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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Services and System Aspects;

Study on application layer support for V2X services;

(Release 16)

** 

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# Foreword

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

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# 1 Scope

The present document is a technical report which identifies the application architecture aspects to support V2X services, and corresponding architectural solutions. The study includes identifying architecture requirements that are necessary to ensure efficient use and deployment of V2X services over 3GPP systems.

The study takes into consideration 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 [8], as well as V2X application standards defined outside 3GPP.

This document will provide recommendations for normative work.

# 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 22.804: "Study on Communication for Automation in Vertical domains (CAV)".

[5] 3GPP TR 22.886: "Study on enhancement of 3GPP Support for 5G V2X Services".

[6] 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description".

[7] 3GPP TS 23.280: "Common functional architecture to support mission critical services; Stage 2".

[8] 3GPP TS 23.285: "Architecture enhancements for V2X services".

[9] 3GPP TS 23.303: "Proximity-based services (ProSe); Stage 2".

[10] 3GPP TS 23.468: "Group Communication System Enablers for LTE (GCSE\_LTE); Stage 2".

[11] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[12] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2"

[13] 3GPP TS 23.682: "Architecture enhancements to facilitate communications with packet data networks and applications".

[14] 3GPP TR 23.780: "Study on Multimedia Broadcast and Multicast Service (MBMS) usage for mission critical communication services".

[15] 3GPP TS 26.238: "Uplink Streaming".

[16] 3GPP TS 24.386: "User Equipment (UE) to V2X control function; protocol aspects; Stage 3".

[17] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".

[18] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".

[19] 3GPP TS 26.347: "Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL".

[20] 3GPP TS 26.348: "Northbound Application Programming Interface (API) for Multimedia Broadcast/Multicast Service (MBMS) at the xMB reference point".

[21] 3GPP TS 28.530: "Management of 5G networks and network slicing; Concepts, use cases and requirements".

[22] 3GPP TS 29.214: "Policy and Charging Control over Rx reference point".

[23] 3GPP TS 29.468: "Group Communication System Enablers for LTE (GCSE\_LTE); MB2 Reference Point; Stage 3".

[24] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[25] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[26] 3GPP TS 36.443: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); M2 Application Protocol (M2AP)".

[27] ETSI TS 102 723-8 (V1.1.1): "Intelligent Transport Systems (ITS); OSI cross-layer topics; Part 8: Interface between security entity and network and transport layer".

[28] ETSI TS 102 940 (V1.3.1): "Intelligent Transport Systems (ITS); Security; ITS communications security architecture and security management".

[29] ETSI TS 103 097 (V1.3.1): "Intelligent Transport Systems (ITS); Security; Security header and certificate formats".

[30] ETSI TS 103 301 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services".

[31] ETSI EN 302 637-2 (V1.3.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

[32] ETSI EN 302 637-3 (V1.2.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

[33] ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications Architecture".

[34] IEEE 1609.0-2013: "IEEE Guide for Wireless Access in Vehicular Environments (WAVE) architecture".

[35] International Organization for Standards, ISO 21217:2014: "Intelligent transport systems -- Communications access for land mobiles (CALM) – Architecture", <https://www.iso.org/standard/61570.html>.

[36] International Organization for Standards, ISO/DIS 17515-3: " Intelligent transport systems -- Evolved-universal terrestrial radio access network -- Part 3: LTE-V2X", <https://www.iso.org/standard/73238.html>.

[37] SAE International, SAE J3016: "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles", <https://www.sae.org/standards/content/j3016>.

[38] SAE International, SAE J2945/3: "Requirements for V2I Weather Applications", <https://www.sae.org/standards/content/j2945/3>.

[39] SAE International, SAE J2945/4: "DSRC Messages for Traveler Information and Basic Information Delivery", <https://www.sae.org/standards/content/j2945/4>.

[40] SAE International, SAE J2945/6: "Performance Requirements for Cooperative Adaptive Cruise Control and Platooning", <https://www.sae.org/standards/content/j2945/6>.

[41] SAE International, SAE J3161: "On-Board System Requirements for LTE V2X V2V Safety Communications", <https://www.sae.org/standards/content/j3161.>

# 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].

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.285 [8] apply:

**Intelligent Transport Systems**

**Road Side Unit**

**Geographical Area**

## 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].

5G 5th Generation

5GS 5G System

AN Access Network

AS Application Server

BM-SC Broadcast-Multicast Service Centre

BTP Basic Transport Protocol

CAM Cooperative Awareness Message

CoR Category of Requirements

DANE DASH Aware Network Element

DENM Decentralized Environmental Notification Message

E-UTRAN Evolved Universal Terrestrial Radio Access Network

ECGI E-UTRAN Cell Global Identifier

EPS Evolved Packet System

ETSI European Telecommunications Standards Institute

FLUS Framework for Live Uplink Streaming

GCS Group Communication System

IMA Intersection Movement Assist

ITS Intelligent Transport Systems

LoA Level of Automation

LTA Left Turn Assist

LTE Long-Term Evolution

MBMS Multimedia Broadcast Multicast Service

MBSFN Multimedia Broadcast multicast service Single Frequency Network

MCE MBMS Coordination Entity

MCH Multicast Channel

MSI MCH Scheduling Information

OEM Original Equipment Manufacturer

OSI Open System Interconnect

PCF Policy Control Function

PCRF Policy and Charging Rules Function

PLMN Public Land Mobile Network

QCI QoS Class Identifier

QoE Quality of Experience

QoS Quality of Service

RAN Radio Access Network

RSU Road Side Unit

SAE Society of Automotive Engineers

SAI Service Area Identifier

SAND Server and Network Assisted DASH

SC-PTM Single Cell Point To Multipoint

SDO Standards Development Organization

SIPTO Selected IP Traffic Offload

TMGI Temporary Mobile Group Identity

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

WAVE Wireless Access in Vehicular Environments

# 4 Analysis of V2X standards

## 4.1 3GPP V2X service requirements

### 4.1.1 Description

The V2X service requirements are specified in 3GPP TS 22.185 [2] and 3GPP TS 22.186 [3].

