic group.

9.12.6.2 VAE client initiated on network dynamic group information update procedure

The procedure for on-network dynamic group information (e.g. group leader) update is illustrated in figure 9.12.6.2-1.

Pre-conditions:

1. The on network dynamic group has already been defined and V2X UE A and V2X UE B are members of the group;
2. V2X UE A is the current group leader; and
3. The V2X application specific client in V2X UE A has determined to update the group information (e.g., update group leader ID from identity of V2X UE A to identity of V2X UE B) and informed the updates and other relevant information about the update (e.g. if the update is temporary, like time bound, or permanent) to VAE client A to update the group information.

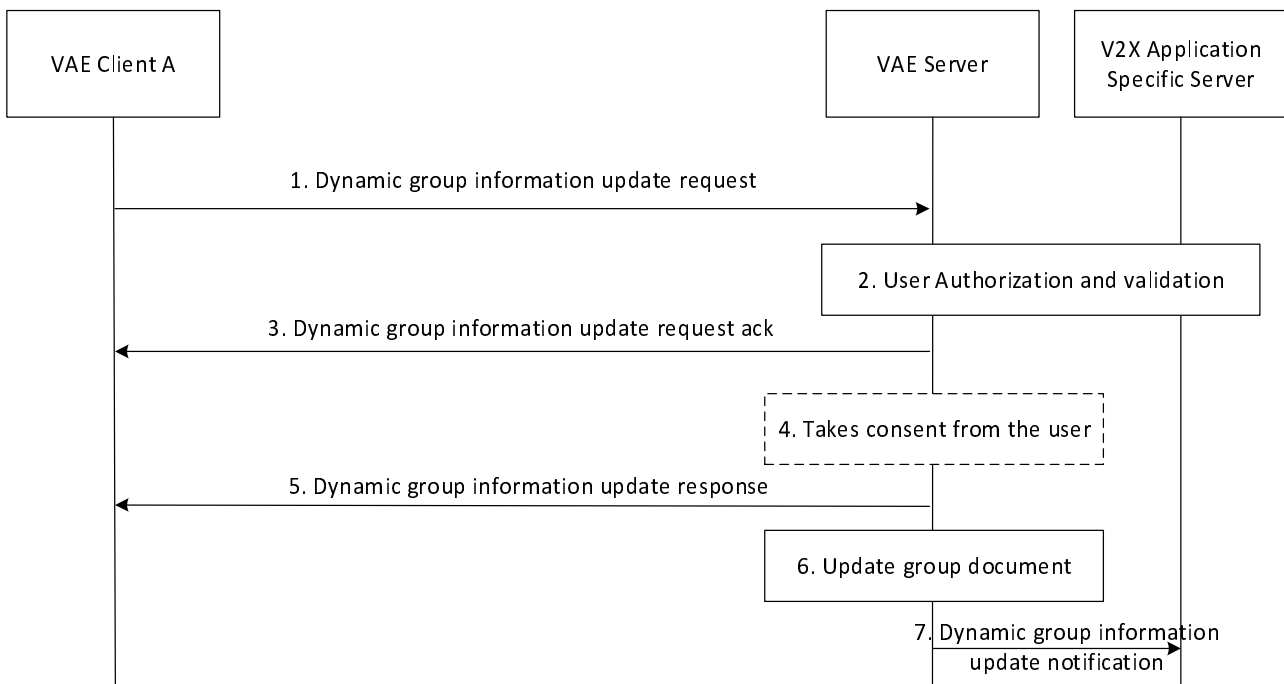


Figure 9.12.6.2-1: VAE client initiated on network dynamic group information update procedure

1. The VAE client A sends a Dynamic group information update request to the VAE server. The request includes the group-ID of the group for which group information update request is sent. The request also includes the updated group information (e.g. identity of V2X UE B as group leader ID) and other relevant information about the update (e.g. if the update to the group information are temporary and time bound or permanent).
2. Upon receiving the Dynamic group information update request from VAE client A, the VAE server checks for the V2X user authorization to update the group information. If required, the VAE server also checks validity of the updated group information (e.g. if the request is to update the group leader ID to V2X UE B, the VAE server checks with V2X application specific server about the capabilities of the proposed group leader V2X UE B to ensure it is capable of sufficient fuel, sensors and applications to communicate and coordinate with other group members to act as group leader). If required, then the VAE server consults with V2X application specific server to ratify the updated group information or seek changes to the requested update (e.g. a different V2X UE as group leader). If the authorization fails or if the updated group information is not valid, then steps 3 to 6 are skipped.
3. If the request from the VAE client is authorized and the updated group information is valid, the VAE server acknowledges the VAE client A.
4. If the update in group information requires consent from other group member(s) (e.g. consent from the proposed new group leader, V2X UE B, to accept the role of group leader), then the VAE server obtains the consent from the user as specified in clause 9.12.6.4. This step is skipped if user consent is not required.
5. The VAE server sends the Dynamic group information update change response to VAE client A indicating success or failure. If:
 - the request was authorized but the updated group information was not valid, as determined in step 2; or
 - a reject response to the Dynamic group information update consent request was received from VAE client B;
 then, the VAE server may include suggestions for the updated group information (e.g. identity of the V2X UE C as potential group leader). These suggestions are based on consultation with the V2X application specific server.
6. If the group information update request was successful, the VAE server updates the group document.
7. Upon successful update of the group document, the VAE server triggers a group information update notification to other group members and to the V2X application specific server.

9.12.6.3 VAE server initiated on network dynamic group information update procedure

The procedure for on-network dynamic group information (e.g. group leader) update is illustrated in figure 9.12.6.3-1.

Pre-conditions:

1. The on network dynamic group has already been defined and V2X UE A and V2X UE B are members of the group;
2. V2X UE A is the current group leader; and
3. The V2X application specific server has determined to update the group information (e.g., update group leader ID from identity of V2X UE A to identity of V2X UE B) and informed the updates and other relevant information about the update (e.g. if the update is temporary, like time bound, or permanent) to the VAE server to update the group information.

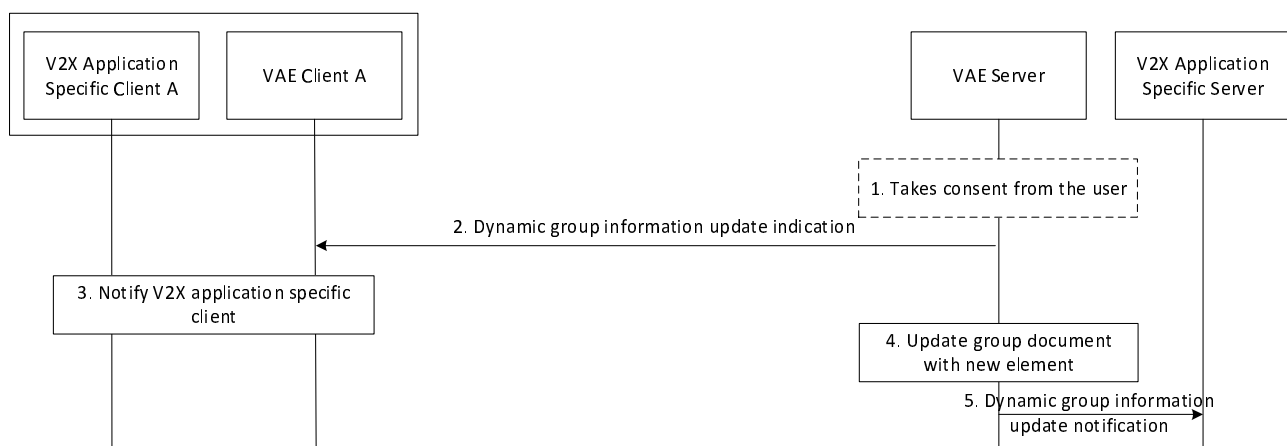


Figure 9.12.6.3-1: VAE server initiated on network dynamic group information update procedure

1. If the update in group information requires consent from the group member(s) (e.g. consent from the proposed new group leader, V2X UE B, to accept the role of group leader), then the VAE server obtains the consent from the user as specified in clause 9.12.6.4. This step is skipped if user consent is not required.
2. If required (e.g. when group leader ID is being changed from V2X UE A to V2X UE B), the VAE server sends Dynamic group information update indication to the VAE client A about the possible update to group information.

NOTE: Step 1 and step 2 can happen in parallel.

3. Upon receiving the indication from the VAE server, the VAE client A notifies the V2X application specific client A about the possible update to group information.
4. If group leader information update request is successful, the VAE server updates the group document.
5. Upon successful update of the group document, the VAE server triggers a Dynamic group information update notification to other group members and to the V2X application specific server.

9.12.6.4 VAE Server taking consent from user

The procedure for the VAE server to take consent form the user is illustrated in figure 9.12.6.4-1.

Pre-conditions:

1. VAE client A has initiated dynamic group information update procedure as specified in clause 9.12.6.2, or the V2X application specific server has determined to update the dynamic group information.

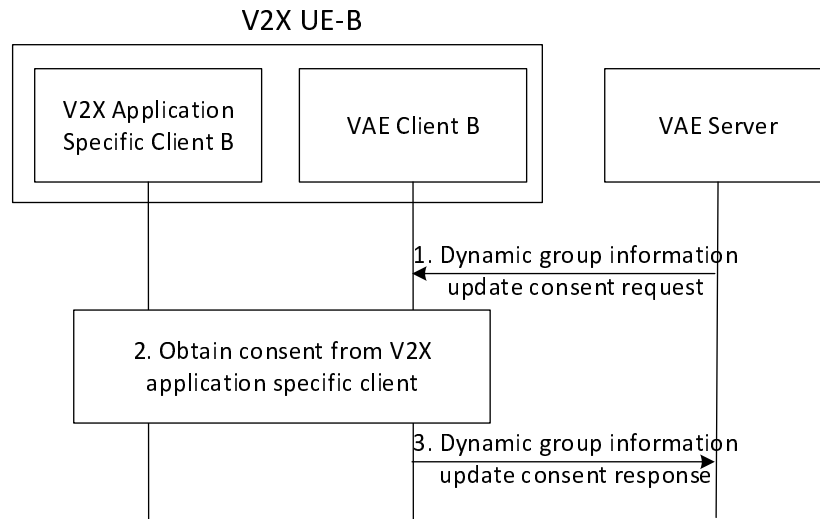


Figure 9.12.6.4-1: VAE Server taking consent from user procedure

1. If the update in group information requires consent from other group member(s) (e.g. consent from the proposed new group leader, V2X UE B, to accept the role of group leader), then the VAE server sends a dynamic group information update consent request to VAE client B. The request includes the group-ID of the group for which the request is sent. The request also includes other relevant information about the update (e.g. if the update to the group information are temporary and time bound or permanent).
2. The VAE client B notifies the V2X application specific client B about the Dynamic group information update consent request. The V2X application specific client or the V2X user decides to accept or reject the request.
3. The VAE client B sends a Dynamic group information update consent response to the VAE server. The response includes the decision whether the request is accepted or rejected.

9.12.7 Off network dynamic group information update procedure

This subclause provides procedures to update dynamic group information of an off-network V2X dynamic group.

The procedure for off-network dynamic group information update procedure is illustrated in figure 9.12.7-1.

Pre-conditions:

1. The off network dynamic group has already been defined and V2X UE A and V2X UE B are members of the group;
2. V2X UE A is the current group leader;
3. The V2X application specific client in V2X UE A has determined to update the group information (e.g., update group leader ID from identity of V2X UE A to identity of V2X UE B) and informed the updates and other relevant information about the update (e.g. if the update is temporary, like time bound, or permanent) to the VAE client in V2X UE A to update the group information.

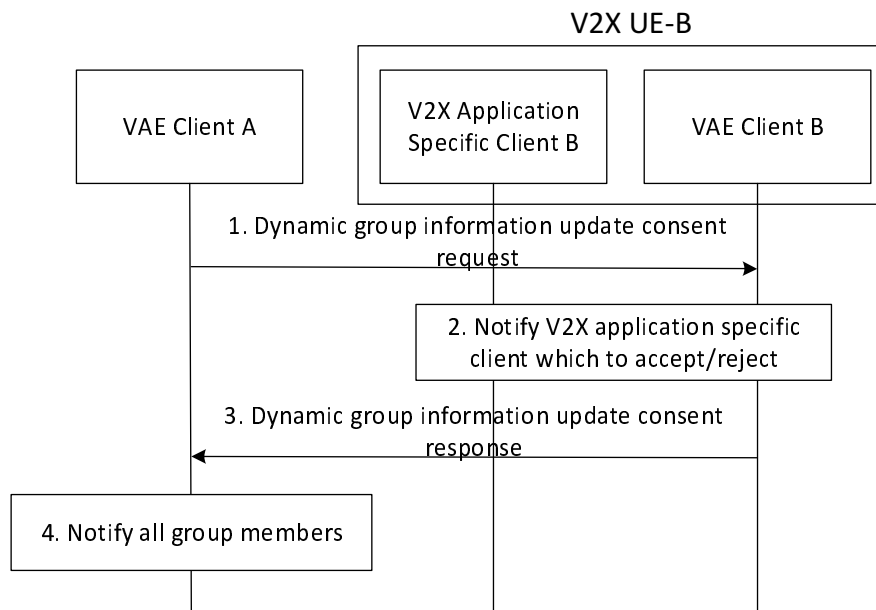


Figure 9.12.7-1: Off network dynamic group information update procedure

1. If the update in group information requires consent from other group member(s) (e.g. consent from the proposed new group leader, V2X UE B, to accept the role of group leader), then the VAE client sends a dynamic group information update consent request to VAE client B. The request includes the updated group information along with the group-ID of the group. The request also includes other relevant information about the update (e.g. if the update to the group information are temporary and time bound or permanent).
2. The VAE client B notifies the V2X application specific client B about the Dynamic group information update consent request and the V2X application specific client or the V2X user decides to accept or reject the request.
3. The VAE client B sends a Dynamic group information update response to the VAE client A. The response includes the decision whether the request is accepted or rejected.
4. If the group information update consent request is successful, then the VAE client A sends notification to other group members.

9.13 Network situation and QoS monitoring and reporting

9.13.1 General

The VAE server supports monitoring of 3GPP systems' network situation for V2X services. The VAE server receives and processes access network-related monitoring events/reports from SCEF (EPS entity of the 3GPP network system) as specified in 3GPP TS 23.682 [8]. The monitoring events/report may also include RAN-related resource/traffic situation information and QoS related notifications per UE or group of UEs. The VAE server initiates monitoring of the QoS for single or aggregately for groups of vehicles (supporting a V2X service and being in proximity) having ongoing sessions. The information from V2X UE related to monitoring events (e.g. location, groups, resource usage) can be available at the VAE server using the network resource management and location management services of the SEAL.

9.13.2 Information flows

9.13.2.1 Monitoring request

The information flow monitoring request from VAE server (acting as SCS/AS) to SCEF over T8 reference point is specified in clause 5.6 and clause 5.8 (when monitoring request comprises Network Status Request) in 3GPP TS 23.682 [8].

9.13.2.2 Monitoring response

The information flow monitoring response from SCEF to VAE server (acting as SCS/AS) over T8 reference point is specified in clause 5.6 and clause 5.8 (when monitoring request comprises Network Status Response) in 3GPP TS 23.682 [8].

9.13.2.3 Monitoring report

The information flow monitoring report from the SCEF to the VAE server over T8 reference point is specified in clause 5.6, clause 5.8 (when monitoring report comprises Network Status Information Report) and clause 5.11 (when monitoring report comprises notification of QoS/bearer level events) in 3GPP TS 23.682 [8].

9.13.3 Procedure

The VAE server acts as SCS/AS and initiates the procedure for monitoring with the SCEF as specified in the clause 5.6 and clause 5.8 in 3GPP TS 23.682 [8] by including the V2X application information corresponding to one or many V2X UEs.

The SCEF provides the monitoring reports (including the RAN related network situation information and QoS notification information for the corresponding V2X application, V2X UE or group of V2X UEs) to the VAE server as specified in the clause 5.6, clause 5.8 and clause 5.11 in 3GPP TS 23.682 [8].

9.14 Service negotiation with underlying 3GPP network

9.14.1 General

This subclause describes the procedures for the VAE server to provide service requirements to the 3GPP network system. The Service Capability Exposure Function (SCEF) can be used for this purpose. As described in 3GPP TS 23.682 [8], the SCEF provides a means to expose the services and capabilities provided by 3GPP network interfaces and provides a means for the discovery of the exposed services and capabilities.

9.14.2 Information flows

9.14.2.1 On-demand QoS request

The information flow On-demand QoS request from VAE server (acting as SCS/AS) to SCEF over T8 reference point is specified in clause 5.11 (when setting up a session with required QoS) in 3GPP TS 23.682 [8].

9.14.2.2 On-demand QoS response

The information flow On-demand QoS response from SCEF to VAE server (acting as SCS/AS) over T8 reference point is specified in clause 5.11 in 3GPP TS 23.682 [8].

9.14.2.3 Background data transfer request

The information flow Background data transfer request from VAE server (acting as SCS/AS) to SCEF over T8 reference point is specified in clause 5.9 (resource management for background data transfer) in 3GPP TS 23.682 [8].

9.14.2.4 Background data transfer response

The information flow Background data transfer response from SCEF to VAE server (acting as SCS/AS) over T8 reference point is specified in clause 5.9 in 3GPP TS 23.682 [8].

9.14.2.5 Network Status Request

The information flow Network Status Request from VAE server (acting as SCS/AS) to SCEF over T8 reference point is specified in clause 5.8 in 3GPP TS 23.682 [8].

9.14.2.6 Network Status Response

The information flow Network Status Response from SCEF to VAE server (acting as SCS/AS) over T8 reference point is specified in clause 5.8 in 3GPP TS 23.682 [8].