The V2X service requirements specified in 3GPP are identified by taking into account the V2X service requirements defined in other SDOs, e.g. ETSI ITS, US SAE.

The following types of V2X applications are addressed:

- Vehicle-to-Vehicle (V2V);

- Vehicle-to-Infrastructure (V2I);

- Vehicle-to-Network (V2N); and

- Vehicle-to-Pedestrian (V2P).

The following V2X scenarios are addressed:

- Safety-related V2X scenarios: e.g. automated driving, vehicle platooning

- Non-safety-related V2X scenarios: e.g. mobile high data rate entertainment, mobile hotspot/office/home, dynamic digital map update

A relevant aspect of advanced V2X applications is the Level of Automation (LoA), which reflects the functional aspects of the technology and affects the system performance requirements. The following LoA are defined by SAE J3016 [37]:

- 0 – No Automation;

- 1 – Driver Assistance;

- 2 – Partial Automation;

- 3 – Conditional Automation;

- 4 – High Automation; and

- 5 – Full Automation.

### 4.1.2 Analysis

Table 4.1.2-1 lists the 3GPP specifed V2X service requirements which may have impact on V2X application layer. The requirements are grouped by functional areas.

Table 4.1.2-1: 3GPP V2X service requirements which may have impact on V2X application layer

|  |  |  |
| --- | --- | --- |
| Sl. | Reference | V2X service requirement description |
| 1 | Network situation | |
| 1.1 | Subclause 5.1 of 3GPP TS 22.185 [2] | General message transmission related requirements in [R-5.1-001], [R-5.1-006], [R-5.1-007] and [R-5.1-008] corresponds to application needs for QoS required for V2X communications |
| 1.2 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-015] corresponds to V2X application knowledge of network attachment by the V2X UE |
| 2 | Configurations | |
| 2.1 | Subclause 5.1 of 3GPP TS 22.185 [2] | Configuration related requirements in [R-5.1-002] and [R-5.1-006] corresponds to enablement of configurations of V2X UE, V2X application server, RSU |
| 3 | Messaging | |
| 3.1 | Subclause 5.1 of 3GPP TS 22.185 [2] | Requirements for RSU controlling the message transmission area in [R-5.1-011] corresponds to supporting V2I application messaging. |
| 3.2 | Subclause 5.1 of 3GPP TS 22.185 [2] | Requirements for application server controlling the message transmission area in [R-5.1-011a] corresponds to supporting V2N application messaging |
| 3.3 | Subclause 5.1 of 3GPP TS 22.185 [2] | Requirements for supporting V2X application messaging as per the resource constraints on the UE in [R-5.1-014]. |
| 3.4 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-002] corresponds to group communication based on proximity as per V2X application needs |
| 3.5 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-003] corresponds to group management for V2X applications |
| 3.6 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-004] corresponds to group communications amongst the V2X UEs |
| 3.7 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-005] corresponds to one-to-one communications between UEs in a group |
| 3.8 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-013] corresponds to one-to-one and group communication between UEs belonging to different PLMN networks |
| 3.9 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-016], [R-5.1-017], [R-5.1-018] correspond to supporting UE-to-Network relay to enable V2X communications |
| 3.10 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-022] corresponds to V2X application usage of suitable group management and communications for a RSU |
| 3.11 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-001] corresponds to conveying V2X application layer message characteristics |
| 4 | Location | |
| 4.1 | Subclause 5.1 of 3GPP TS 22.185 [2] | Requirements for location accuracy support to V2X UEs in [R-5.1-015] |
| 4.2 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-007] corresponds to V2X application layer usage of relative lateral position |
| 5 | Discovery | |
| 5.1 | Subclause 5.2.1 and subclause 5.2.2 of 3GPP TS 22.185 [2] | Requirements for latency/reliability and message size. |
| 5.2 | Subclause 5.2.5 of 3GPP TS 22.185 [2] | Requirements for supporting UEs travelling in high speeds |
| 5.3 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-014] corresponds to discovery of the UEs belonging to the same V2X application |
| 5.4 | Subclause 5.1 of 3GPP TS 22.186 [3] | General requirements in [R-5.1-024] corresponds to discovery of the V2X application server |
| 6 | Vehicle platooning | |
| 6.1 | Subclause 5.2 of 3GPP TS 22.186 [3] | Requirements to support vehicle platooning in [R.5.2-004], [R.5.2-005], [R.5.2-006], [R.5.2-007] |
| 7 | Extended sensors | |
| 7.1 | Subclause 5.4 of 3GPP TS 22.186 [3] | Requirements to support extended sensors in [R.5.4-001], [R.5.4-002], [R.5.4-003], [R.5.4-004], [R.5.4-005], [R.5.4-006], |

## 4.2 3GPP EPS architecture for V2X communications

### 4.2.1 Description

The V2X architecture, functional entities to facilitate vehicular communications for Vehicle-to-Everything (V2X) services, which includes Vehicle-to-Vehicle (V2V), Vehicle-to-Pedestrian (V2P), Vehicle-to-Infrastructure (V2I), and Vehicle-to-Network (V2N) are specified based on EPS in 3GPP TS 23.285 [8].

NOTE: Analysis of 3GPP 5GS architecture for V2X communications is out of scope of the present document.

### 4.2.2 Analysis

The following reference points described in 3GPP TS 23.285 [8] have V2X application layer impact:

1. V1: The reference point between V2X application in the UE and the V2X application server. This reference point is considered out of scope of 3GPP TS 23.285 [8].

2. V2: The reference point between the V2X Application Server and the V2X Control Function in the operator's network. The V2X Application Server may connect to V2X Control Functions belonging to multiple PLMNs. V2 is used by V2X control function for obtaining PC5 configuration parameters for V2X communications, from the V2X Application Server.

3. V3: The reference point between the UE and the V2X Control Function in UE's home PLMN. It is applicable to both PC5 and LTE-Uu based V2X communication and optionally MBMS and LTE-Uu based V2X communication. V3 is used by V2X control function for provisioning V2X configuration parameters to the UE.

4. V5: The reference point between the V2X applications in the UEs. This reference point is considered out of scope of 3GPP TS 23.285 [8].

NOTE: The PC5 parameters provisioned by the V2X control function over V3 take precedence over the PC5 parameters provisioned over V1 on the V2X UE as specified in 3GPP TS 23.285 [8].

The following high level functions specified in 3GPP TS 23.285 [8] have V2X application layer impact:

1. Authorization and provisioning for V2X communications over PC5 reference point

2. V2X message transmission/reception over PC5 reference point

3. V2X message transmission/reception over LTE-Uu reference point

4. V2X Application Server discovery

5. QoS handling for V2X communication

6. MBMS bearer announcement for V2X use

7. Support for V2X communication for UEs in limited service state

8. V2X communication in roaming scenarios (home routing and local break-out of SIPTO type)

9. V2X Message Distribution Server deployments

## 4.3 ETSI ITS communication architecture and requirements

### 4.3.1 Description

This subclause considers the specifications related to facilities layer which have impact on the V2X application support layer for analysis.

The ITS station reference architecture follows the principles of the OSI model and the communication protocol stack is specified in ETSI EN 302 665 [33] consisting of:

- Access layer;

- Networking and transport layer;

- Facilities layer; and

- Applications layer.

The facilities layer protocols and communication requirements most commonly used are specified in ETSI EN 302 637‑2 [31], ETSI EN 302 637-3 [32], and ETSI TS 103 301 [30]. Those services provide application support to construct, manage and process messages distributed between end users or between infrastructure and end-users based on payload received from the V2X application(s).

### 4.3.2 Analysis

The facilities layer acts as the application support layer between the networking and transport layer and the application layer. The facilities layer provides generic messaging support for the application layer and thus is not meant to address transport issues such as optimized use of LTE-Uu and PC5 communications of the 3GPP network systems (EPS/5GS). The solutions in the present document can be utilized by the facilities layer to enhance the interaction with the 3GPP system. The network and transport layers are the appropriate ITS layers that could be aware of the physical interface between communication endpoints to enable tightly coupled operation.

## 4.4 SAE and related standards communication architecture and requirements

### 4.4.1 Description

This subclause analyzes the SAE and related specifications for message and facilities layers which may have impact on the V2X application support.

The WAVE ITS station reference architecture in IEEE 1609.0 [34] follows the principles of the OSI model and the communication protocol stack is specified in ISO 21217:2014 [35], consisting of:

- Access layer;

- Networking and transport layer;

- Message layer or Facilities layer; and

- Applications layer.

The message layer (SAE/IEEE) or facilities layer (ISO) protocols and communication requirements most commonly used are specified in current standards SAE J2945/3 [38], SAE J2945/4 [39], and SAE J2945/6 [40] as well as ISO 21217:2014 [35].  Those services provide application support to construct, manage and process messages distributed between end users or between infrastructure and end-users based on payload received from the V2X application(s). Upper layer standards in SAE as well as ISO are currently being adapted to work with C-V2X as specified in SAE J3161 [41] and ISO/DIS 17515-3 [36].

### 4.4.2 Analysis

The message/facilities layer acts as the application support layer between the networking and transport layer and the application layer. The message/facilities layer provides generic messaging support for the application layer and thus is not meant to address transport issues such as optimized use of LTE-Uu and PC5 communications of the 3GPP network systems (EPS/5GS). The solutions in the present document can be utilized by the message/facilities layer to enhance the interaction with the 3GPP system. The network and transport layers are the appropriate WAVE/ITS layers that could be aware of the physical interface between communication endpoints to enable tightly coupled operation.

# 5 Key issues

## 5.1 Key issue 1 - Communication of V2X application QoS requirements with 3GPP systems

### 5.1.1 General

The V2X services described in 3GPP TS 22.186 [3], require ultra-reliable and low latency characteristics, and may require high data rates due to the very high expected payloads. The Categories of Requirements (CoR) and Level of Automation (LoA) is defined, which reflects the functional aspects of the technology and affects the system performance requirements.are defined to support such V2X scenarios.

The following CoRs are defined:

- General Aspects;

- Vehicle Platooning;

- Advanced Driving;

- Extended Sensors; and

- Remote Driving.

The following LoAs are defined:

- No Automation (0);

- Driver Assistance (1);

- Partial Automation (2);

- Conditional Automation (3);

- High Automation (4); and

- Full Automation (5).

For the combination of each CoR scenario and each degree of LoA, requirements are specified in terms of Payload (Bytes), Transmission rate (Message/Sec), Maximum end-to-end latency (ms), Reliability (%), Data rate (Mbps), Minimum required communication range (meters).

V2X scenarios are delay and reliability critical while the rate (and thus the resource) requirement may vary for each CoR and LoA, since they may support different payloads (from 300 B to 12000 B) under the strict delay requirement. Also, different CoR and LoA combination may require different QoS parameters (even for the same V2X application, e.g. platooning). This poses additional challenges regarding the accommodation of QoS and resource requests by 3GPP systems from numerous and resource demanding services.