9.14.2.7 Network Status Report

The information flow Network Status Report from SCEF to VAE server (acting as SCS/AS) over T8 reference point is specified in clause 5.8 in 3GPP TS 23.682 [8].

9.14.2.8 Network Status Acknowledgment

The information flow Network Status Acknowledgment from VAE server (acting as SCS/AS) to SCEF over T8 reference point is specified in clause 5.8 in 3GPP TS 23.682 [8].

9.14.3 Communication of service requirements from the VAE server

The procedure uses the APIs defined in subclauses 5.8, 5.9 and 5.11 in 3GPP TS 23.682 [8] for setting up an AS session with required QoS procedure. This procedure defines the information elements that need to be exchanged between the VAE server (acting as SCS/AS) and the SCEF function during service negotiation.

9.14.4 Notification generation by the SCEF function

The procedure notification generation by the SCEF function in response to the service requirements from the VAE server. The SCEF function notifies the VAE server if the service requirements can be satisfied. This procedure uses the APIs defined in subclause 5.8 in 3GPP TS 23.682 [8] for informing about potential network issues.

9.15 PC5 Provisioning in multi-operator V2X scenarios

9.15.1 General

The VAE server provides PC5 provisioning for multi-operator V2X services, based on the requirement received by the V2X application specific server.

9.15.2 Information flows

9.15.2.1 V2X PC5 provisioning requirement

Table 9.15.2.1-1 describes the information flow V2X PC5 provisioning requirement from the V2X application specific server to the VAE server.

Table 9.15.2.1-1: V2X PC5 provisioning requirement

Information element	Status	Description
V2X UE ID	M (NOTE)	Identity of the V2X UE for which V2X application requirement is initiated.
V2X group ID	M (NOTE)	Identity of the V2X group for which the V2X application requirement is initiated.
V2X service ID	M	The V2X service ID for which application requirement corresponds to.
PLMN ID list	O	The list of the PLMN identities for the PLMNs which offer the V2X service
V2X application QoS requirements	O	The application QoS requirements (reliability, delay, jitter) for the V2X service
NOTE: Either of the information element should be present.		

9.15.2.2 PC5 provisioning status request

Table 9.15.2.2-1 describes the information flow PC5 provisioning status request from the VAE server to the VAE client.

Table 9.15.2.2-1: PC5 provisioning status request

Information element	Status	Description
VAE Server ID	M	Identity of the VAE server which is requester of the PC5 parameters status.
V2X service ID	M	The V2X service ID for which the VAE server's request corresponds to.
PC5 provisioning status report configuration	O	The configuration of the VAE-client reporting related to the PC5 Policy/Parameters status, and optionally PC5 events like PC5 unavailability, PQI load/congestion info

9.15.2.3 PC5 provisioning status response

Table 9.15.2.3-1 describes the information flow PC5 provisioning status response from the VAE client to the VAE server.

Table 9.15.2.3-1: PC5 provisioning status response

Information element	Status	Description
Result	M	The result of the PC5 provisioning status request.
PC5 Policy/Parameters status report	M	The report based on the PC5 Policy/Parameters status request. This includes up-to-date policies/parameters: <ul style="list-style-type: none"> - selected PQI attributes for the V2X service - PQI load information - communication range for the V2X service - a RAT /interface (NR-PC5, LTE-PC5) preference - an expected RAT availability / unavailability indication - an expected V2X-UE moving out of coverage indication

9.15.2.4 Void

9.15.2.5 Void

9.15.2.6 V2X PC5 provisioning requirement notification

Table 9.15.2.6-1 describes the information flow V2X PC5 provisioning requirement notification from the VAE server to the V2X application specific server.

Table 9.15.2.6-1: V2X PC5 provisioning requirement notification

Information element	Status	Description
Result	M	The result corresponding to the V2X PC5 provisioning requirement.

9.15.3 PC5 provisioning for multi-operator V2X services

9.15.3.1 General

This subclause describes the procedure for PC5 provisioning for multi-operator V2X services.

9.15.3.2 Procedure

Figure 9.11.3.2-1 illustrates the procedure where the VAE server supports the PC5 provisioning for multi-operator V2X services.

Pre-conditions:

1. The V2X UEs have connected to the V2X application server.
2. The V2X UEs are authorized by their corresponding PLMNs to use PC5 communication.

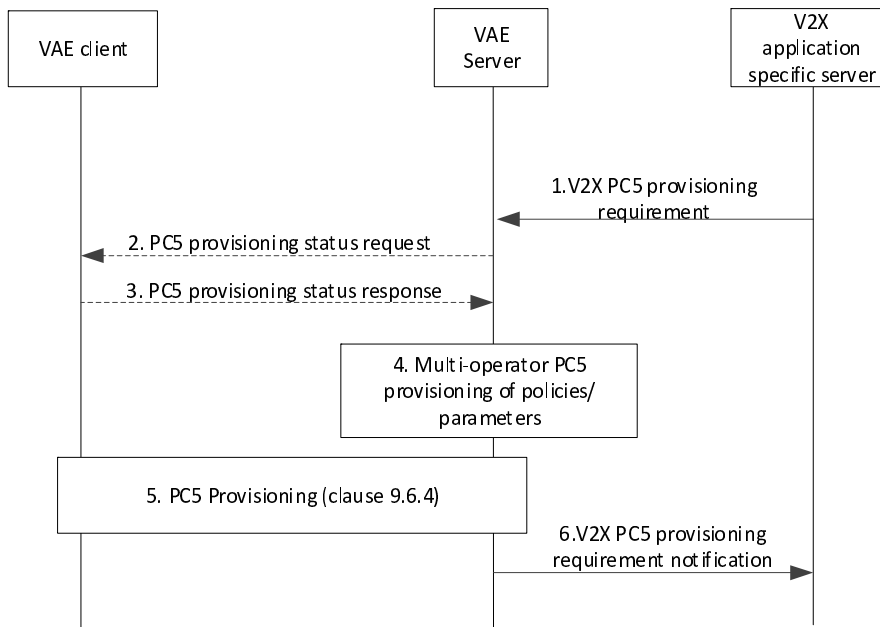


Figure 9.15.3.2-1: PC5 provisioning for multi-operator V2X services

1. The V2X application specific server provides a V2X PC5 provisioning requirement to the VAE server.
2. Optionally, the VAE Server sends a PC5 provisioning status request to the VAE Client (within the multi-operator V2X service) to receive up-to-date information on the per PLMN provisioning policies/ parameters.

3. Optionally, upon receiving the request as in Step 2, the VAE Client sends a PC5 provisioning status response to VAE server, which includes a report on the up-to-date policies /parameters per PLMN (e.g. application QoS - to - PQI mapping, range, radio parameters) and optionally PC5 related events (PC5 expected link downgrade).
4. The VAE Server determines the updated PC5 provisioning policies/parameters to be jointly used across the V2X-UEs within the multi-operator V2X service.

NOTE: How the VAE server derives a merged set of PC5 policies is implementation dependent.

5. The VAE Server provides the PC5 parameter provisioning information to the V2X UE via V1-AE reference point for V2X communication on PC5 as specified in clause 9.6.4.

NOTE: How the V2X UE selects which policy to apply is implementation dependent.

6. VAE Server sends a V2X PC5 provisioning requirement notification to the V2X application specific server to inform on the result of the multi-operator PC5 provisioning.

9.16 Support for HD map dynamic information

9.16.1 General

The V2X application specific server can be responsible for managing HD maps and providing the HD map information to the V2X application specific client on V2X UE (e.g. host vehicle controlled by advanced/remote driving). As per a proximity range set by the application layer, the VAE layer support providing the dynamic information (i.e. location information) required for HD maps management to the V2X application specific server.

This feature is feasible for scenarios where host vehicle (V2X UE) is in advanced/remote driving mode with slow to moderate speed and deployed in areas like campus (e.g. autonomous shuttle vehicles), factories or ports (e.g. autonomous/remotely controlled guided vehicles).

This feature utilizes the following procedures:

- V2X application specific server subscription for host vehicle's HD map dynamic information with VAE server.
- VAE server tracking host vehicle's UE location with support from SEAL's location management server.
- VAE server management of dynamic UE location based group.
- VAE server obtaining dynamic information from the UEs in proximity range of the host vehicle.
- VAE server notification of host vehicle's HD map dynamic information to V2X application specific server.

NOTE: The details of the usage (e.g. distribution to V2X UE) of HD maps by V2X application specific server is out of scope of this specification.

9.16.2 Information flows

9.16.2.1 Subscribe HD map dynamic information request

Table 9.16.2.1-1 describes the information flow for a V2X application specific server to subscribe to HD map dynamic information at the VAE server.

Table 9.16.2.1-1: Subscribe HD map dynamic information request

Information element	Status	Description
V2X UE ID	M	Identifier of the host V2X UE.
Application defined proximity range information	M	Description of the range information over which the HD map dynamic information is required.

9.16.2.2 Subscribe HD map dynamic information response

Table 9.16.2.2-1 describes the information flow for VAE server to respond for HD map dynamic subscription request from the V2X application specific server.

Table 9.16.2.2-1: Subscribe HD map dynamic information response

Information element	Status	Description
Result	M	Result from the VAE server in response to subscription request indicating success or failure
Subscription ID (NOTE)	O	Identifier of a successful subscription.
NOTE: This IE is included when the Result indicates success		

9.16.2.3 Notify HD map dynamic information

Table 9.16.2.3-1 describes the information flow for a V2X application specific server to receive notification about HD map dynamic information from the VAE server.

Table 9.16.2.3-1: Notify HD map dynamic information

Information element	Status	Description
Subscription ID	M	Identifier of the subscription for this notification.
Location of the host V2X UE	M	The location of the host V2X UE during the HD map dynamic information subscription.
List of V2X UEs information	M	The information of the V2X UEs which were detected in the application defined proximity range.
>Nearby V2X UE ID	M	The identifier of nearby V2X UE
>Location information	M	Location information of the nearby V2X UE within the application defined proximity range
>Distance information	M	Distance information of the nearby V2X UE, relative to the host V2X UE.

9.16.2.4 Notification of dynamic information

Table 9.16.2.4-1 describes the information flow for notification of dynamic information from VAE client to the VAE server.

Table 9.16.2.4-1: Notification of dynamic information

Information element	Status	Description
Subscription ID	M	Identifier of the subscription for this notification.
List of V2X UEs information	M	The information of the V2X UEs which were detected in the proximity area of the reporting V2X UE.
>Nearby V2X UE ID	M	The identifier of nearby V2X UE
>Local dynamic information	M	The local dynamic information of the nearby V2X UE (e.g. location)

9.16.3 Subscription for HD map dynamic information

Figure 9.16.3-1 describes the procedure for subscription for HD map dynamic information.

Pre-condition:

- V2X application specific server has registered with VAE server 1 which is responsible for the host vehicle.

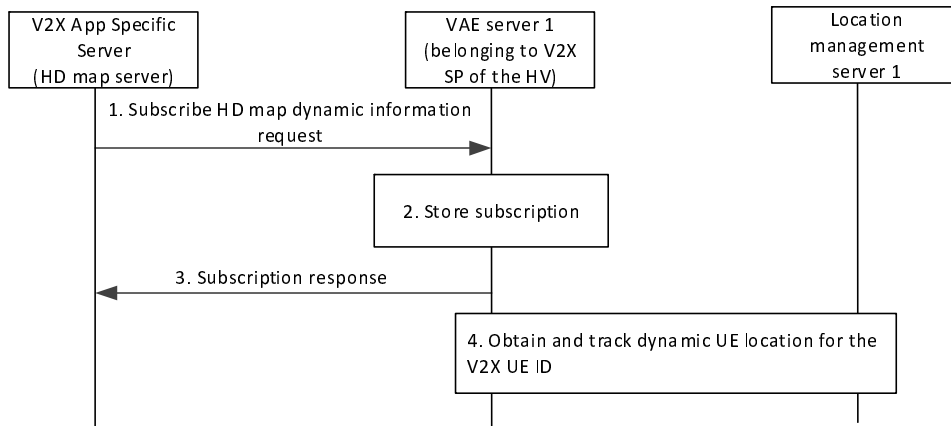


Figure 9.16.3-1: Subscription for HD map dynamic information

1. The V2X application specific server sends a subscribe HD map dynamic information request to the VAE server 1. The request includes the V2X UE ID of the host vehicle, application defined proximity range information.
2. The VAE server 1 stores the subscription information.
3. The VAE server 1 sends subscription response to the V2X application specific server.
4. The VAE server 1 obtains and initiates tracking the host vehicle location from the location management server 1 as specified in 3GPP TS 23.434 [6].

9.16.4 Management of dynamic UE location based group

Figure 9.16.4-1 describes the procedure for management of dynamic UE location based group.

Pre-condition:

- VAE server 1 has received an updated location of the host vehicle as per procedure specified in 3GPP TS 23.434 [6].

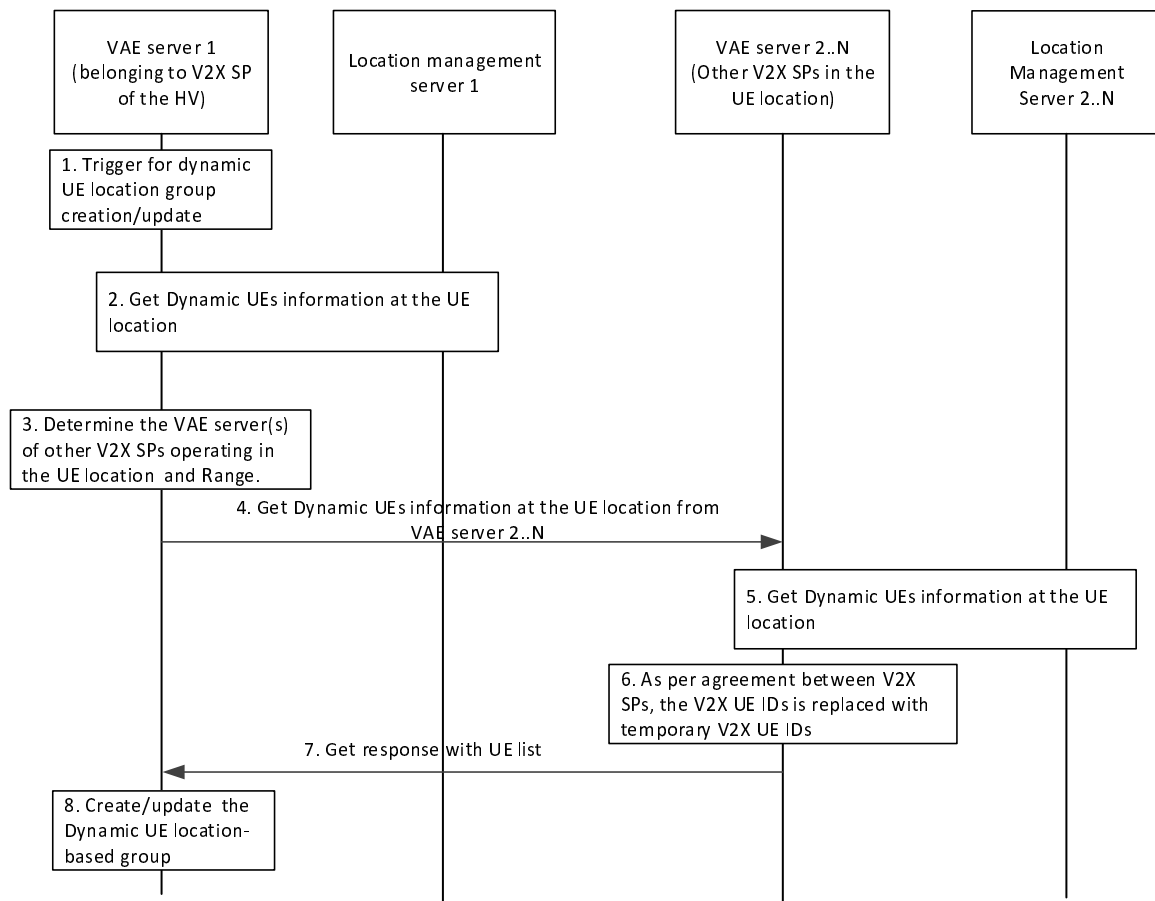


Figure 9.16.4-1: Management of dynamic UE location group

1. Dynamic UE location based group creation or update is triggered (e.g. notified of the UE location of host vehicle) via the step 4 in clause 9.16.3 for the V2X UE ID of the host vehicle.
2. VAE server 1 uses its associated LMS 1 to obtain the dynamic UE list and the corresponding location information in the proximity area of the host vehicle by providing the application defined proximity range and the UE location of the host vehicle as specified in clause 9.3.10 of 3GPP TS 23.434 [6].
3. VAE server 1 determines the list of other VAE servers 2..N operating in the same location as per clause 9.10.2.1.
4. For each VAE server determined in step 4, VAE server 1 requests the dynamic UE list and its corresponding location information for the application defined proximity range by providing the UE location of the host vehicle.
5. The VAE server(s) 2..N obtain UE information corresponding to the UE location and application defined proximity range from its corresponding LMS 2..N as specified in 3GPP TS 23.434 [6].
6. As per the agreement between the V2X SPs, if the V2X UE IDs are not shareable, then VAE server(s) 2..N may replace the V2X UE IDs with temporary V2X UE IDs.
7. The VAE server(s) 2..N sends get response with UE list in the UE location and application defined proximity range to VAE server 1.
8. If VAE server 1 has no dynamic UE location group for the V2X UE ID, the VAE server 1 creates a dynamic UE location based group with the UE list received from its LMS and other VAE server(s) 2..N. Further VAE server 1 stores the dynamic UE location based group. Otherwise, the VAE server 1 updates the dynamic UE location group with the latest UE information. The V2X UEs whose locations are no more within the application defined proximity range are removed from the dynamic UE location group.