### 5.1.2 Key issue 1a - Communication of V2X application network QoS requirements with 3GPP systems

Some V2X scenarios are group-based communications (e.g. platooning); hence a request for resources may involve numerous users, possibly in different cells or even different systems. The request for QoS and resource allocations may need to be satisfied jointly for all users (or a specified set of users) within a short amount of time, considering the fact that 3GPP systems (EPS, 5GS) are expected to accommodate significant load by other requests requiring resources. Furthermore, if the request is not entirely successful, the request cannot result in any resources being held temporarily, as those resources may need to be available to other requests. To this end, it may be also necessary to queue for resources while resolving potential congestions.

In stage 2 specification, 3GPP TS 23.285 [8], the QoS handling for V2X communication over LTE Uu reference point specifies the use of:

- QCI 3 and QCI 79 for unicast delivery for V2X messages.

- QCI 75 for multicast delivery of V2X messages.

The V2X application, due to the different LoA options (1-5) and different modes of operation (e.g. unicast vs multicast broadcast) may require to change the QoS and resource demand un-predictably (e.g. LoA adjustment due to application demand), so the 3GPP systems needs to be able to adapt fast and decide accordingly whether it can fulfill the new requirement for all users (or a specified set of users).

Given the aforementioned considerations and the increased complexity of scenarios and the wider variety of requirements, it is required to further study the following aspects:

- Abstract the knowledge of network QoS to the applications.

- Whether the capability provided by the core network to the V2X application for allocation of unicast and multicast resources is sufficient.

### 5.1.3 Key issue 1b - Communication of V2X application PC5 QoS requirements with 3GPP systems

In stage 2 specification, 3GPP TS 23.303 [9], the QoS handling over PC5 is achieved by ProSe Per-Packet Priority selected by the application layer (based on criteria that are outside the scope of 3GPP TS 23.303 [9]) from a range of 8 possible values.

It is required to further study the following aspects:

- Defining ProSe Per-Packet Priority usage for V2X communication over PC5.

## 5.2 Key issue 2 - Monitoring network situation of 3GPP systems by V2X application

In a V2X scenario, for a given CoR, the LoA can be adjusted in the range between 1 and 5 and this adjustment in LoA may be a result of a particular network situation (e.g. congestion). The V2X application may monitor the network situation and adapt the LoA for a given CoR corresponding to a V2X scenario. This change in LoA should also be communicated to the V2X UE by the V2X application server.

This aspect where V2X application server is capable to adjust the LoA for single or specified sets of users of the same service (e.g. platooning), by monitoring the network situation (e.g. network load) and communicating the change of LoA with V2X UE over V1 reference point is currently not addressed in 3GPP TS 23.285 [8].

The ability to provide the V2X application with the 3GPP network conditions (e.g. network load) and the aspect of communicating the change of LoA to the V2X UE requires further study.

## 5.3 Key issue 3 - V2X USD provisioning via V1 reference point

In 3GPP TS 23.285 [8], the V2X USD is used for receiving MBMS based V2X traffic. As it is stated in 3GPP TS 23.285 [8], there are three approaches for the V2X USD provisioning as follows:

*"- Provided with V2X USDs for receiving MBMS based V2X traffic via existing MBMS service announcement mechanisms, or provisioned from V2X Control Function, or provisioned from the V2X Application Server via V1 reference point"*

*"To provide the UE with the V2X USD(s), the following ways may be used:*

*- Existing MBMS service announcement mechanisms specified in TS 23.246 [8] and TS 26.346 [11].*

*- Provisioning as described in clause 4.4.1.2.2, i.e. pre-configuration in the UE and/or configuration from V2X Control Function.*

*- Provisioning from the V2X Application Server via V1 reference point"*

As one of the V2X USD provisioning options, the implementation of provisioning via V1 reference point is not defined as it is outside the scope of SA2.

Gap:

- How to implement the option of provisioning the V2X USD from the V2X application server via V1 reference point.

## 5.4 Key issue 4 - Local service information

The V2X application server discovery related information is specified in subclause 4.4.1.2.2 of 3GPP TS 23.285 [8] and V2X application discovery procedure is specified in subclause 5.4.1 of 3GPP TS 23.285 [8]. The V2X application server discovery via MBMS is shown below.



Figure 5.4-1: V2X application server discovery using broadcast as specified in 3GPP TS 23.285 [8]

The local service information in step 2 includes the V2X application server discovery parameters defined in subclause 4.4.1.2 and subclause 4.4.7.3 of 3GPP TS 23.285 [8].

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. However, it is not specified in SA2 how to deliver local service information to V2X UE.

Gap:

- It is for further study how to deliver local service information at the application layer.

## 5.5 Key issue 5 - Service continuity during MBMS based V2X traffic

In 3GPP TS 23.285 [8], V2X communication can be delivered over unicast or MBMS. The service continuity issue including transferring V2X traffic from MBMS to unicast is to be considered. The V2X service interruption due to high speed mobility should be minimized. This key issue refers to the key issue#1 in 3GPP TR 23.780 [14] with the difference that V2X application server is the instance of GCS AS.

The different use cases can be described as follows:

1. The V2X UE moves from one cell to another within the same MBSFN area. Both cells are contributing to the MBSFN transmission. This mobility case is supported in current RAN specification, see subclause 15.4 in 3GPP TS 36.300 [24].

2. The V2X UE moves from one MBSFN area to another MBSFN area. In this scenario both MBSFN areas are transmitting on the same MBMS bearer, i.e. the same TMGI. MBSFN area 1 and MBSFN area 2 may use different frequencies. In this mobility case the V2X UE detects bad reception from MBSFN area 1 and triggers a transfer to unicast. After some time the V2X UE will detect the MBSFN area 2 transmission and return to reception over MBMS. In this scenario it is not possible to avoid going to unicast.

3a. The V2X UE moves from one MBMS service area to another MBMS service area. In this scenario, the two MBMS service area transmissions use different MBMS bearers i.e. different TMGI. Furthermore a specific V2X group communication is not required to be transmitted in both MBMS service areas. In this mobility case the V2X UE detects bad reception from MBSFN area 2 and triggers a transfer to unicast. After some time the V2X UE will detect the MBSFN area 3 transmission and if the same V2X group communication is transmitted in the new area the V2X UE will return to reception over MBMS. In this scenario it is not possible to avoid going to unicast.

3b. The V2X UE moves from one MBMS service area to another MBMS service area. In this scenario the two MBMS service area transmissions use different MBMS bearers with the same TMGI, separated by the application with the use of different flow IDs. The flow IDs is not visible to the UE.

4. The V2X UE moves out from an MBSFN area to a new cell that is not transmitting over MBMS. This service continuity use case is defined in 3GPP TS 23.468 [10].

5. The UE A moves out of coverage and uses UE-R as a UE-to-network relay UE. In this scenario the UE A moves from in coverage and listening to an MBMS bearer to out of coverage but remains in on-network by using UE-R as a relay. There is currently no service continuity procedure defined for this scenario.

The key issue described is the service continuity issues in use case 2 and use case 3 according to the description above.

**

Figure 5.5-1: Service continuity use cases

Gaps:

- The MBMS listening status report about the MBMS reception quality for V2X service is missing;

- The switching of MBMS bearer to unicast over V1 reference points for V2X service is missing; and

- Evaluate whether the existing solution to key issue#1 in 3GPP TR 23.780 [14] can be resued for V2X services.

## 5.6 Key issue 6 - Handling MBMS bearer suspension

In Rel-12, 3GPP has introduced the capability of automatically suspending (pre-empting) / resuming MBMS bearers in case of MBMS congestion. Some signalling procedures are specified (see 3GPP TS 36.321 [25], 3GPP TS 36.443 [26], and 3GPP TS 23.468 [10]) to notify the UEs of MBMS bearer suspension and to allow the UEs to notify the application server. Currently the efficient handling of MBMS bearer suspension/resumption by the V2X application server has not been considered.

This key issue includes the following aspects for further study:

- How the V2X application server acquires the MBMS bearer suspension.

- Efficient signalling of MBMS bearer suspension / resumption over V1 reference point.

- Minimized V2X services impact of MBMS bearer suspension, especially in the case of high connection density for congested traffic.

- Efficient application recovery from conditions of MBMS congestion and MBMS bearer suspension.

## 5.7 Key Issue 7 - V2X UE capabilities reporting

This key issue refers to the key issue#8 in 3GPP TR 23.780 [14] with the difference that V2X application server is the instance of GCS AS.

The V2X application server acts as the instance of GCS AS. In LTE based MBMS, two MBMS delivery mode named SC-PTM and MBSFN are defined. In current specifications, the GCS AS is responsible for making the decision to use MBMS or not, while the MCE is responsible for selecting the MBMS delivery mode. In both entities, the UE's supporting MBMS delivery mode is missing to make the decision, which may cause the case that GCS AS determines to use MBMS with MCE determining the MBMS delivery mode that most of UEs do not support, then the UEs can not receive the traffic via MBMS. To achieve the coherent MBMS operation, the following information should be made available to the GCS AS, e.g.

- The MBMS mechanism selected by the MCE (if it has already selected);

- The UE's support of the MBMS mechanism(s); and

- The eNB cell the UE is located.

Gap:

- How to coordinate MBMS operation between V2X UE, V2X application server and MCE.

- Evaluate whether the existing solution to key issue#8 in 3GPP TR 23.780 [14] can be reused for V2X services.

## 5.8 Key issue 8 - PC5 parameters provisioning over V1

Currently, the PC5 based discovery and communication parameters specified in sub clause 4.4.1.1 of 3GPP TS 23.285 [8] are pre-configured at the UE or provisioned by the V2X control function, which may not be sufficient for the business model that the V2X application server is dominated by 3rd party e.g., vehicle OEM, and the 3rd party would like to provide the PC5 parameters directly to the V2X application client located in the V2X UE. 3GPP TS 23.285 [8] also indicates that these parameters may be configured on the UE through the V1 reference point from the V2X Application Server. To support this business model, the provisioning PC5 based discovery and communication parameters over V1 is for further study.

Gap:

- Evaluate whether the existing provisioning mechanisms for PC5 based discovery and communication parameters are sufficient where the V2X application server is deployed by a 3rd party; and

- Study how to provision PC5 based discovery and communication parameters over V1 reference point.

## 5.9 Key issue 9 – V2X group communication

The existing one-to-many ProSe direction communication in 3GPP TS 23.285 [8] is mainly designed for safety V2X application such as Intersection Movement Assist (IMA), Left Turn Assist (LTA). In those use cases, the V2V messages have to be exchanged with all the other vehicles around. Therefore, the Layer-2 ID used for one-to-many ProSe direct communication is configured per V2X services.

However, when it comes to platooning scenario, the situation is different. Some messages for platoon management and coordination, e.g., vehicles of the platoon need to exchange information regarding when to take which road, whether to brake or accelerate and when, etc., should be exchanged only within the platoon. In Uu-based V2X communication, the V2X application server will guarantee that those messages are only sent to the platoon members. But in PC5-based V2X communication, the existing preconfigured Layer-2 ID per V2X service in 3GPP TS 23.285 [8] is not enough. Because the platoon member has to differentiate the messages only for its own platoon and from other vehicles or platoons. In fact, ProSe Layer-2 Group ID is specified in 3GPP TS 23.303 [9], but it is only used for public safety off-network group commination. Further study is needed to support V2X group communication in following aspects:

- Support the platoon specific ProSe Layer-2 Group ID.

- How to maintain the mapping of ProSe Layer-2 Group ID and V2X application group.

- How to deliver the mapping of ProSe Layer-2 Group ID and V2X application group to V2X UE.