9.16.5 Obtaining dynamic information of the UEs in proximity range

9.16.5.1 Subscription procedure within V2X SP

Figure 9.16.5.1-1 describes the subscription procedure within V2X SP to obtain dynamic information from the UEs in application defined proximity range.

Pre-condition:

- VAE server 1 is tracking the host vehicle and has created the dynamic UE location based group as per procedure in clause 9.16.4.

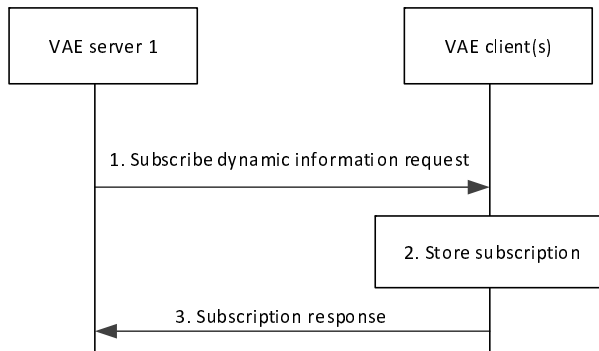


Figure 9.16.5.1-1: Subscription procedure within V2X SP

1. The VAE server 1 managing the dynamic UE location group sends subscribe dynamic information request to the VAE clients who are part of the dynamic UE location group. These VAE clients (V2X UEs) belong to the same V2X SP as the host vehicle. The request consists of reporting configuration (e.g. frequency of reporting, event based).
2. The VAE client(s) store the subscription information.
3. The VAE client(s) send a subscription response to the VAE server 1.

9.16.5.2 Subscription procedure across V2X SPs

Figure 9.16.5.2-1 describes the subscription procedure across V2X SPs to obtain dynamic information from the UEs in application defined proximity range.

Pre-condition:

- VAE server 1 has created the dynamic UE location based group as per procedure in clause 9.16.4.

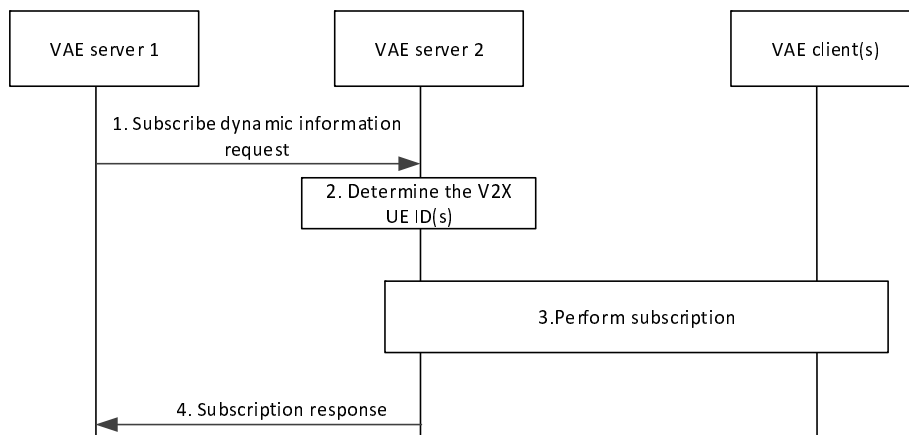


Figure 9.16.5.2-1: Subscription procedure across V2X SPs

1. The VAE server 1 managing the dynamic UE location group sends subscribe dynamic information request to the VAE server(s) who's V2X UEs are part of the dynamic UE location group. The request consists of temporary V2X UE IDs, reporting configuration (e.g. frequency of reporting, event based).
2. As per the agreement between V2X SPs, if V2X UE IDs are not shareable, then VAE server 2 determines the V2X UE IDs corresponding to the temporary V2X UE IDs provided in step 1.
3. The VAE server 2 performs subscription procedure as specified in clause 9.16.5.1 with the VAE client(s).
4. The VAE server 2 sends a subscription response to the VAE server 1.

NOTE: VAE server 1 initiates this procedure with other VAE servers operating in the area.

9.16.5.3 Notification procedure

Figure 9.16.5.3-1 describes the notification procedure of dynamic information from the UEs in application defined proximity range.

Pre-condition:

- VAE server 2 has received the notification of dynamic information from its subscribed VAE client(s).

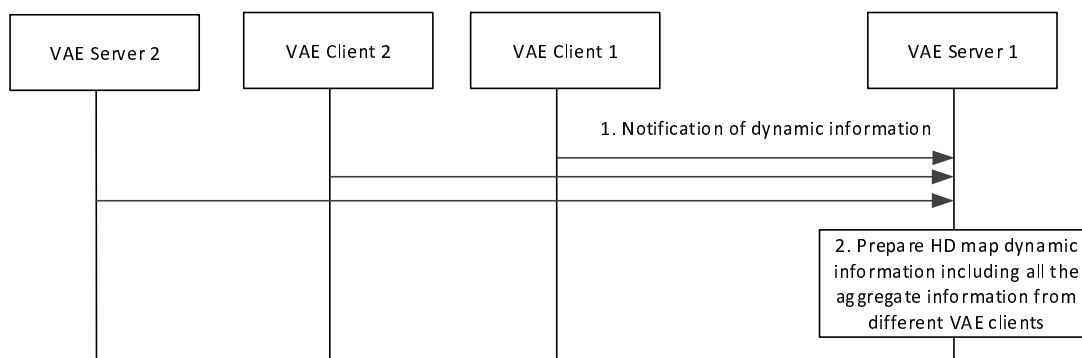


Figure 9.16.5.3-1: Notification procedure

1. As per subscription procedure in clause 9.16.5.1 and clause 9.16.5.2, the VAE client(s) and VAE server 2 (of another V2X SP) send notification of dynamic information to the VAE server 1. The notification includes the nearby UE information (e.g. vehicles, pedestrians), distance with nearby UEs, UEs location information. As per agreement between V2X SPs, if V2X UE IDs are not shareable, then VAE server 2 includes the temporary V2X UE IDs in the notification.
2. The VAE server 1 aggregates information from different VAE clients to create the HD map dynamic information.

9.16.6 Notification of HD map dynamic information

Pre-conditions:

- V2X application specific server has performed subscription as per procedure in clause 9.16.3 with VAE server 1.
- VAE server 1 has prepared the HD map dynamic information as per procedure in clause 9.16.5.3.

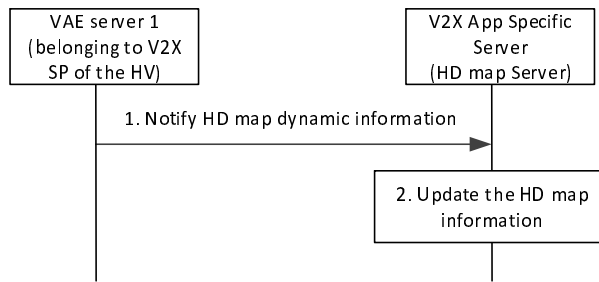


Figure 9.16.6: Notification for HD map dynamic information

1. The VAE server 1 sends notification of HD map dynamic information to the V2X application specific server. The notification includes the aggregated information of all the UEs in the application defined proximity range of the host vehicle and the location of the host vehicle.
2. The V2X application specific server updates the HD map information with the HD map dynamic information received in step 1.

9.17 V2X groupcast/broadcast configuration by VAE layer

9.17.1 General

The VAE client configures policies for the UE-to-UE broadcast/groupcast delivery, based on the requirement received by the VAE server, to reduce V2X broadcast flooding, while ensuring meeting the KPIs for one or more V2X services in a service area.

Following procedures are provided for this feature:

- the UE-to-UE broadcast/groupcast configuration by VAE client as specified in clause 9.17.3; and
- the UE-to-UE delivery which is handled by VAE clients over V5-AE as specified in clause 9.17.4.

9.17.2 Information flows

9.17.2.1 V2V configuration requirement request

Table 9.17.2.1-1 describes the information flow V2V configuration requirement request from the V2X application specific server to the VAE server.

Table 9.17.2.1-1: V2V configuration requirement request

Information element	Status	Description
V2X group ID	M (NOTE)	Identity of the V2X group for which the V2X application requirement is initiated.
V2X service ID	M (NOTE)	The V2X service ID for which application requirement corresponds to.
Candidate Relay V2X-UE ID list	O	List of identities of the V2X UEs, which are candidate to serve as application layer relays.
V2X application QoS requirements	O	The application QoS requirements (reliability, delay, jitter) for the V2X service.
NOTE: Either of the information element should be present.		

9.17.2.2 V2V configuration requirement response

Table 9.17.2.2-1 describes the information flow V2V configuration requirement response from the VAE server to the V2X application specific server.

Table 9.17.2.2-1: V2V configuration requirement response

Information element	Status	Description
Result	M	The result corresponding to the V2V configuration requirement request.

9.17.2.3 V2X groupcast/broadcast configuration request

Table 9.17.2.3-1 describes the information flow V2X groupcast/broadcast configuration request from the VAE server to the VAE client.

Table 9.17.2.3-1: V2X groupcast/broadcast configuration request

Information element	Status	Description
VAE Server ID	M	Identity of the VAE server which is requester of the V2X groupcast/broadcast configuration
V2X group ID	M (NOTE)	Identity of the V2X group for which the V2X groupcast/broadcast configuration is requested.
V2X service ID	M (NOTE)	The V2X service ID for which the groupcast/broadcast configuration is requested
PC5 Provisioning policies/parameters	M	PC5 provisioning policies/parameters to be used by the V2X-UEs within the V2X service (list provided in TS 23.287)
Relay V2X-UE ID list	O	List of identities of the V2X UEs to serve as application layer relays.
Minimum number of re-transmissions	O	Minimum Number of allowed re-transmissions for the V2X message delivery.

9.17.2.4 V2X groupcast/broadcast configuration response

Table 9.17.2.4-1 describes the information flow V2X groupcast/broadcast configuration response from the VAE client to the VAE server.

Table 9.17.2.4-1: V2X groupcast/broadcast configuration response

Information element	Status	Description
Result	M	The result corresponding to the V2X groupcast/broadcast configuration request.

9.17.2.5 UE-to-UE groupcast/broadcast configuration request

Table 9.17.2.5-1 describes the information flow UE-to-UE groupcast/broadcast configuration request from a VAE client to another VAE client within the group or the V2X service.

Table 9.17.2.5-1: UE-to-UE groupcast/broadcast configuration request

Information element	Status	Description
VAE client ID	M	Identity of the VAE client which is requester of the UE-to-UE groupcast/broadcast configuration
V2X group ID	M (NOTE)	Identity of the V2X group for which the UE-to-UE groupcast/broadcast configuration is requested.
V2X service ID	M (NOTE)	The V2X service ID for which the UE-to-UE groupcast/broadcast configuration is requested
UE-to-UE groupcast/broadcast configuration policies/ parameters	M	The requested configuration policies to be applied for the UE-to-UE broadcast/groupcast communications. The policies / parameters may be the following: <ul style="list-style-type: none"> - activation / de-activation of the application relaying capability - adaptation of the application QoS parameters of the PC5 session - adaptation of the frequency and number of re-transmissions of the application messages - activation / de-activation of bundling of V2X messages to containers
NOTE: Either of the information element should be present.		

9.17.2.6 UE-to-UE groupcast/broadcast configuration response

Table 9.17.2.6-1 describes the information flow UE-to-UE groupcast/broadcast configuration response from a VAE client to another VAE client within the group or the V2X service.

Table 9.17.2.6-1: UE-to-UE groupcast/broadcast configuration response

Information element	Status	Description
Result	M	The result corresponding to the UE-to-UE groupcast/broadcast configuration request.

9.17.2.7 VAE message

Table 9.17.2.7-1 describes the information flow for a VAE client to deliver a VAE message to another VAE client.

Table 9.17.2.7-1: VAE message

Information element	Status	Description
VAE client ID	M	Identity of the VAE client which provides the V2X message
V2X group ID	M (NOTE 1)	Identity of the V2X group (for groupcast delivery)
V2X service ID	M (NOTE 1)	Identity of the V2X service (for broadcast delivery)
V2X Message ID(s)	O	Identity of the V2X message(s) within the VAE message (CPM, PCM, MCM, DENM)
Management Container	O	Management Container provides basic information about the transmitter, including the V2X-UE type (e.g. vehicle or RSU) and position
VAE payload	M (NOTE 2)	V2X message(s) payload carried by the VAE message.
NOTE 1: Either of the information element should be present.		
NOTE 2: One or more V2X messages may be carried within a VAE payload (e.g. CPM, PCM, MCM, DENM) depending on whether V2X message bundling is activated		

9.17.3 V2X groupcast/broadcast configuration by VAE layer

9.17.3.1 General

This subclause describes the procedure for V2X groupcast/broadcast configuration by the VAE layer.

9.17.3.2 Procedure

Figure 9.17.3.2-1 illustrates the procedure where the VAE client configures policies for the UE-to-UE broadcast/groupcast delivery to other VAE clients (within the V2X group or the V2X service), based on the requirement received by the VAE server.

Pre-conditions:

1. The V2X UEs have connected to the V2X application server.
2. VAE client 1 is registered with VAE server.

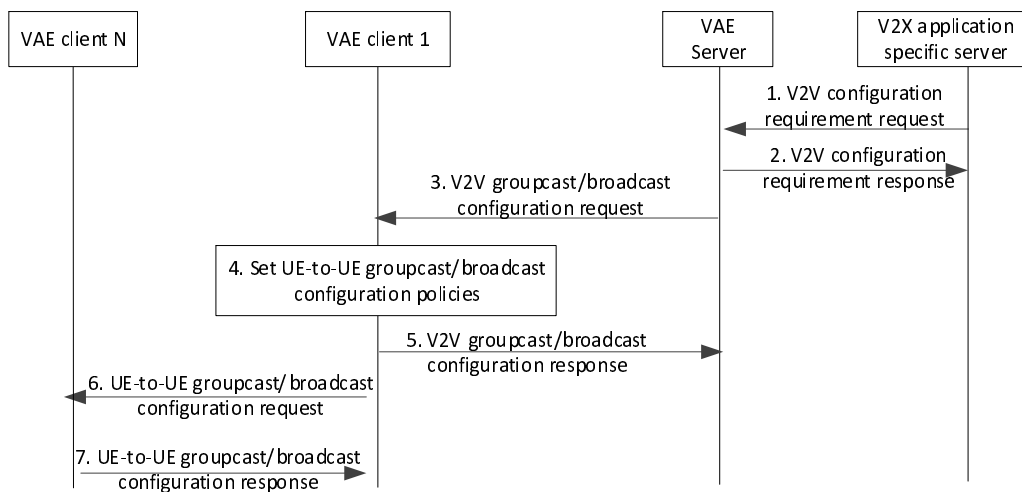


Figure 9.17.3.2-1: V2V groupcast/broadcast configuration by VAE layer

1. The V2X application specific server provides an V2V configuration requirement request to the VAE server to manage the UE-to-UE broadcast/groupcast communication. The VAE server may also provide within the request the list of V2X-UEs which are capable to serve as application layer relays.
2. The VAE server sends a V2V configuration requirement response to the V2X application specific server.
3. The VAE server provides a V2V broadcast/groupcast configuration request to VAE client 1. The VAE server may also provide within the request the list of V2X-UEs to serve as application layer relays based on the candidate list of relay V2X-UEs provided in step 1.

NOTE: How the V2X-UE 1 (or more V2X-UEs) is selected in step 3 is up to implementation.

4. The VAE client 1 selects and stores one or more UE-to-UE groupcast/broadcast configuration policies per V2X application for the UE-to-UE broadcast/groupcast communications.
5. The VAE client 1 sends a V2V broadcast/groupcast configuration response to VAE server to notify on the result.
6. The VAE client 1 sends a request to VAE client N (can be any VAE client within the V2X group or V2X service) with the requested UE-to-UE groupcast/broadcast configuration policies for the UE-to-UE broadcast/groupcast communications.

NOTE: When V2X-UE 1 distributes the UE-to-UE groupcast/broadcast configuration message and how V2X-UE N (or more V2X UEs) is selected is up to implementation.

- The VAE client 1 receives a response from the VAE client 2, which includes either a positive or a negative acknowledgement of the message.

9.17.4 V2X groupcast/broadcast delivery by VAE layer

9.17.4.1 General

This subclause describes the procedure for V2X groupcast/broadcast delivery by the VAE layer.

9.17.4.2 Procedure

Figure 9.17.4.2-1 illustrates the procedure where the VAE client delivers the VAE message based on the configured policies (based on the procedure in clause 9.17.3).

Pre-conditions:

- The VAE clients of the V2X-UEs have received and stored the UE-to-UE broadcast/groupcast configuration policies per V2X application.