## 5.10 Key issue 10 – UE location report over V1

In 3GPP TS 23.285 [8], in order to support V2X communication with MBMS, V2X application server acts as the GCS AS. The V2X application server performs the related functions and procedures as defined in 3GPP TS 23.468 [10], and maps UE provided location information to a form that is understood by the 3GPP MBMS system (e.g. MBMS SAI(s), ECGI(s)). The UE may provide its geographic location information in the V2X message and Cell ID information in the signalling to the V2X application server over V1 reference point. However, V1 reference point is outside scope of 3GPP SA2.

How to report the UE location (e.g. MBMS SAI(s), ECGI(s)) in the signalling over V1 reference point for MBMS based V2X communication requires further study.

## 5.11 Key issue 11 - Support for uplink video streaming

Uplink video streaming from multiple UEs is required for several V2X applications as detailed in 3GPP TS 22.186 [3] and 3GPP TR 22.804 [4].

While traditional approaches consider the processing of camera images inside the vehicle, the post-processing can take place inside the network or at an application server outside the 3GPP system as illustrated in 3GPP TR 22.804 [4]. This allows to offload complex operations from the vehicle and provides the external server with more detailed view of the road situation as compared to sending only selected features from the processed data. The mobile network should provide the uplink capacity to upload the images and videos. The post-processing module is responsible for analysing the images coming from multiple cameras.

The present document defines an application layer model for supporting interaction between a VAE client and a VAE server. To support uplink video streaming use-cases multiple clients connected to different PLMNs need to communicate with the V2X server.

The key issue should study the VAE capabilities (e.g., message procedures, grouping) required to support the above use-case.

## 5.12 Key issue 12 - Handling multiple V2X application priorities at the V2X UE

The present document defines an application enabler model which allows V2X clients and V2X application servers to exchange information over the 3GPP system. There is a gap when multiple in-vehicle applications at the client (V2X UE) with different priorities communicate to V2X application servers over the 3GPP system. The VAE client should allow different V2X applications with different priorities to communicate with the V2X application servers according to their requirements.

The key issue should further study how to handle multiple V2X applications with different priorities at the UE.

## 5.13 Key issue 13 - Communicating application requirements from the V2X application server

The 3GPP network system may be enriched with the exchange of information from the V2X application server for certain V2X use-cases (e.g. local map acquisition or lane merge) that are expected to be delivered in certain time/space horizons. This can include information about the service demand (e.g. number of involved vehicles, aumont of data to be transferred, time windows for transfer,). This can also include timing requirements provided by the V2X application. Examples of the timing requirements are whether periodic or event-based interaction is needed, interaction performed either before or during an ongoing session, possible time windows for the interaction (e.g. the interaction should happen in a window of XX sec before a network change or a V2X application adaptation is expected to happen). This information allows the 3GPP network system to properly provision the required resources for the V2X application and meet the requirements of the V2X application.

Gap:

- Defining which information to be provided by the V2X application to 3GPP network system to enable the 3GPP network system to provision the required resources for the V2X application considering the demand and timing requirements of the V2X application.

- Defining the VAE capabilities to provide the demand and timing requirements to the 3GPP network system.

## 5.14 Key issue 14 - Network assistance for enhancing QoE in V2X applications

3GPP TS 22.186 [3] describes several use-cases and service requirements to enhance 3GPP network system support for V2X services. In several use-cases (e.g., platooning, HD/3D local map download, infotainment), providing a high QoE to the V2X UE is desired. The 3GPP network system typically assigns QoS bearers for different UEs. Nevertheless, the quality experienced by a V2X UE changes dynamically during an ongoing session due to mobility, channel quality and content variability (e.g., bit-rate variation) which requires further adaptation by the V2X application server. The V2X application specific server is responsible for applying the necessary adaptations at the application to enhance the QoE.

This contribution proposes to study the enabling functionalities at the V2X application server and the V2X UE to support the V2X UE application. In particular, the key issue should study the required VAE capabilities to support QoE enhancements.

## 5.15 Key issue 15 - V2X USD provisioning using existing MBMS service announcement mechanisms

3GPP TS 23.285 [8] describes three approaches for the V2X USD provisioning: *"- Provided with V2X USDs for receiving MBMS based V2X traffic via existing MBMS service announcement mechanisms, or provisioned from V2X Control Function, or provisioned from the V2X Application Server via V1 reference point"*

*"To provide the UE with the V2X USD(s), the following ways may be used:*

*- Existing MBMS service announcement mechanisms specified in TS 23.246 [8] and TS 26.346 [11].*

*- Provisioning as described in clause 4.4.1.2.2, i.e. pre-configuration in the UE and/or configuration from V2X Control Function.*

*- Provisioning from the V2X Application Server via V1 reference point"*

3GPP TS 23.285 [8] does not specify any mechanisms for V2X USD provisioning by the V2X application server using MBMS service announcement mechanisms.

Gap:

- How to provision V2X USDs from the V2X application server using existing MBMS service announcement mechanisms specified in 3GPP TS 23.246 [10] and 3GPP TS 26.346 [14].

## 5.16 Key issue 16 - Supporting larger files or V2X messages

3GPP TR 22.886 [5] introduces the case of sending larger files or messages (e.g. subclause 5.3 of 3GPP TR 22.886 [5]). Sending larger files or messages typically requires a partitioning step to separate the file / message payload over multiple IP packet payloads.

3GPP TR 22.886 [5] does not further define "large message". However, software updates or HD map files are easily larger than 100Kbyte in size. The VAE capabilities should provide common functions to application specific functions.

Gaps:

- How does a V2X application server provide larger files or V2X messages using unicast and multicast.

- How does a V2X UE provide larger files or V2X messages for uplink distribution.