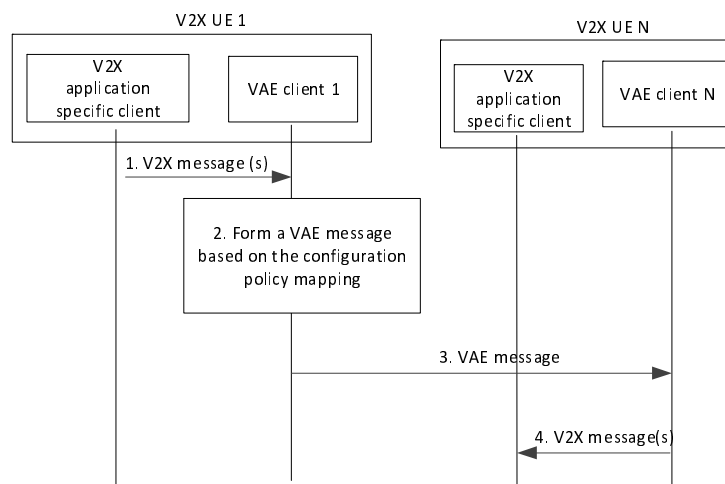


Figure 9.17.4.2-1: V2X groupcast/broadcast delivery by VAE layer

- The V2X application specific client of the V2X UE 1 sends to the VAE client 1, the V2X message to be broadcasted/groupcasted. This message may be for example a PCM, CPM, MCM, DENM.
- The VAE client 1 retrieves the mapping for the V2X service and configuration policy related to the V2X message. The VAE client 1 forms a VAE message, based on the V2X message(s) and the applied configuration policy.
- The VAE message is sent from the transmitting V2X-UE 1 to the receiving V2X-UE N (which may be application relay or destination V2X-UEs). For the case when a V2X-UE acts as application relay, the message is relayed towards the destination VAE client.
- The V2X message is provided from the destination VAE client to the corresponding V2X application specific client. In case of message bundling, the receiving VAE client first un-bundles the V2X message and then sends to the V2X application specific client.

9.18 Local MBMS support

For local MBMS based MBMS data delivery as defined in 3GPP TS 23.285 [5], the BM-SC can be provided with the local MBMS information (i.e. M1 interface information including transport network IP Multicast Address, IP address of multicast source and C-TEID, as well as MB2-U or xMB-U interface information including IP address and UDP port number for the user plane) from the V2X application plane. Such local MBMS information can be pre-configured in the VAE server based on service requirements or deployment needs. The VAE server may request SEAL NRM server to establish the MBMS bearers by providing the local MBMS information as described in subclause 14.3.4.3.2 and subclause 14.3.4.3.2 of TS 23.434 [6].

9.19 Session-oriented services

9.19.1 General

The VAE layer provides support at the application layer for V2X application specific server and V2X UE to initiate session-oriented services by providing mechanisms for establishing, updating and terminating sessions.

9.19.2 Information flows

9.19.2.1 Session-oriented service trigger request

Table 9.19.2.1-1 describes the information flow session-oriented service trigger request from the V2X application specific server to the VAE server.

Table 9.19.2.1-1: Session-oriented service trigger request

Information element	Status	Description
Remote V2X UE ID	M	Identity of the V2X UE (VAE client) which is the remote vehicle.
V2X service ID	M	The V2X service ID for which application requirement corresponds to.
V2X application specific server identity information	M	Identity information of the V2X application specific server.
Session ID	O	The session identifier to be used for the session-oriented service.
V2X application QoS requirements for the session	O	The application QoS requirements (reliability, delay, jitter) for the session-oriented service.

9.19.2.2 Session-oriented service trigger response

Table 9.19.2.2-1 describes the information flow session-oriented service trigger response from the VAE server to the V2X application specific server.

Table 9.19.2.2-1: Session-oriented service trigger response

Information element	Status	Description
Acknowledgement	M	Acknowledgement for the request

9.19.2.3 Session-oriented service establishment notification

Table 9.19.2.3-1 describes the information flow session-oriented service establishment notification from the VAE server to the V2X application specific server.

Table 9.19.2.3-1: Session-oriented service establishment notification

Information element	Status	Description
Result	M	The result indicating success or failure to establish session-oriented service
Remote V2X UE ID	M	Identity of the V2X UE (VAE client) which is the remote vehicle.
Session ID	O (NOTE)	The session identifier to be used for the session-oriented service.
NOTE: This IE is present when Result is success. It is generated by the VAE server if not provided by the requester.		

9.19.2.4 Session-oriented change trigger request

Table 9.19.2.4-1 describes the information flow session-oriented change trigger request from the V2X application specific server to the VAE server.

Table 9.19.2.4-1: Session-oriented change trigger request

Information element	Status	Description
Session ID	M	The session identifier of the session-oriented service.
V2X application QoS requirements for the session	M	The application QoS requirements (reliability, delay, jitter) for the session-oriented service that is to be updated.

9.19.2.5 Session-oriented change trigger response

Table 9.19.2.5-1 describes the information flow session-oriented change trigger response from the VAE server to the V2X application specific server.

Table 9.19.2.5-1: Session-oriented change trigger response

Information element	Status	Description
Acknowledgement	M	Acknowledgement for the request

9.19.2.6 Session-oriented service change notification

Table 9.19.2.6-1 describes the information flow session-oriented service change notification from the VAE server to the V2X application specific server.

Table 9.19.2.6-1: Session-oriented service change notification

Information element	Status	Description
Result	M	The result indicating success or failure to change session-oriented service

9.19.2.7 Session-oriented termination trigger request

Table 9.19.2.7-1 describes the information flow session-oriented termination trigger request from the V2X application specific server to the VAE server.

Table 9.19.2.7-1: Session-oriented termination trigger request

Information element	Status	Description
Session ID	M	The session identifier of the session-oriented service.

9.19.2.8 Session-oriented termination trigger response

Table 9.19.2.8-1 describes the information flow session-oriented termination trigger response from the VAE server to the V2X application specific server.

Table 9.19.2.8-1: Session-oriented termination trigger response

Information element	Status	Description
Acknowledgement	M	Acknowledgement for the request

9.19.2.9 Session-oriented service termination notification

Table 9.19.2.9-1 describes the information flow session-oriented service termination notification from the VAE server to the V2X application specific server.

Table 9.19.2.9-1: Session-oriented service termination notification

Information element	Status	Description
Result	M	The result indicating success or failure to terminate session-oriented service

9.19.3 UE initiated session-oriented service

9.19.3.1 General

The VAE layer provides support at the application layer for V2X UE to initiate session-oriented services by providing mechanisms for establishing, updating and terminating sessions.

9.19.3.2 UE initiated session-oriented service establishment

Pre-conditions:

- The V2X UE (acting as remote controller) has been authenticated for using session-oriented services and has connected to the VAE server.
- The V2X application-specific client has triggered the VAE client to establish a session with the remote V2X UE (vehicle).

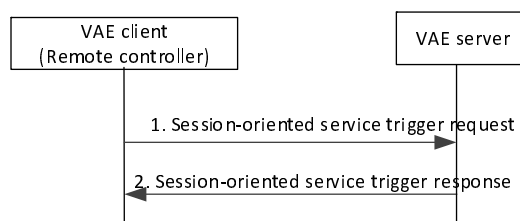


Figure 9.19.3.2-1: Procedure for establishing a UE initiated session-oriented service between the VAE client (remote controller) and the VAE client (remote vehicle)

1. The VAE client (acting as remote controller) sends a trigger request to the VAE server to establish a session-oriented service with one or more V2X UEs (remote vehicle). It may include the identity of the VAE client, the identity of the service session, the V2X service ID, the "type" or "QoS requirements" of the session, service information (e.g. geo-referenced information for tele-operated driving service in the form of geographical area where the service is expected to be delivered or in the form of expected/planned vehicle trajectory, or time interval during which the service is expected) and requirements (e.g. reporting configuration).

- The VAE server checks whether the VAE client is authorized to establish session-oriented service with one or more V2X UEs (remote vehicles). The VAE server provides a session-oriented service trigger response to the VAE client indicating the ability or inability of VAE server to initiate a session-oriented service with the VAE client. The VAE server performs the procedure to establish session oriented service with VAE client (e.g. remote vehicle).

NOTE 1: The VAE server performs the procedure specified in clause 9.19.5.2 to establish session oriented service with VAE client (e.g. remote vehicle).

NOTE 2: The resulting application session occurs over IP connectivity (Uu based) between the remote controller and the remote vehicle.

9.19.3.3 UE initiated session-oriented service update

Pre-condition:

- The VAE client (remote controller) has established a session-oriented service with a VAE client (remote vehicle) via the VAE server.

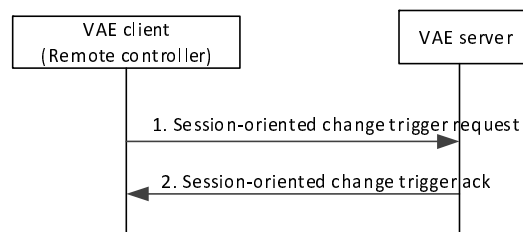


Figure 9.19.3.3-1: Procedure for updating an UE initiated session-oriented service between the VAE client (remote controller) and the VAE client (remote vehicle)

- The VAE client (acting as remote controller) sends a change trigger request to the VAE server to update the session-oriented service to one or more VAE clients (remote vehicle) including the identity of the service session, updates to service information (e.g. activated services, updates to vehicle trajectory), requirements (e.g. change of network/QoS requirements), or server information (e.g. change of VAE server).
- The VAE server provides a session-oriented change trigger response to the VAE client indicating the ability or inability of VAE server to continue the session-oriented service with the VAE client with the updated conditions. The VAE server performs the procedure to change session oriented service with VAE client (e.g. remote vehicle).

NOTE: The VAE server performs the procedure specified in clause 9.19.5.3 to change session oriented service with VAE client (e.g. remote vehicle).

9.19.3.4 UE initiated session-oriented service termination

Pre-condition:

- The VAE client (remote controller) has established a session-oriented service with the VAE client (remote vehicle).

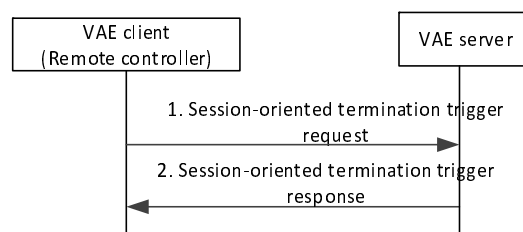


Figure 9.19.3.4-1: Procedure for terminating an UE initiated session-oriented service between the VAE client (remote controller) and the VAE client (remote vehicle)

1. The VAE client (acting as remote controller) sends a session-oriented termination trigger request to the VAE server to terminate the session (e.g. end of session with VAE server or requirements for session-oriented service not satisfied) with one or more V2X UEs (remote vehicles) including the identity of the service session.
2. The VAE server sends a session-oriented termination trigger response to the VAE client indicating the result of the session-oriented service termination with one or more V2X UEs (remote vehicles). The VAE server performs the session-oriented service termination procedure to terminate session oriented service with VAE client (e.g. remote vehicle).

NOTE: The VAE server performs the procedure specified in clause 9.19.5.4 to terminate session oriented service with VAE client (e.g. remote vehicle).

9.19.4 V2X application specific server triggered session-oriented service

9.19.4.1 General

The VAE layer provides support at the application layer for V2X application specific server triggered session-oriented services by providing mechanisms for establishing, updating and terminating sessions.

9.19.4.2 Triggering of session-oriented service establishment

Pre-conditions:

- The V2X application-specific server has decided to trigger the session-oriented service.

NOTE: The reasons that the V2X application-specific server decides to trigger the V2X application specific layer session are out of scope of the present document.

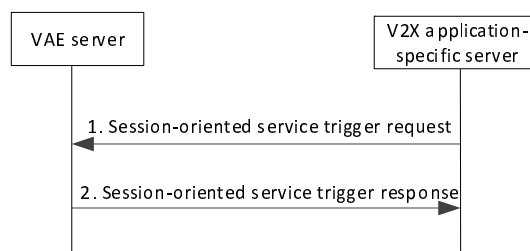


Figure 9.19.4.2-1: Triggering of session-oriented service establishment

1. The V2X application-specific server triggers the VAE server to initiate a session-oriented service to the VAE client. This request can include information such as the identity of the VAE client, the identity of the V2X application specific server, the identity of the service session, the V2X service ID and the "type" or "QoS requirements" of the session.
2. The VAE server provides a session-oriented service trigger response to the V2X application-specific server indicating the ability or inability of VAE server to initiate a session-oriented service with the VAE client.

NOTE: The VAE server performs the procedure specified in clause 9.19.5.2 to establish session oriented service with VAE client (e.g. remote vehicle).

9.19.4.3 Triggering of session-oriented service update

Pre-conditions:

- The VAE server has established a session-oriented service with the VAE client as described in clause 9.19.5.2.
- The V2X application-specific server needs to update parameters of the session.

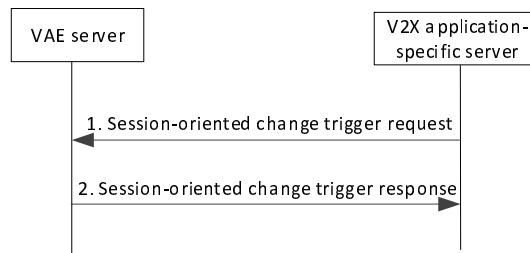


Figure 9.19.4.3-1: Triggering of session-oriented service update

1. The V2X application-specific server provides the VAE server with the identity of the session and the update of session parameters, e.g. change of QoS requirements of the session.
2. The VAE server provides a session-oriented service update response to the V2X application specific server including the ability or inability to continue the session-oriented service with the VAE client with the updated conditions.

NOTE: The VAE server performs the procedure specified in clause 9.19.5.3 to change session oriented service with VAE client (e.g. remote vehicle).

9.19.4.4 Triggering of session-oriented service termination

Pre-conditions:

- The VAE server has established a session-oriented service with the VAE client as described in clause 9.19.5.2.
- The V2X application specific server has decided to terminate the session-oriented service.

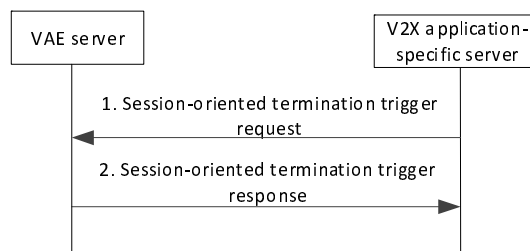


Figure 9.19.4.4-1: Triggering of session-oriented service termination

1. The V2X application-specific server provides the VAE server with a request to terminate the session-oriented service with the VAE client. It may include the identity of the service session.
2. The VAE server provides a session-oriented service termination response to the V2X application-specific server that the session can be terminated.

NOTE: The VAE server performs the procedure specified in clause 9.19.5.4 to terminate session oriented service with VAE client (e.g. remote vehicle).

9.19.5 Session-oriented service

9.19.5.1 General

The VAE layer provides support at the application layer for session-oriented services by providing mechanisms for establishing, updating and terminating sessions.

9.19.5.2 Session-oriented service establishment

Pre-conditions:

- The V2X UE has been authenticated for using session-oriented services and has connected to the V2X application server.

- The VAE server has agreed to establish a session upon the request from the V2X application specific server or from the VAE client.
- The V2X application specific client has subscribed with the VAE client to receive notifications related to session-oriented service and the V2X application specific server has subscribed with VAE server to receive notifications related to session-oriented service.
- The V2X application specific client for the terminating V2X UE has been informed about the already negotiated session oriented service to VAE client.

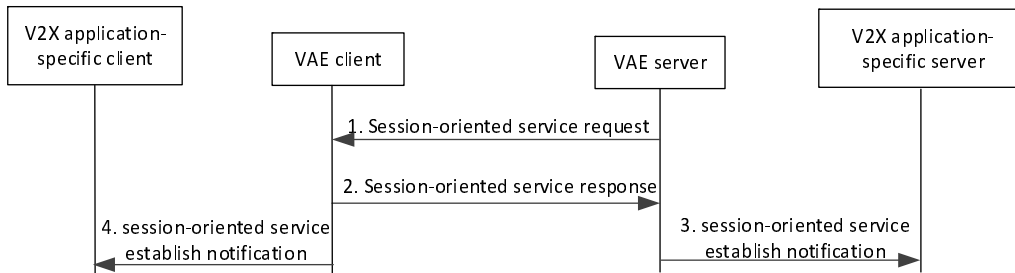


Figure 9.19.5.2-1: Procedure for establishing a session-oriented service between the VAE server and the VAE client

1. The VAE server sends a request to one or more VAE clients to establish a session-oriented service including identity of the VAE client, identity of the session, V2X service ID and reporting configuration.
2. The VAE client sends a session-oriented service response to the VAE server indicating approval of session establishment request by the VAE server.
3. If V2X application specific server has triggered then, the VAE server sends a session-oriented service establish notification to the V2X application-specific server.
4. The VAE client sends a session-oriented service establish notification to the V2X application-specific client.

9.19.5.3 Session-oriented service update

Pre-condition:

- The VAE server has established a session-oriented service with the VAE client.
- The VAE server has received a session-oriented service update from the V2X application-specific server or from the VAE client or a change in QoS and network conditions from 3GPP network system.
- The V2X application specific client has subscribed with the VAE client to receive notifications related to session-oriented service and the V2X application specific server has subscribed with VAE server to receive notifications related to session-oriented service.
- The VAE server has agreed to continue the session-oriented service with the VAE client with the updated conditions upon the request from the V2X application specific server or from the VAE client.

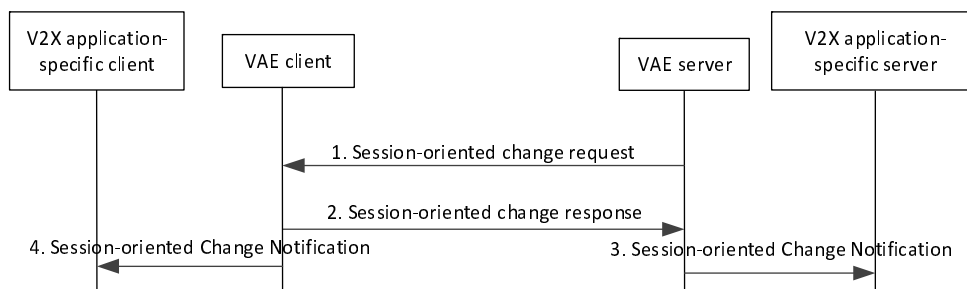


Figure 9.19.5.3-1: Procedure for updating a session-oriented service between the VAE server and the VAE client

1. The VAE server sends a change request to one or more VAE clients including the identity of the session, updates requirements (e.g. change of network/QoS requirements), or server information (e.g. change of VAE server).
2. The VAE client sends a change response to the VAE server indicating acceptance of the change request by the VAE server.
3. If V2X application specific server has triggered then, the VAE server sends a session-oriented service change notification to the V2X application-specific server.
4. The VAE client sends a session-oriented service change notification to the V2X application-specific client.