## 5.17 Key issue 17 - Determining UE location for a geographical area

3GPP TR 22.886 [5] introduces the case of sending larger files or messages into a defined geographical area (e.g. subclause 5.3 of 3GPP TR 22.886 [5]). In particular, in case of unicast file / message delivery, delivery into certain geographical areas should be studied so that only UEs inside of the targeted geographical areas receive the file / message.

Gap:

- How to map between the application geographical definition and the network geographical area definition.

## 5.18 Key issue 18 - Resolving UE address for ETSI ITS facility layer messages

3GPP Cellular-V2X PC5 interface can support ETSI ITS facility layer messages using BTP/GeoNetworking as the transport and network protocols. As specified in 3GPP TS 24.386 [16], the PC5 interface of 3GPP V2X can directly support non-IP traffic. However, conveying ETSI ITS messages over the 3GPP Uu interface, which only supports IP as the network layer protocol, is not standardized. Although the current ETSI ITS standards do not preclude transmitting ETSI ITS facility layer messages using TCP/IP or UDP/IP protocol as the transport and network layer protocols, there are clear gaps for supporting ITS facility layer messages over the 3GPP Uu interface. UE addressing specified in ETSI ITS is non-IP based. Hence all ETSI ITS facility layer messages require VAE capabilities support for translating the UE addressing of ETSI ITS to IP based addressing.

## 5.19 Key issue 19 - Resolving security issues for ETSI ITS distribution

The current ETSI ITS standards and specifications are not complete for delivering ETSI ITS facility layer messages using the TCP/IP or UDP/IP protocol stack, especially for delivering secured messages. Security in ETSI-ITS context includes authenticity/integrity (certificates assuring information comes from trusted sources and was not corrupted) and privacy (especially prevent geographic tracking of individual vehicles or persons). In particular, how to fulfil the ITS security requirements as specified in ETSI TS 102 940 [28] using the ETSI security specifications as specified in ETSI TS 103 097 [29] and ETSI TS 102 723-8 [27] at the V2X application layer needs to be studied.

Editor's note: The security solution needs input from SA3.

It requires further study:

- How to resolve the security issues for ETSI ITS at the application layer.

## 5.20 Key issue 20 – V2X dynamic groups

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. Dynamic groups can be formed for a specific purpose decided at the application layer. However the members of a dynamic groups are 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. The focus of this key issue is to support the application layer for forming V2X dynamic groups by including the V2X UEs to the group, determined in an ad-hoc fashion. In V2X dynamic groups, the group management operations that need to be supported include adding or removing members of the group, splitting or merging of groups.

Further study is needed for enabling layer to support application layer V2X dynamic groups formation and communication, on the following aspects:

For V2X dynamic groups formation with the V2X UEs in Uu communication range:

a) providing support to identify V2X UEs from one or more PLMNs, belonging to a dynamic group.

b) providing support to provision PC5 parameters enabling dynamic group communication continuity over V5.

c) providing support to dynamic groups management (adding or removing members, split or merge dynamic groups).

For V2X dynamic groups formed with the V2X UEs in PC5 communication range:

a) providing support to identify V2X UEs belonging to a dynamic group.

b) providing support to enable dynamic group communication over V5.

c) providing support to dynamic groups management (adding or removing members, split or merge dynamic groups).

## 5.21 Key issue 21 – V2X application support for network slicing

Network slicing is a set of technologies to support network service differentiation and meet the diversified requirements from tenants like vertical industries as specified in subclause 5.15 of 3GPP TS 23.501 [11]. Network slice is a logical network that provides specific network capabilities and network characteristics. The application support for slices is a standardized feature in 3GPP 5GS and mainly involves the interaction between the 5GS (e.g. slice management system) and the 3rd party (tenants) for the pre-commissioning, operation and management of the slice end-to-end as specified in 3GPP TS 28.530 [21].

In V2X use cases as defined in 3GPP TS 22.186 [3], both safety and non-safety communications need to be supported with diverse and conflicting KPIs (latency, reliability, throughput). A V2X service provider may use one or more network slices for V2X to bundle one or more V2X services to support multiple KPI and QoS requirements.

The network slice for V2X will be of slice type URLLC. The slice types are specified in 3GPP TS 23.501 [11]. The specific details of the network slice for V2X is not yet defined.

Editor's note: How the SA2 definition of the V2X slice impacts this key issue is FFS.

Further study is required to determine how to abstract the network slice details from the V2X application to enable the most efficient utilization of network resources across V2X services.

## 5.22 Key issue 22 – Support for operation modes selection for V2V communications

The V2X services need to support different modes of operation for V2V (PC5 and Uu) communications, to ensure meeting the tight service requirements especially for the reliability and delay critical services. In particular, V2V should be supported via PC5 for direct V2V communication and/or Uu for indirect V2V communication considering KPI improvement. The V2X application layer requires to control the operation modes selection considering the V2V service KPIs for reliability and latency as specified in 3GPP TS 22.186 [3].

The aforementioned considerations for operation mode selection for V2V scenarios are not addressed in 3GPP TS 23.285 [8]. Hence, it is required to study whether and how the VAE capabilities should support the selection of Uu and PC5 modes of operation for V2V services considering KPI improvement (especially reliability and latency).

## 5.23 Key issue 23 – Support for service continuity between Uu and UE-to-network relay for V2X communications

The V2X services specified in 3GPP TS 22.186 [3] require support for service continuity between Uu and UE-to-network relay for V2X communications (e.g. where V2X UEs have mobility in areas of limited or no coverage). The V2N service should be supported via Uu direct V2N communication or PC5 and Uu in a UE-to-Network Relay operation mode to ensure service continuity.

It is required to study whether and how the VAE capabilities should support the V2N service continuity when changing between Uu and UE-to-Network relay mode of operation.

# 6 Assumptions and architectural requirements

## 6.1 Assumptions

V2X communication using MBMS is applicable only to EPS in the present document.