9.19.5.4 Session-oriented service termination

Pre-condition:

- The VAE server has established a session-oriented service with the VAE client.
- The VAE server has received a session-oriented service termination request from the V2X application-specific server or from the VAE client or a change in QoS or network conditions from 3GPP network system that prevents the VAE server from continuing the session-oriented service.
- The V2X application specific client has subscribed with the VAE client to receive notifications related to session-oriented service and the V2X application specific server has subscribed with VAE server to receive notifications related to session-oriented service.
- The VAE server has indicated to terminate the session-oriented service with the VAE client upon the request from the V2X application specific server or from the VAE client.

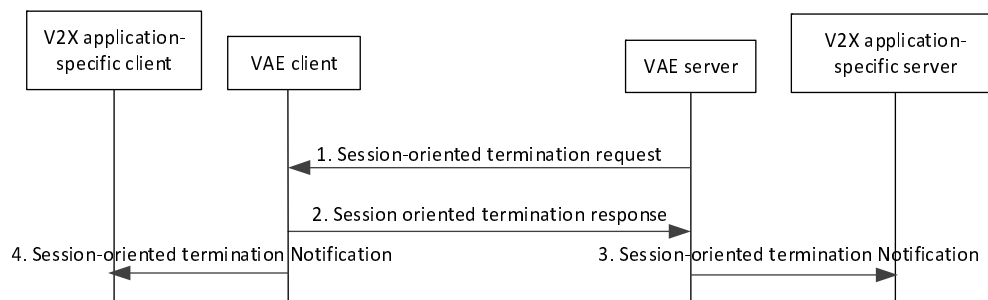


Figure 9.19.5.4-1: Procedure for terminating a session-oriented service between the VAE server and the VAE client

1. The VAE server sends a session-oriented termination request to the VAE client to terminate the session (e.g. end of session with VAE server or requirements for session-oriented service not satisfied) including the identity of the session.
2. The VAE client sends a session-oriented termination response to the VAE server indicating acceptance of the termination request by the VAE server.
3. If V2X application specific server has triggered then, the VAE server sends a session-oriented service termination notification to the V2X application-specific server.
4. The VAE client sends a session-oriented service termination notification to the V2X application-specific client.

9.20 Monitoring and control of QoS for eV2X communications

9.20.1 General

5GS supports eV2X communications with extended QoS monitoring and reporting. The VAE layer utilizes these monitoring and reporting mechanisms to support control of QoS for eV2X communications. The V2X application specific server subscribes to service adaptation and QoS control events from the VAE layer and receives notifications about the relevant service requirement adaptations and corresponding QoS changes.

9.20.2 Information flows

9.20.2.1 Service adaptation and QoS control subscription request

Table 9.20.2.1-1 describes the information flow Service adaptation and QoS control subscription request from the V2X application specific server to the VAE server.

Table 9.20.2.1-1: Service adaptation and QoS control subscription request

Information element	Status	Description
V2X group ID	M (see NOTE)	Identity of the V2X group for which the service adaptation and QoS control subscription is initiated.
V2X service ID	M (see NOTE)	The V2X service ID for which subscription corresponds to.
V2X UE ID	M (see NOTE)	The V2X UE ID for which subscription corresponds to.
NOTE: Either of the information element should be present.		

9.20.2.2 Service adaptation and QoS control subscription response

Table 9.20.2.2-1 describes the information flow for VAE server to respond for Service adaptation and QoS control subscription request from the V2X application specific server.

Table 9.20.2.2-1: Service adaptation and QoS control subscription response

Information element	Status	Description
Result	M	Result from the VAE server in response to subscription request indicating success or failure
Subscription ID (see NOTE)	O	Identifier of a successful subscription.
NOTE: This IE is included when the Result indicates success		

9.20.2.3 Service requirement adaptation notification request

Table 9.20.2.3-1 describes the information flow for service requirement adaptation notification request from VAE server to the V2X application specific server.

Table 9.20.2.3-1: Service requirement adaptation notification request

Information element	Status	Description
Subscription ID	M	Identifier of the subscription for this notification.
List of V2X UEs information	O	The information of the V2X UEs which are affected by this service requirement adaptation notification
> V2X UE ID	M	The identifier of V2X UE
QoS change information	M	The actual or expected QoS change information

9.20.2.4 Service requirement adaptation notification response

Table 9.20.2.4-1 describes the information flow for service requirement adaptation notification response from V2X application specific server to the VAE server.

Table 9.20.2.4-1: Service requirement adaptation notification response

Information element	Status	Description
Subscription ID	M	Identifier of the subscription for this notification.
Acknowledgement Result (see NOTE)	M	Indicates positive or negative acknowledgement.
List of V2X UEs information (see NOTE)	O	The information of the V2X UEs which are affected by the service requirement adaptation and requires QoS change to be applied.
> V2X UE ID	M	The identifier of V2X UE
NOTE: If Acknowledgement Result IE indicates positive, then List of V2X UEs information IE is included.		

9.20.3 Subscription Procedure

Pre-conditions:

1. The VAE server includes an Application Function (AF) functionality, as defined in 3GPP TS 23.287 [8].
2. The VAE server has subscriptions with SEAL servers to receive V2X service-related information (e.g. UE IDs, location, group, configuration info, etc.).

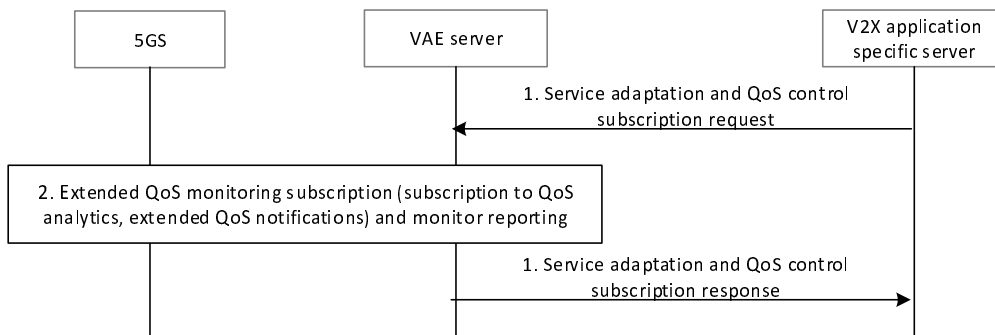


Figure 9.20.3-1: Subscription for monitoring and control of QoS for eV2X communications

1. The V2X application specific server sends a service adaptation and QoS control subscription request to the VAE server.
2. The VAE server, who acts as an AF, subscribes to QoS monitoring service from 5GS (e.g. PCF/NWDAF). This subscription may be active for a certain period of time or a given geographical area. The monitoring may either include the request for QoS sustainability events as specified in 3GPP TS 23.288 [24], or can include a QoS change notification requests as provided by SMF and specified in 3GPP TS 23.287 [8]. The reporting may be configured by the application enabler layer for a given area, time, periodicity etc taking into account the service requirement and other parameters (e.g. expected congestion in certain area, time of the day, road conditions).
3. The VAE server sends a service adaptation and QoS control subscription response indicating success or failure of subscription.

9.20.4 Notification Procedure

Pre-condition:

1. The subscription procedure specified in clause 9.20.3 is performed.

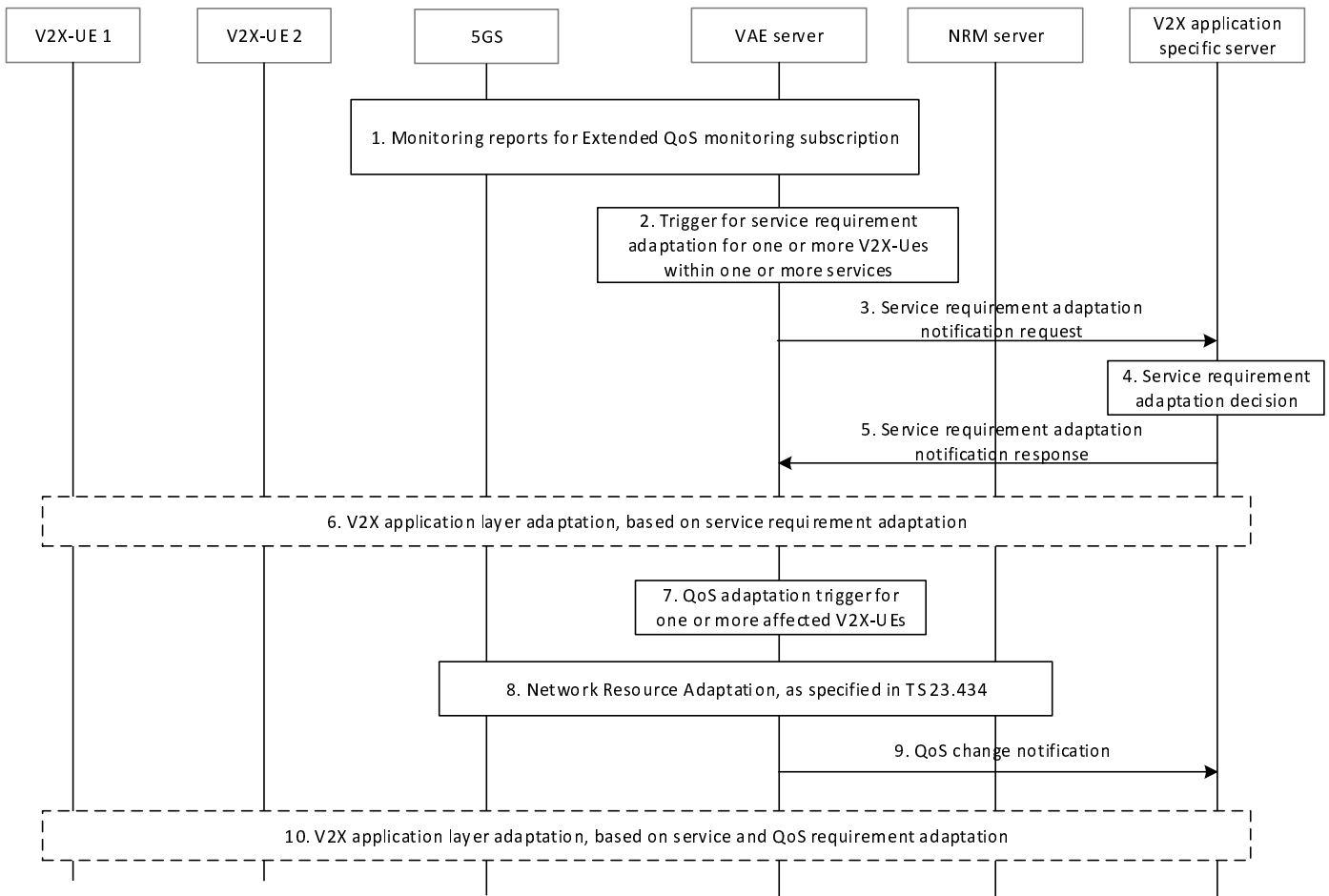


Figure 9.20.3-1: Notification for monitoring and control of QoS for eV2X communications

1. Based on the subscription, as specified in 3GPP TS 23.287 [8], 5GS provides the extended QoS monitoring report, over N33 interface. This report may come either from NWDAF or SMF via PCF/NEF.
2. The VAE server, based on the monitoring events (step 1) for one or multiple V2X-UEs within one service or across multiple services, may trigger a service requirement adaptation (step 3) based on the actual or expected QoS change for one or more V2X services.
3. The VAE server sends a service requirement adaptation notification request to V2X application specific server to identify the action which is needed, based on the actual or expected QoS change. This could be the adaptation of the Level of Automation (LoA) for one or more V2X-UEs or V2X services.
4. The V2X application specific server decides whether to adapt the service requirement based on step 3.
5. The V2X application specific server sends a response to VAE server with a positive or negative acknowledgment. Optionally, this may include the list of a sub-set of V2X-UEs within a service for which the requirement change should be applied
6. If no QoS adaptation is required, V2X application layer may adapt based on the adapted service requirements; and steps 7-10 are optional.
7. If a QoS adaptation is required, the VAE server, triggers the adaptation of QoS for the affected V2X-UE(s) within the service or across multiple services in close vicinity.
8. The VAE server performs network resource adaptation by interacting with the NRM server as specified in the 3GPP TS 23.434 [10].
9. The VAE server also notifies about the QoS adaptation to the V2X application specific server.
10. The V2X application layer adapts based on the adapted service and QoS requirements.

9.21 Support for VRU zone configuration and operation

9.21.1 General

This capability supports the configuration and provisioning of the VRU high risk zone at the VAE layer based on a request from the V2X application specific server (VASS).

9.21.2 Information flows

9.21.2.1 VRU zone management subscription request

Table 9.21.2.1-1 describes information elements for the VRU zone management subscription request from the VASS to the VAE server.

Table 9.21.2.1-1: VRU zone management subscription request

Information element	Status	Description
Requestor ID	M	The identifier of the service requestor (VASS, VAL server, App ID)
VRU zone ID	O	The identifier of the VRU zone which may be provided by the requestor.
VRU zone information	M	This information identifies, based on the VRUP scenario, which type of UEs (V2X UEs, pedestrian UEs) are to be considered. Also, whether it is a static or dynamic zone can be identified.
VRU application requirements	M	This includes requirements include the types of supported messages and requirements (e.g. requirements for VAM messages), and application QoS requirement dedicated for the VRU zone (e.g. URLLC like).
List of VAL UE IDs	O	The identifiers of the VAL UEs for which the VRU zone is applicable
Area of Interest	O	The geographical or service area for which the subscription request applies
Time validity	O	The time validity of the request

9.21.2.2 VRU zone management subscription response

Table 9.21.2.2-1 describes information elements for the VRU zone management subscription response from the VAE server to VASS.

Table 9.21.2.2-1: VRU zone management subscription response

Information element	Status	Description
Result	M	The result of the VRU zone management subscription request (positive or negative acknowledgement)

9.21.2.3 VRU zone info notification

Table 9.21.2.3-1 describes information elements for the VRU zone info notification from the VAE server to the VAE clients.

Table 9.21.2.3-1: VRU zone info notification

Information element	Status	Description
VRU zone ID	M	The identifier of the VRU zone
VRU zone information	M	This information identifies based on the VRUP scenario, which type of UEs (V2X UEs, pedestrians) are to be considered. Also, whether it is a static or dynamic zone.
VRU zone area	M	The geographical (coordinates) or topological area for the zone (cell IDs, TAs)
QoS requirements	M	The application QoS requirements for the services within the zone
VRU zone configuration parameters	M	These parameters include: <ul style="list-style-type: none"> - The list of value-add VAE services required within the zone (e.g. location tracking, V2X message bundling), - the supported transmission modes (unicast, groupcast, broadcast) within the applications within the zone, - the allowed interface selection within the zone (Uu, PC5), - the use of application relaying or not
VRU zone adaptation assistance info	O	If the VRU zone is dynamic, this IE provides assistance info on the configuration adaptation triggers or to provide the planning (e.g. based on a school bus route) to allow the network to adapt the configuration.

9.21.2.4 Enter/Leave Notification

Table 9.21.2.4-1 describes information elements for the Enter/Leave Notification from the VAE server to the VASS or the VAE client(s) within the zone.

Table 9.21.2.4-1: Enter/Leave Notification

Information element	Status	Description
VAL UE ID	M (NOTE)	The identity of the UE of interest (GPSI, or external ID)
VAL group ID	M (NOTE)	The group UE identity (if this applies to a group of UEs).
VRU zone ID	M	The identifier of the VRU zone
VRU zone information	M	This information identifies based on the VRUP scenario, which type of UEs (V2X UEs, pedestrians) are to be considered. Also, whether it is a static or dynamic zone.
Enter/Leave timing info	M	The timing info for the UE enter / leave the zone. This includes for entering a start time of VRUP and an expected duration, and for leaving an expected leave time (if the UE is approaching the VRU zone boundaries)
UE/group mobility info	O	The expected mobility/speed/direction of the UE or group of interest
NOTE: One of these shall be present.		

9.21.3 Procedure on VAL server - triggered VRU zone configuration

Figure 9.21.3-1 illustrates the procedure where the VAE server configures the VRU zone based on application requirement; and supports the run-time operation based on an expected UE entrance to the zone.

Pre-conditions:

1. V2X application specific server or client has subscribed to VAE layer to provide support for V2P communication.

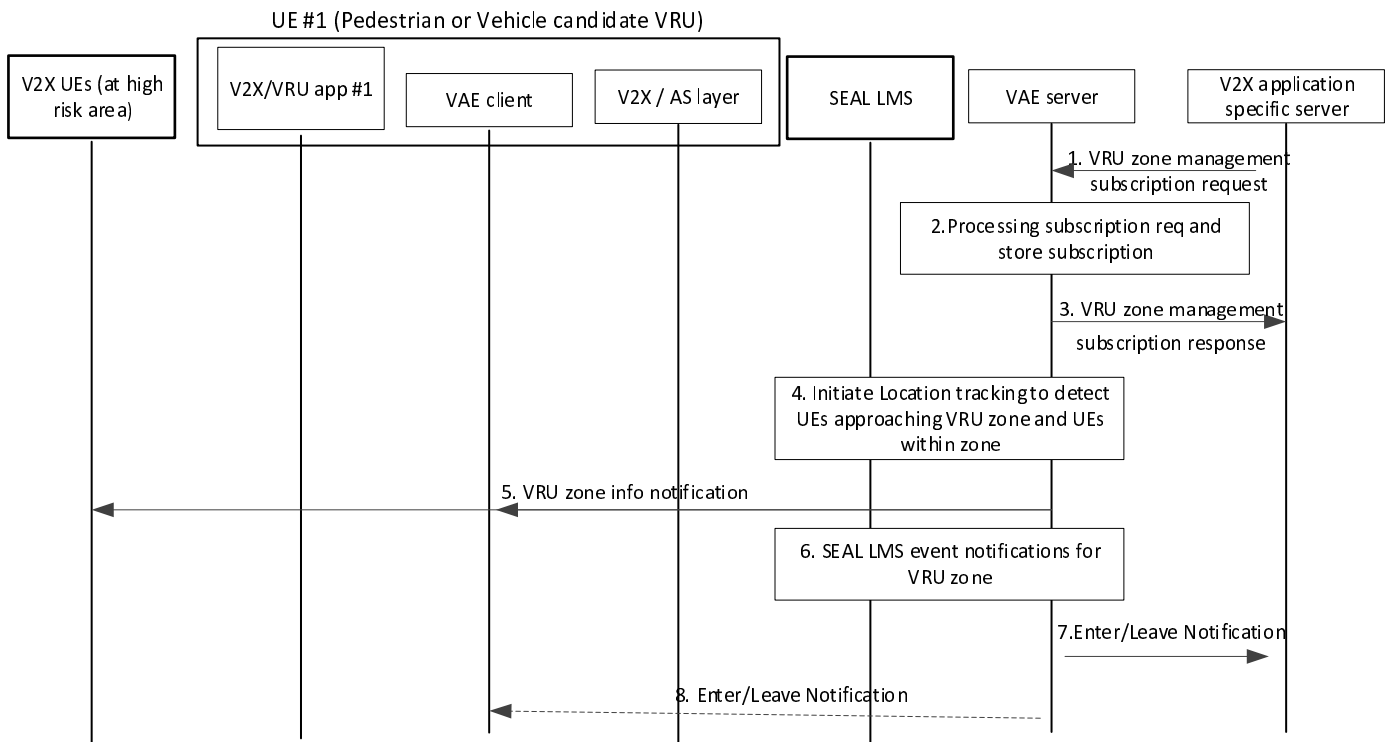


Figure 9.21.3-1: VAL server - triggered VRU zone configuration

1. The V2X application specific server sends a subscription request to manage the configuration of a new high-risk area zone and requires the VAE server support to translate it to a network-related zone configuration and provisioning to the UEs within the requested area.
2. The VAE server processes the request and stores the subscription. The processing includes the translation of the zone requirement of step 1 and determines a set of network-related zone parameters which indicates the configuration parameters.
3. The VAE sever sends a VRU zone management subscription response to VASS.
4. The VAE server initiates the SEAL LMS service for location tracking both for static location and dynamically changing location for all UEs within the VRU zone area. VAE server obtains and initiates tracking the V2X UEs location from the location management server 1 as specified in 3GPP TS 23.434 (clause 9.3.12) or, for static area, it obtains location area monitoring information based on clause 9.3.10 of 3GPP TS 23.434.
5. The VAE server sends a notification message including the VRU zone configuration parameters. Parameters can be based on the parameters provided in step 2. This configuration will be provided to the V2X-UEs (and pedestrians) within the area that will be covered by the VRU zone.
6. The VAE server keeps monitoring the VRU zone area based on monitoring SEAL LMS events. This includes events on whether a UE (e.g. UE1) is moving in or out a target area of interest.

The VAE server translates the UE1 mobility event to an expected entrance to a VRU high risk zone, and based on the configuration of the zone, it identifies whether to generate and send a notification to the VASS on the expected entrance / leave of UE1.

7. The VAE server alerts the VASS that the UE1 is expected to move to the VRU zone area in a given time horizon and provides also information on its mobility as well as the UE1 capabilities (e.g. VRU capable).
8. The VAE server may also alert the VAE client (if deployed at the UE1) that it is expected to enter the VRU zone and requests the confirmation for allowing the push of VRU messages within the zone.

9.22 VAE support for Energy Efficient V2P communications

9.22.1 General

Vehicle to Pedestrian (V2P) is one of the V2X scenarios, which enables communication between vehicles and pedestrians for both safety and traffic efficiency related applications. One of the key V2P applications is the Vulnerable Road User Protection (VRUP) as specified in ETSI TS 103 300-2 [13]. VRUP provides warning to vehicles of the presence of vulnerable road users, e.g. pedestrian or cyclist, in case of dangerous situation. In VRUP, multiple V2X messages need to be exchanged between the pedestrian and the vehicular UEs, originating by one or more applications. Such messages can be standard VRU messages (e.g. VAM) and other V2X messages (CAM, DENM, BSM, CPM) and can be exchanged via different transmission modes (unicast, groupcast, broadcast).

In such scenario, one challenge is that a pedestrian UE might have a lower battery capacity and limited radio capability, and therefore may have to work in a low power consumption mode, e.g. not being able to send/receive V2X messages with the same periodicity as a Vehicular UE. Continuous sending/receiving V2X messages by the pedestrian UE would affect UE power efficiency. A further challenge is that multiple applications related to VRU may be deployed, which may have differentiated traffic/QoS requirements as well as transmission/reception schedules.

The VAE layer may provide support functionality for enabling V2P applications, by consolidating the V2P application requirements and aligning the communication traffic pattern with the PC5 QoS setting and the AS layer configurations (e.g. DRX cycles).

9.22.2 Information flows

9.22.2.1 V2P application requirement request

Table 9.22.2.1-1 describes information elements for the V2P application requirement request from the V2X Application Specific Server (VASS) to the VAE server or from the V2X application specific client to the VAE client.

Table 9.22.2.1-1: V2P application requirement request

Information element	Status	Description
Requestor ID	M	The identifier of the service requestor (VASS, VAL server, App ID)
V2X service ID	M (see NOTE)	The V2X service ID for which application requirement corresponds to.
V2X group ID	M (see NOTE)	Identity of the V2X group for which the V2P application requirement is initiated.
V2P QoS requirements	M	The application QoS requirements (reliability, delay, jitter) for the V2P service
Application Traffic Pattern	M	The application transmission cycle or traffic schedule for the V2P service. This may be in form of a schedule of an expected transmission/reception of a V2X message over a pre-defined time window.
PC5 Provisioning policies/parameters	O	PC5 provisioning policies/parameters to be used by the V2X-UEs within the V2X service (list provided in TS 23.287)
NOTE: One of these shall be present.		

9.22.2.2 V2P application requirement response

Table 9.22.2.2-1 describes information elements for the V2P application requirement response from the VAE server to V2X Application Specific Server or from the VAE client to the V2X application specific client.

Table 9.22.2.2-1: V2P application requirement response

Information element	Status	Description
Result	M	The result of the V2P application requirement request (positive or negative acknowledgement)

9.22.2.3 V2P schedule configuration request

Table 9.22.2.3-1 describes information elements for the V2P schedule configuration request from the VAE server to the VAE clients.

Table 9.22.2.3-1: V2P schedule configuration request

Information element	Status	Description
VAE server ID	M	The identifier of the VAE server
V2X service ID	M (see NOTE)	The V2X service ID for which the configuration request applies.
V2X group ID	M (see NOTE)	Identity of the V2X group for which the configuration request applies.
Traffic Communication pattern	M	The traffic communication pattern includes the information for the V2P communication transmission/reception schedule, and optionally the inactivity period, sleep period
DRX cycle configuration	O	The DRX cycle configuration for out of coverage and groupcast/broadcast communications
V2P QoS requirements	O	The application QoS requirements (reliability, delay, jitter) for the V2P service
NOTE: One of these shall be present.		

9.22.2.4 V2P schedule configuration response

Table 9.22.2.4-1 describes information elements for the V2P schedule configuration response from the VAE client to the VAE server.

Table 9.22.2.4-1: V2P schedule configuration response

Information element	Status	Description
Result	M	The result corresponding to the V2P schedule configuration request.

9.22.2.5 V2P schedule notification

Table 9.22.2.5-1 describes information elements for the V2P schedule notification from the VAE client to the V2X app specific client.

Table 9.22.2.5-1: V2P schedule notify

Information element	Status	Description
V2X service ID	M	The V2X service ID for which the configuration corresponds to.
Traffic Communication pattern	M	The traffic communication pattern includes the information for the V2P communication transmission/reception schedule, and optionally the inactivity period, sleep period
DRX cycle configuration	O	The DRX cycle configuration for out of coverage and groupcast/broadcast communications

9.22.2.6 V2P schedule update request

Table 9.22.2.6-1 describes information elements for the V2P schedule update request from a first VAE client to a second VAE client.

Table 9.22.2.6-1: V2P schedule update request

Information element	Status	Description
VAE client ID	M	The identifier of the VAE client
V2X service ID	M (see NOTE)	The V2X service ID for which the schedule update applies.
V2X group ID	M (see NOTE)	Identity of the V2X group for which the schedule update applies.
Proposed Traffic Communication pattern	M	The proposed consolidated traffic communication pattern includes the information for the V2P communication transmission/reception schedule, and optionally the inactivity period, sleep period
NOTE: One of these shall be present.		

9.22.2.7 V2P schedule update response

Table 9.22.2.7-1 describes information elements for the V2P schedule update response from the second VAE client to the first VAE client.

Table 9.22.2.7-1: V2P schedule update response

Information element	Status	Description
Result	M	The result corresponding to the V2P schedule update request.
Cause	O	The cause in case of negative result.
Updated Traffic Communication pattern	O	The updated (after negotiation) traffic communication pattern.

9.22.3.1 Procedure on VAE server enabled V2P communication schedule configuration

This subclause describes the procedure for V2P communication schedule configuration and update support by the VAE server.

Figure 9.22.3.1-1 illustrates the procedure where the VAE server configures the traffic schedule for V2P communications based on application requirement; and communicates with the VAE clients to trigger the translation to an AS layer/ QoS configurations update.

Pre-conditions:

1. V2X Application Specific Server has subscribed to VAE server to provide support for V2P communication.
2. VAE client of V2X UE #1 and V2X UE #2 are registered with VAE server.

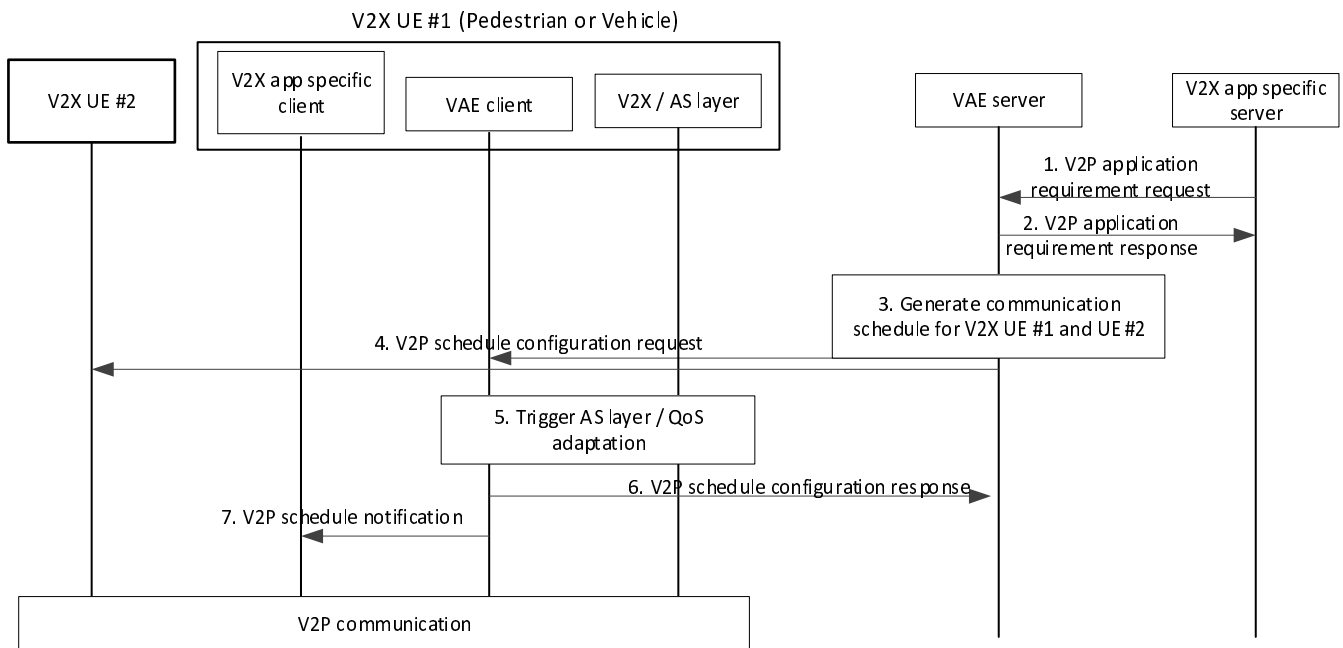


Figure 9.22.3.1-1: VAE server - enabled V2P communication schedule configuration

1. A V2P application specific server provides the V2P application requirements in form of a request to the VAE server, including application QoS requirements for the V2P applications and provisioning policies and parameters for the PC5 communication.
2. The VAE server authorizes the request and sends a V2P application requirement response.
3. The VAE server generates a communication schedule for one or more involved V2X UEs, so that the off duration is maximized. The determination of the transmission schedule can be determined based on the V2P service KPIs. Such communication schedule may include the transmission/reception schedule for the application messages and may also include the DRX cycle configuration for out of coverage and groupcast/broadcast communications.
4. The VAE server sends a V2P communication schedule configuration request message to the involved VAE clients. This includes the generated UE level transmission schedules and may also include the DRX cycle configuration for PC5 communication in out of coverage and groupcast/broadcast modes.
5. V2X UE #1's and V2X UE #2's VAE clients provide the updated traffic pattern as V2X Application Requirements to V2X layer, also including QoS requirements such as delay requirements, priority, etc., for the PC5 communication for both applications, as specified in 3GPP TS 23.287 [19] clause 5.4.1.1. VAE client may also indicate the transmission mode (unicast, groupcast) per application. The V2X layer of UEs #1 and #2 process the requirements from VAE client and generates a UE level DRX schedule. The AS layer of UE #1 and #2 applies/configures the DRX schedule for the corresponding V2X communication.
6. VAE clients of V2X UEs #1 and #2 send a response to the configuration request as positive or negative acknowledgement to the VAE server.
7. VAE clients of V2X UEs #1 and #2 may send a notification to the V2X application specific client(s) to inform on the communication traffic pattern.

9.22.3.2 Procedure on VAE client enabled V2P communication schedule configuration

This subclause describes the procedure for V2P communication schedule configuration and update support by the VAE client.

Figure 9.22.3.2-1 illustrates the procedure where the VAE client configures the traffic schedule for V2P communications based on application requirement; and triggers the translation to an AS layer/ QoS configurations update.

Pre-conditions:

1. VAE client 1 has been configured by the VAE server to configure the communication schedule for V2P communications.
2. V2X UE #1 and V2X UE#2 have discovered each other based upon V2P service and established a unicast connection using the V2X Service oriented Layer-2 link establishment procedure as specified in 3GPP TS 23.287 [19] clause 6.3.3.1.

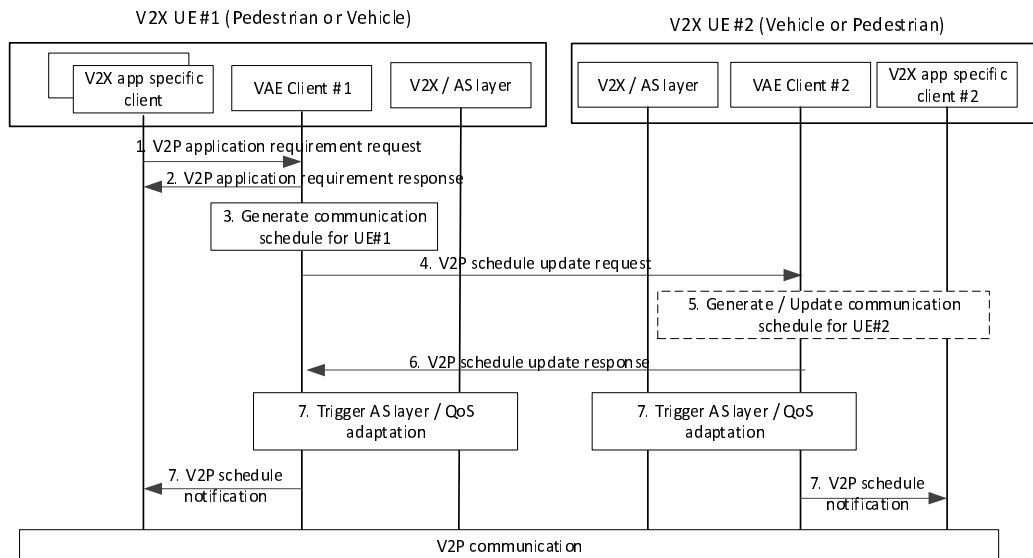


Figure 9.22.3.2-1: VAE client - enabled V2P communication schedule configuration

1. On V2X UE #1, one or more V2X application specific clients send V2P application requirement request to the VAE client, including application QoS requirements for the V2P applications and provisioning policies and parameters for the PC5 communication.
2. The VAE client sends a V2P application requirement response to the requestor V2X application specific client (s).
3. V2X UE #1's VAE client consolidates requirements (from one or more application specific clients) and generates a UE level transmission schedule, so that the off-duration is maximized. The determination of the transmission schedule can be determined based on the configuration on the UE (energy efficiency target) and the service KPIs.
4. V2X UE #1's VAE client sends a V2P communication schedule update request which includes the generated UE level transmission schedule to other VAE client 2 (in vicinity, or in service-based group), in order to negotiate the optimal transmission pattern or inform on the expected reception pattern.
5. V2X UE #2's VAE client optionally generates or updates the communication schedule for V2X UE #2, based on step 4, or negotiates the traffic pattern.
6. VAE client of V2X UE #2 may send a V2P communication schedule update response indicating the result or an expected/generated UE #2 transmission pattern (in case of negotiation).
7. V2X UE #1's and V2X UE #2's VAE clients provide the updated traffic pattern as V2X Application Requirements to V2X layer, also including QoS requirements such as delay requirements, priority, etc., for the PC5 communication for both applications, as specified in 3GPP TS 23.287 [x] clause 5.4.1.1. VAE client may also indicate the transmission mode (unicast, groupcast) per application. The V2X layer of UEs #1 and #2 process the requirements from VAE client and generates a UE level DRX schedule. The AS layer of UE #1 and #2 applies/configures the DRX schedule for the corresponding V2X communication.
8. VAE clients of V2X UEs #1 and #2 may send a V2P schedule notification to the V2X application specific client(s) to inform on the communication traffic pattern.

10 VAE layer APIs

10.1 General

The following VAE capabilities are offered as APIs:

- VAE server APIs;

The following SEAL service APIs are specified in 3GPP TS 23.434 [6]:

- Group management server APIs;
- Location management server APIs;
- Configuration management server APIs;
- Identity management server APIs; and
- Key management server APIs.

10.2 VAE server APIs

10.2.1 General

Table 10.2.1-1 illustrates the VAE server APIs.

Table 10.2.1-1: List of VAE server APIs

API Name	API Operations	Known Consumer(s)	Communication Type
VAE_MessageDelivery API	Deliver_DL_Message	V2X application specific server	Request/Response
	Deliver_UL_Message	V2X application specific server	Subscribe/notify
	V2X_MessageDelivery_Subscribe V2X_MessageDelivery_Unsubscribe		
VAE_FileDistribution API	Distribute_File	V2X application specific server	Request/Response
VAE_ApplicationRequirement API	Reserve_NetworkResource	V2X application specific server	Subscribe/notify
	Notify_NetworkResource		
VAE_DynamicGroup API	Configure_DynamicGroup	V2X application specific server	Request/Response
	Notify_DynamicGroup		
VAE_ServiceContinuity API	Query_ServiceContinuity	VAE server	Request/Response
VAE_HDMapDynamicInfo API	Subscribe_HDMapDynamicInfo	V2X application specific server	Subscribe/notify
	Notify_HDMapDynamicInfo		
VAE_SessionOrientedService API	Establish_Session	V2X application specific server	Subscribe/notify
	Notify_Establish_Session		
	Update_Session		
	Notify_Update_Session		
	Terminate_Session		
VAE_PC5ProvisioningRequirement API	Config_PC5ProvisioningRequirement	V2X application specific server	Subscribe/notify
	Notify_PC5ProvisioningRequirement		
VAE_V2VConfigRequirement API	Request_V2VConfigRequirement	V2X application specific server	Request/Response
VAE_ServiceAdaptationQoSControlInfo API	Subscribe_ServiceandQoSControlInfo	V2X application specific server	Subscribe/notify
	Notify_ServiceandQoSControlInfo		
VAE_VRUzoneManagement API	Subscribe_VRUzoneManagement operation	V2X application specific server	Subscribe/notify
	Notify_Enter/Leave		
VAE_V2PApplicationRequirement API	Request_V2PApplicationRequirement	V2X application specific server, V2X application specific client	Request/Response

The SEAL server(s) APIs available via SEAL-S reference point as specified in 3GPP TS 23.434 [6] are consumed by the V2X application specific server via the VAE server (acting as a VAL server) over the Vs reference point. When V2X application specific server invokes a SEAL server API via the VAE server over the Vs reference point, the VAE

server shall interact with the corresponding SEAL server over the SEAL-S reference point for the API invocation request and response.

NOTE: When V2X application specific server invokes a SEAL server API directly, the V2X application specific server acting as VAL server shall interact with the corresponding SEAL server over the SEAL-S reference point for the API invocation request and response as specified in 3GPP TS 23.434 [6].

Editor's note: Whether the VAE_DynamicGroup API is to be moved to SEAL is FFS.

10.2.2 VAE_MessageDelivery API

10.2.2.1 General

API description: This API enables the V2X application specific server to subscribe/unsubscribe to the VAE server and communicate with the VAE server to send and receive V2X messages to and from the V2X UEs (including V2X groups).

10.2.2.2 Deliver_DL_Message operation

API operation name: Deliver_DL_Message

Description: Delivers the V2X messages to the V2X UEs.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.4.2.1, 9.4.2.3.

Outputs: None.

See subclause 9.4.3 and subclause 9.4.4 for the details of usage of this API operation.

10.2.2.3 Deliver_UL_Message operation

API operation name: Deliver_UL_Message

Description: Delivers the uplink V2X messages from the V2X UEs to the V2X application specific server.

Known Consumers: V2X application specific server.

Inputs: None

Outputs: Refer subclause 9.4.2.4.

See subclause 9.4.5 for the details of usage of this API operation.

10.2.2.4 V2X_MessageDelivery_Subscribe operation

API operation name: V2X_MessageDelivery_Subscribe

Description: Subscribe to the VAE server for sending and receiving V2X messages.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.4.2.6.

Outputs: Refer subclause 9.4.2.7.

See subclause 9.4.6 for the details of usage of this API operation.

10.2.2.5 V2X_MessageDelivery_Unsubscribe operation

API operation name: V2X_MessageDelivery_Unsubscribe

Description: Unsubscribe to the VAE server for sending and receiving V2X messages.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.4.2.8.

Outputs: Refer subclause 9.4.2.9.

See subclause 9.4.6 for the details of usage of this API operation.

10.2.3 VAE_FileDistribution API

10.2.3.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to initiate file distribution to the V2X UEs.

10.2.3.2 Distribute_File operation

API operation name: Distribute_File

Description: Distributes files to the V2X UEs.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.5.2.

Outputs: Refer subclause 9.5.2.

See subclause 9.5.2 for the details of usage of this API operation.

10.2.4 VAE_ApplicationRequirement API

10.2.4.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to provide V2X application requirement to the underlying 3GPP network.

10.2.4.2 Reserve_NetworkResource operation

API operation name: Reserve_NetworkResource

Description: Provides V2X application requirement to underlying 3GPP network.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.11.2.1

Outputs: Refer subclause 9.11.2.2

See subclause 9.11.3 for the details of usage of this API operation.

10.2.4.3 Notify_NetworkResource operation

API operation name: Notify_NetworkResource

Description: Notify the result of network resource adaptation corresponding to the V2X application requirement.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.11.2.3

Outputs: None

See subclause 9.11.3 for the details of usage of this API operation.

10.2.5 VAE_DynamicGroup API

10.2.5.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to configure dynamic group information.

10.2.5.2 Configure_DynamicGroup operation

API operation name: Configure_DynamicGroup

Description: Configures the dynamic group information at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.12.2.2.

Outputs: Refer subclause 9.12.2.3.

See subclause 9.12.3 for the details of usage of this API operation.

10.2.5.3 Notify_DynamicGroup operation

API operation name: Notify_DynamicGroup

Description: Notify the dynamic group information (i.e. group member joins or leaves) at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.12.2.4.

Outputs: None.

See subclause 9.12.5 for the details of usage of this API operation.

10.2.6 VAE_ServiceContinuity API

10.2.6.1 General

API description: This API enables the VAE server to query whether the target VAE server can serve the GEO ID and V2X Service ID for service continuity.

10.2.6.2 Query_ServiceContinuity operation

API operation name: Query_ServiceContinuity

Description: Query the service continuity information.

Known Consumers: VAE server.

Inputs: Refer subclause 9.10.2.1.

Outputs: Refer subclause 9.10.2.2.

See subclause 9.10.3 for the details of usage of this API operation.

10.2.7 VAE_HDMapDynamicInfo API

10.2.7.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to subscribe and receive notifications for HD map dynamic information.

10.2.7.2 Subscribe_HDMapDynamicInfo operation

API operation name: Subscribe_HDMapDynamicInfo

Description: Subscribes for the HD map dynamic information at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.16.2.1.

Outputs: Refer subclause 9.16.2.2.

See subclause 9.16.3 for the details of usage of this API operation.

10.2.7.3 Notify_HDMapDynamicInfo operation

API operation name: Notify_HDMapDynamicInfo

Description: Notify the HD map dynamic information at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.16.2.3.

Outputs: None.

See subclause 9.16.6 for the details of usage of this API operation.

10.2.8 VAE_SessionOrientedService API

10.2.8.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to trigger establishment, update and termination of session-oriented service.

10.2.8.2 Establish_Session operation

API operation name: Establish_Session

Description: Triggers the establishment of the session-oriented service by the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.19.2.1.

Outputs: Refer subclause 9.19.2.2.

See subclause 9.19.4.2 for the details of usage of this API operation.

10.2.8.3 Notify_Establish_Session operation

API operation name: Notify_Establish_Session

Description: Notification about the establishment of the session-oriented service by the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.19.2.3.

Outputs: None.

See subclause 9.19.5.2 for the details of usage of this API operation.

10.2.8.4 Update_Session operation

API operation name: Update_Session

Description: Triggers the update to the session-oriented service by the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.19.2.4.

Outputs: Refer subclause 9.19.2.5.

See subclause 9.19.4.3 for the details of usage of this API operation.

10.2.8.5 Notify_Update_Session operation

API operation name: Notify_Update_Session

Description: Notification about the update to the session-oriented service by the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.19.2.6.

Outputs: None.

See subclause 9.19.5.3 for the details of usage of this API operation.

10.2.8.6 Terminate_Session operation

API operation name: Terminate_Session

Description: Triggers the termination of the session-oriented service by the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.19.2.7.

Outputs: Refer subclause 9.19.2.8.

See subclause 9.19.5.4 for the details of usage of this API operation.

10.2.8.7 Notify_Terminate_Session operation

API operation name: Notify_Terminate_Session

Description: Notification about the termination of the session-oriented service by the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.19.2.9.

Outputs: None.

See subclause 9.19.5.4 for the details of usage of this API operation.

10.2.9 VAE_PC5ProvisioningRequirement API

10.2.9.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to request from VAE server the PC5 provisioning service in multi-operator V2X scenarios.

10.2.9.2 Config_PC5ProvisioningRequirement operation

API operation name: Config_PC5ProvisioningRequirement

Description: The V2X application specific server provides a V2X PC5 provisioning requirement to the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.15.2.1

Outputs: Acknowledgement message.

See subclause 9.15.3 for the details of usage of this API operation.

10.2.9.3 Notify_PC5ProvisioningRequirement operation

API operation name: Notify_PC5ProvisioningRequirement

Description: Notify the result of multi operation PC5 provisioning requirement to the V2X UEs.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.15.2.6

Outputs: None

See subclause 9.15.3 for the details of usage of this API operation.

10.2.10 VAE_V2VConfigRequirement API

10.2.10.1 General

API description: This API enables the V2X application specific server to provide a V2V configuration requirement to the VAE server to manage the UE-to-UE broadcast/groupcast communication.

10.2.10.2 Request_V2VConfigRequirement operation

API operation name: Request_V2VConfigRequirement

Description: The V2X application specific server provides a V2V configuration requirement request to the VAE server to manage the UE-to-UE broadcast/groupcast communication.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.17.2.1

Outputs: Refer subclause 9.17.2.2

See subclause 9.17.3 for the details of usage of this API operation.

10.2.11 VAE_ ServiceAndQoSControlInfo API

10.2.11.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to subscribe and receive notifications for service adaptation and QoS control information.

10.2.11.2 Subscribe_ ServiceAndQoSControlInfo operation

API operation name: Subscribe_ ServiceAndQoSControlInfo

Description: Subscribes for the service adaptation and QoS control information at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.20.2.1.

Outputs: Refer subclause 9.20.2.2.

See subclause 9.20.3 for the details of usage of this API operation.

This service operation also enables to update/delete an existing subscription at the VAE server. For the update case, the parameters that may be updated are V2X group ID, V2X service ID, and V2X UE ID.

10.2.11.3 Notify_ ServiceAndQoSControlInfo operation

API operation name: Notify_ ServiceAndQoSControlInfo

Description: Notify the service adaptation and QoS control information at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.20.2.3.

Outputs: None.

See subclause 9.20.4 for the details of usage of this API operation.

10.2.12 VAE_ VRUzoneManagement API

10.2.12.1 General

API description: This API enables the V2X application specific server to communicate with the VAE server to subscribe and receive notifications for VRU zone management.

10.2.12.2 Subscribe_VRUzoneManagement operation

API operation name: Subscribe_VRUzoneManagement

Description: Subscribes for the VRU zone management / configuration at the VAE server.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.21.2.1.

Outputs: Refer subclause 9.21.2.2.

See subclause 9.21.3 for the details of usage of this API operation.

10.2.12.3 Notify_ Enter/Leave operation

API operation name: Notify_ Enter/Leave

Description: Notify the entry or leave of the V2X UE to / from the VRU zone area, based on the subscription.

Known Consumers: V2X application specific server.

Inputs: Refer subclause 9.21.2.4.

Outputs: None.

See subclause 9.21.3 for the details of usage of this API operation.

10.2.13 VAE_V2PApplicationRequirement

10.2.13.1 General

API description: This API enables the V2X application specific server or the V2X application specific client to communicate with the VAE server to provide a requirement to manage the support functionality for enabling V2P applications.

10.2.13.2 Request_V2PApplicationRequirement

API operation name: Request_V2PApplicationRequirement

Description: The V2X application specific server or client provides a V2P application requirement request to the VAE server to provide the support functionality for enabling V2P applications.

Known Consumers: V2X application specific server, V2X application specific client.

Inputs: Refer subclause 9.22.2.1.

Outputs: Refer subclause 9.22.2.2.

See subclause 9.22.3.1 and 9.22.3.2 for the details of usage of this API operation.

Annex A (informative): Detailed V2X application layer functional model

Figure A-1 illustrates the detailed V2X application layer functional model including all the functional entities of the VAE layer and the functional entities of the SEAL as specified in 3GPP TS 23.434 [6].

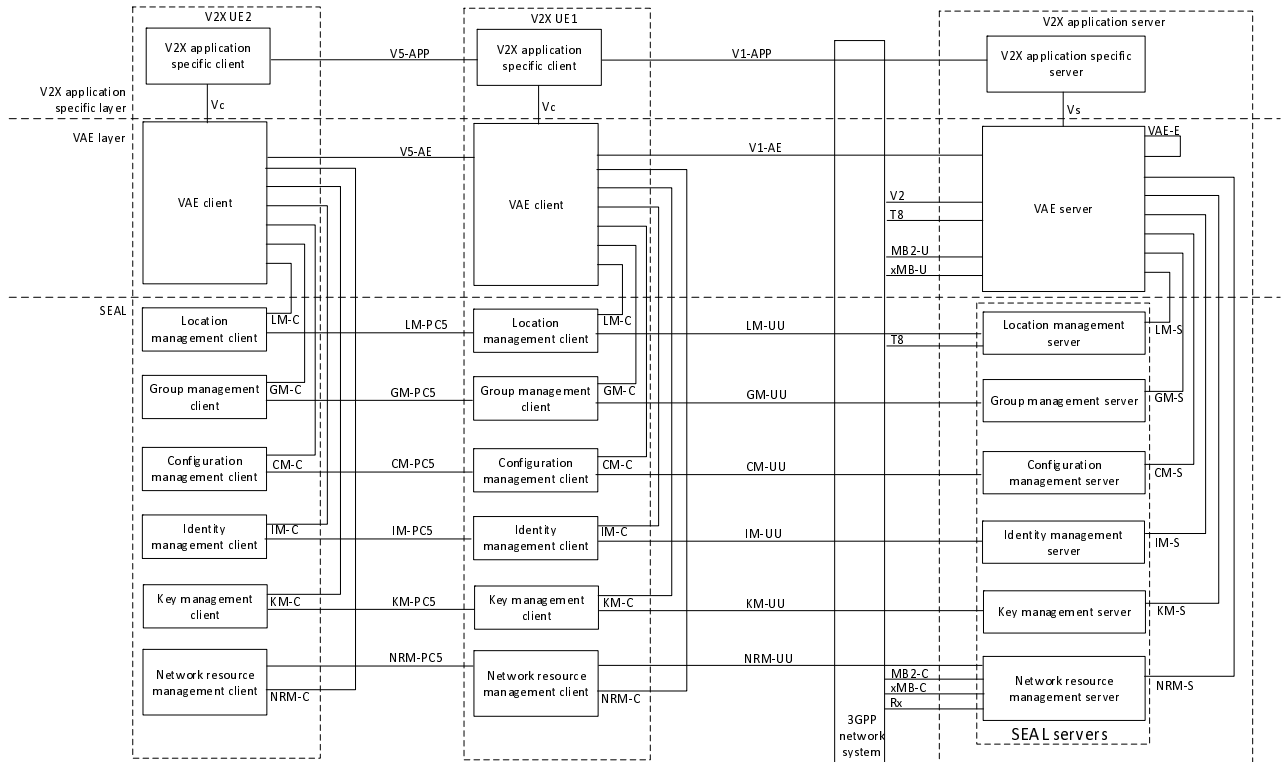


Figure A-1: Detailed V2X application layer functional model

Annex B (informative): Functionalities with SA2 dependency

B.1 Service negotiation with underlying 3GPP network

B.1.1 General

The following information flows for service negotiation with the 3GPP network are not supported in 3GPP TS 23.682 [8].

B.1.2 Information flows

B.1.2.1 Supporting information request

Table B.1.2.1-1 describes the information flow for a VAE server to provide the network with supporting information for service negotiation with the 3GPP network.

Table B.1.2.1-1: Supporting information request

Information element	Status	Description
Supporting Information	O	Indicating supporting information by the VAE server to increase the network awareness related to the service. Example of supporting information is planned/expected UE trajectory, which can be provided in the form of waypoints (GPS coordinates) and associated timestamps.

Editor's note: Reference to the appropriate SA2 specification is needed and corresponding information flow table can be removed.

Editor's note: Need to verify with SA2 specifications on the exact support provided to this feature.

B.1.2.2 Supporting information response

Table B.1.2.2-1 describes the information flow for a network to provide a response associated to a supporting information request.

Table B.1.2.2-1: Supporting information response

Information element	Status	Description
Result	M	Response from the network if supporting information is supported by the 3GPP network.

Editor's note: Reference to the appropriate SA2 specification is needed and corresponding information flow table can be removed.

B.1.2.3 Void

B.1.2.4 Void

B.1.3 Void

B.1.4 Void

B.2 Void

Annex C (normative): V2X application enabler related configuration data

C.1 General

This Annex provides information about the static data needed for configuration for the V2X application enabler service, which belongs to one of the following categories:

- VAE client configuration data (see subclause C.2); and
- VAE server configuration data (see subclause C.3).

C.2 VAE client configuration data

The procedure of VAE client related configuration are specified in 3GPP TS 23.434 [6]. Data in tables C.2-1 has to be known by the VAE client.

Data in table C.2-1 can be configured using the CM-UU reference point as specified in 3GPP TS 23.434 [6].

Table C.2-1: VAE client related configuration data

Reference	Parameter description
Clause 8.1 and clause 9.1.2.2	V2X user/UE identity
Clause 9.1.2.2	V2X service ID
Clause 9.1.2.2	V2X server USD
Clause 9.2.3 and Clause 9.1.2.3	IP address and port information of the initial VAE server serving the VAE client
Clause 9.3.3	GEO ID information

C.3 VAE server configuration data

The procedure of VAE server related configuration are specified in 3GPP TS 23.434 [6]. Data in tables C.3-1 has to be known by the VAE server.

Data in table C.3-1 can be configured using the CM-S reference point as specified in 3GPP TS 23.434 [6].

Table C.3-1: VAE server related configuration data

Reference	Parameter description
Clause 8.1	List of V2X user identities
Clause 9.7.4.2	IP address of the EPS entity SCEF
Clause 9.10.3.2	List of IP addresses of the neighboring VAE servers
Clause 9.11.3.2	IP address of the NRM server
Clause 9.12.3.2	Unique pool of ProSe Layer-2 Group IDs
Clause 9.5.2	BM-SC information

Annex D (normative): Utilization of edge computing

The application architecture for supporting edge applications are specified in 3GPP TS 23.558 [25]. The V2X application layer functional model as specified in clause 6 may be deployed in edge computing environment.

Figure D-1 illustrates a V2X application layer deployment in edge computing environments.

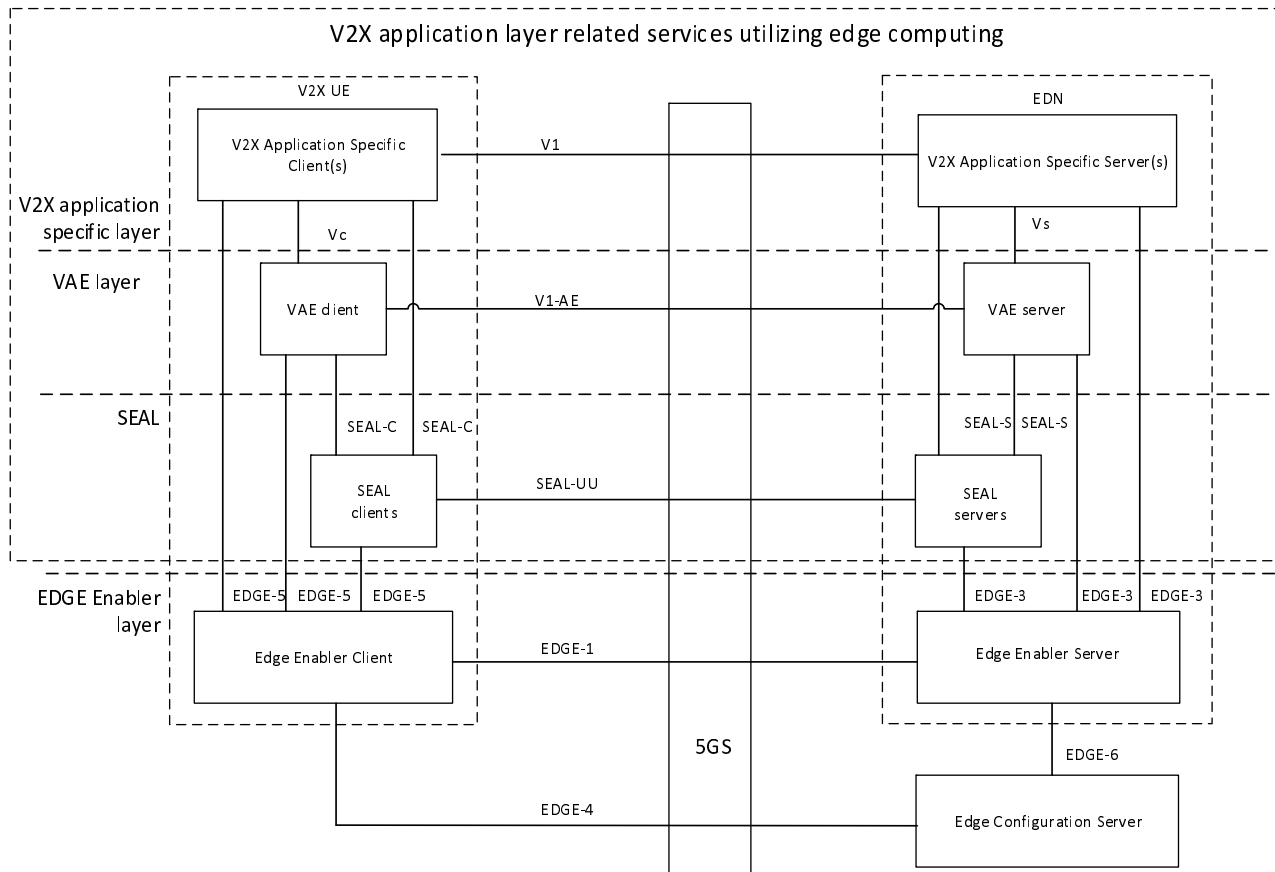


Figure D-1: Utilization of edge computing

Figure D-1 illustrates the utilization of edge computing for V2X application layer based on edge enabler layer specified in 3GPP TS 23.558 [25].

At UE side, V2X Application Specific client(s) and VAE client interact with the Edge Enabler Client (EEC) via EDGE-5 reference point. In an Edge Data Network (EDN), V2X Application Specific Server and VAE server assume the role of EAS (Edge Application Server) and interacts with the Edge Enabler Server (EES) via EDGE-3 reference point, for instance, to register its profile into the EES. Upon service provisioning, the EEC interacts with the EES via EDGE-1 reference point, for instance, to discover V2X Application Specific Server(s) and VAE Server and further the EEC provides the discovered V2X Application Specific Server(s) and VAE server to the V2X Application Specific client and VAE client respectively. The interactions between the entities and 5GS are not shown for the sake of simplicity.

In an EDN, there could be several EES(s) provided by the same or different ECSP. The V2X application specific server(s), VAE server(s) and SEAL servers (e.g. GMS, NRMS, ADAES) shall be able to discover and register into an appropriate EES. If CAPIF is used, this can be done by utilizing the AEF serving area and/or the AEF location as described in 3GPP TS 23.222 [x]; otherwise, local configuration of the EES endpoint may be used.

The services provided by EES over EDGE-3 are not re-exposed by the VAE server or SEAL servers to the V2X application specific server but are directly consumed by the SEAL servers, VAE server and V2X application specific server(s).

NOTE: This clause illustrates an example edge deployment using edge enabler layer and there can be other valid edge deployments enabled for V2X application layer.

Annex D: Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2018-10	SA6#26					TS skeleton	0.0.0
2018-10	SA6#26					Implementation of the following pCRs approved by SA6: S6-181488, S6-181489, S6-181490, S6-181548, S6-181549, S6-181554, S6-181555, S6-181556, S6-181575, S6-181576, S6-181583, S6-181589, S6-181591	0.1.0
2018-12	SA6#27					Implementation of the following pCRs approved by SA6: S6-181693, S6-181777, S6-181779, S6-181781, S6-181783, S6-181785, S6-181836, S6-181837, S6-181838, S6-181839	0.2.0
2019-01	SA6#28					Implementation of the following pCRs approved by SA6: S6-190137, S6-190144, S6-190219, S6-190221, S6-190222, S6-190223, S6-190224, S6-190271, S6-190298	0.3.0
2019-03	SA6#29					Implementation of the following pCRs approved by SA6: S6-190364, S6-190368, S6-190372, S6-190460, S6-190461, S6-190462, S6-190463, S6-190464, S6-190465, S6-190466, S6-190467, S6-190508	0.4.0
2019-03	SA#83	SP-190062				Presentation for information at SA#83	1.0.0
2019-04	SA6#30					Implementation of the following pCRs approved by SA6: S6-190641, S6-190643, S6-190644, S6-190651, S6-190652, S6-190755, S6-190756, S6-190757, S6-190758, S6-190760, S6-190762, S6-190827, S6-190828, S6-190829, S6-190830, S6-190831	1.1.0
2019-05	SA6#31					Implementation of the following pCRs approved by SA6: S6-191020, S6-191021, S6-191030, S6-191032, S6-191126, S6-191028, S6-191129, S6-191130, S6-191131, S6-191191133, S6-191136, S6-191138, S6-191139, S6-191194, S6-191195, S6-191196	1.2.0
2019-05	SA#84	SP-190472				Presentation for Approval at SA#84	2.0.0
2019-06	SA#84	SP-190472				MCC Editorial update for publication after TSG SA approval (SA#84)	16.0.0
2019-09	SA#85	SP-190734	0001	2	F	Remove EN GeoIDs	16.1.0
2019-09	SA#85	SP-190734	0002	3	F	Functionalities with SA2 dependency	16.1.0
2019-09	SA#85	SP-190734	0003		F	Update to functional model	16.1.0
2019-09	SA#85	SP-190734	0004	1	F	Update to network QoS and situation monitoring aligned with SA2	16.1.0
2019-09	SA#85	SP-190734	0005	2	F	Dynamic group API	16.1.0
2019-09	SA#85	SP-190734	0006	1	F	Correction to push layer-2 group ID mapping information flow	16.1.0
2019-09	SA#85	SP-190734	0007	4	F	Corrections on notifications for network monitoring procedure	16.1.0
2019-09	SA#85	SP-190734	0008	1	F	Addition of missing VAE server APIs	16.1.0
2019-09	SA#85	SP-190734	0009	1	F	Update the configurations information	16.1.0
2019-12	SA#86	SP-191112	0010	2	F	CR Message Delivery	16.2.0
2019-12	SA#86	SP-191112	0011		F	Update API names	16.2.0
2019-12	SA#86	SP-191112	0012	3	F	Update to uplink message delivery procedure	16.2.0
2020-03	SA#87-E	SP-200115	0013		F	Add VAE application requirement notification	16.3.0
2020-03	SA#87-E	SP-200115	0014	1	F	Add VAE service continuity API	16.3.0
2020-03	SA#87-E	SP-200115	0015	1	F	Correct Group Management procedure	16.3.0
2020-03	SA#87-E	SP-200115	0016	1	F	Align with TS 23.434	16.3.0
2020-03	SA#87-E	SP-200115	0017	1	F	Clarifications on V2X USD	16.3.0
2020-03	SA#87-E	SP-200115	0018	1	F	Correction of the usage of SEAL services by the V2X application specific server	16.3.0
2020-09	SA#89-E	SP-200842	0019		F	Correct Geo id	16.4.0
2020-09	SA#89-E	SP-200842	0020	1	F	Correction to de-registration procedure	16.4.0
2020-12	SA#90-E	SP-200992	0033	1	F	Clarifications for network monitoring information notification	16.5.0
2020-12	SA#90-E	SP-200998	0021	2	B	PC5 Provisioning in multi-operator V2X scenarios	17.0.0
2020-12	SA#90-E	SP-200998	0022	1	B	V2X application layer architecture enhancement	17.0.0
2020-12	SA#90-E	SP-200998	0023	1	B	Business relationships between V2X service providers	17.0.0
2020-12	SA#90-E	SP-200998	0024	1	B	V2X service discovery across multiple V2X service providers	17.0.0
2020-12	SA#90-E	SP-200998	0025	1	B	Support for HD map dynamic information	17.0.0
2020-12	SA#90-E	SP-200998	0026	1	B	Support CAPIF	17.0.0
2020-12	SA#90-E	SP-200998	0027	2	B	Support local MBMS	17.0.0
2020-12	SA#90-E	SP-200998	0028	2	B	UE-to-UE broadcast/groupcast configuration by VAE layer	17.0.0
2020-12	SA#90-E	SP-200998	0030	1	B	V2V communication mode switching	17.0.0
2020-12	SA#90-E	SP-200998	0031	1	B	Support for local MBMS delivery	17.0.0
2020-12	SA#90-E	SP-200998	0032	2	B	V2X UE registration enhancement	17.0.0
2020-12	SA#90-E	SP-200998	0034	2	B	Network monitoring procedure enhancement	17.0.0
2020-12	SA#90-E	SP-200998	0036	1	F	Clarifications for network monitoring information notification	17.0.0
2021-04	SA#91-E	SP-210182	0037	2	F	Clarifications on network monitoring	17.1.0
2021-04	SA#91-E	SP-210182	0038	1	B	Dynamic local service information in multiple V2X service provider	17.1.0
2021-04	SA#91-E	SP-210182	0039	1	B	UE initiated session oriented service	17.1.0
2021-04	SA#91-E	SP-210182	0040	1	B	Monitoring and control of QoS for eV2X communications	17.1.0
2021-04	SA#91-E	SP-210182	0041	2	B	Support for enhancements to V2X group management and group communication	17.1.0

2021-04	SA#91-E	SP-210182	0042	1	B	Session oriented services	17.1.0
2021-04	SA#91-E	SP-210182	0043		B	Update to VAE server APIs	17.1.0
2021-04	SA#91-E	SP-210182	0044		F	V2X UE identity	17.1.0
2021-06	SA#92-E	SP-210488	0046	2	F	Network resource management service of SEAL for V2X application	17.2.0
2021-06	SA#92-E	SP-210488	0049		D	Editorial changes for references	17.2.0
2021-06	SA#92-E	SP-210488	0049		B	Resolving editor notes in session oriented services	17.2.0
2021-06	SA#92-E	SP-210488	0054	1	F	Editorial corrections for HDMap feature	17.2.0
2021-06	SA#92-E	SP-210488	0055	1	B	Information flows and API definitions for session-oriented service	17.2.0
2021-06	SA#92-E	SP-210488	0056	1	B	Requirements for message distribution	17.2.0
2021-06	SA#92-E	SP-210488	0057	1	B	Alignment of Get V2X UE service discovery response with request	17.2.0
2021-06	SA#92-E	SP-210488	0058	1	B	Alignment of information flows for local service information	17.2.0
2021-06	SA#92-E	SP-210488	0060	1	B	Resolve EN on V2X groupcast/broadcast configuration	17.2.0
2021-06	SA#92-E	SP-210488	0061	1	B	Resolve EN on PC5 provisioning for multi-operator V2X services	17.2.0
2021-06	SA#92-E	SP-210488	0062	1	B	Update of VAE server APIs	17.2.0
2021-06	SA#92-E	SP-210488	0064		B	Updates to usage of SEAL for V2X application layer	17.2.0
2021-09	SA#93-E	SP-210965	0066	2	F	Clarifications for RAT Type usage in network monitoring procedure	17.3.0
2021-09	SA#93-E	SP-210965	0067		F	Clarifications for RAT Type usage in network monitoring procedure	17.3.0
2021-09	SA#93-E	SP-210965	0068		F	Alignment with SEAL key management	17.3.0
2021-09	SA#93-E	SP-210965	0069	1	F	Corrections to HDMap procedures	17.3.0
2022-06	SA#96	SP-220474	0071	1	F	Add location reference in HDmap	17.4.0
2022-12	SA#98-e	SP-221252	0072	2	B	V2X application layer architecture support for edge deployments	18.0.0
2022-12	SA#98-e	SP-221252	0073	2	C	Enhancement to network monitoring	18.0.0
2022-12	SA#98-e	SP-221252	0074	2	B	Support for VRU zone configuration and operation	18.0.0
2023-03	SA#99	SP-230298	0075	1	B	VAE support for Energy Efficient V2P communications	18.1.0
2023-03	SA#99	SP-230298	0076		B	Adding information flows and editorial corrections	18.1.0
2023-06	SA#100	SP-230716	0077		B	VAE client enabled V2P communication schedule configuration	18.2.0
2023-09	SA#101	SP-231011	0078		F	Add VAE server API in clause 10	18.3.0
2023-12	SA#101	SP-231574	0080	2	F	Correction for VAE server APIs General	18.4.0

History

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