## 6.2 Architectural requirements

### 6.2.1 General

#### 6.2.1.1 Description

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

#### 6.2.1.2 Requirements

[AR-6.2.1.2-a] The VAE client and the VAE server shall support one or more V2X applications.

[AR-6.2.1.2-b] The VAE capabilities may be offered as APIs to the V2X applications.

### 6.2.2 Location

#### 6.2.2.1 Description

This subclause specifies the location management requirements to be supported by the VAE capabilities.

#### 6.2.2.2 Requirements

[AR-6.2.2.2-a] The VAE capabilities shall provide location management to support MBMS based V2X communications.

## 6.3 Network situation monitoring requirements

### 6.3.1 Description

This subclause specifies the network situation monitoring requirements for the V2X application server to be supported by the underlying 3GPP network (EPS/5GS).

### 6.3.2 Requirements

[AR-6.3.2-a] The V2X application enabler server shall enable V2X application specific server to monitor network situation and monitoring the QoS for single V2X UE or aggregately for groups of V2X UEs (supporting a V2X service and being in proximity) having ongoing sessions.

[AR-6.3.2-b] The 3GPP network system (EPS/5GS) shall be able to report the change in the QoS for V2X UEs, to the V2X application enabler server.

## 6.4 3GPP system related parameters provisioning

### 6.4.1 Description

This subclause specifies the 3GPP system related parameters (e.g. V2X USD, PC5 parameters specified in 3GPP TS 23.285 [8]) provisioning requirements to be supported by the VAE capabilities.

### 6.4.2 Requirements

[AR-6.4.2-a] The VAE capabilities shall provide 3GPP system related parameters (e.g. V2X USD, PC5 parameters specified in 3GPP TS 23.285 [8]) provisioning capabilities to enable and support V2X communications.

## 6.5 PC5 based V2X group communication

### 6.5.1 Description

This subclause specifies the PC5 based V2X group communication requirements to be supported by the VAE capabilities.

### 6.5.2 Requirements

[AR-6.5.2-a] The VAE capabilities shall provide support functions for PC5 communications on a per V2X group basis.

# 7 Solutions

## 7.1 Solution #1: V2X application layer functional model

### 7.1.1 Solution description

#### 7.1.1.1 General

This solution provides the architecture and functional model required for addressing the application layer support aspects illustrated via the solutions for the key issues described in clause 5.

#### 7.1.1.2 V2X application layer functional model

Figure 7.1.1.2-1 illustrates the simplified architectural model for the V2X application layer. It utilizes the architectural reference model specified in subclause 4.2 in 3GPP TS 23.285 [8] which have impact on the application layer support aspects.



Figure 7.1.1.2-1: 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 [8]. 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 [8].

Figure 7.1.1.2-2 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 7.1.1.2-2: V2X application layer functional model

The V2X application server consists of V2X application enabler (VAE) server 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 V2X UEs consist of the VAE client 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 VAE client communicates with the VAE server over V1-AE reference point. The V2X application specific client communicates with V2X application specific server over V1-APP reference point.

NOTE 1: The V1-APP reference point is out of scope of the present document.

The VAE client of V2X UE2 communicates with VAE client of V2X UE1 over V5-AE reference point. The V2X application specific client of V2X UE2 communicates with VAE client of V2X UE1 over V5-APP reference point.

NOTE 2: The V5-APP reference point is out of scope of the present document.

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 [20]) 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 systems over V2, MB2, xMB, Rx, T8, Npcf and N33 reference points. The EPS and 5GS are considered as the 3GPP network systems.

NOTE The details of interactions between the V2X application layer and 5GS is the responsibility of SA2 and out of scope of the present document.

#### 7.1.1.3 Functional entities description

##### 7.1.1.3.1 General

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

##### 7.1.1.3.2 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.

##### 7.1.1.3.3 V2X application enabler client

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

- providing UE capabilities;

- MBMS monitoring for suspension/resumption;

- MBMS listening status reporting;

- discovering local V2X service information;

- providing location information;

- supporting PC5 based V2X group communication;

- supporting PC5 parameters provisioning;

- supporting V2X USD provisioning; and

- supporting interactions with the V2X application specific client(s).

##### 7.1.1.3.4 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.

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

##### 7.1.1.3.5 V2X application enabler server

The VAE server acts as a GCS AS as described in 3GPP TS 23.468 [10] or acts as a content provider as described in 3GPP TS 26.346 [18].

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

- communicating with the underlying 3GPP network system (EPS/5GS) for unicast and multicast network resource management and QoS adaptation;

- receiving monitoring reports/events from the underlying 3GPP network system (EPS/5GS) regarding network situation corresponding to RAN and core network;

- providing V2X application monitoring events to the V2X application specific server;

- supporting location management for the V2X UEs to support MBMS based V2X communications;

- pushing the assignments of ProSe layer 2 group IDs for V2X groups to the V2X UEs;

- V2X USD provisioning to the connected V2X UE;

- providing V2X server USDs corresponding to the geographic locations; and

- provisioning PC5 parameters to the UE.

#### 7.1.1.4 Reference points

##### 7.1.1.4.1 General

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

##### 7.1.1.4.2 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 [8]. This reference point is supported for both unicast and multicast delivery modes.

##### 7.1.1.4.3 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 [8]. The details of V1-APP reference point is out of scope of the present document.

##### 7.1.1.4.4 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 [8].

##### 7.1.1.4.5 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 [8]. The details of V5-APP reference point is out of scope of the present document.

##### 7.1.1.4.6 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.

##### 7.1.1.4.7 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.

NOTE: The details of the Vc reference point is out of scope of the present document.

#### 7.1.1.5 Reference points between the V2X application layer and the 3GPP network systems

##### 7.1.1.5.1 General

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

##### 7.1.1.5.2 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 [8].

##### 7.1.1.5.3 Rx

The reference point Rx supports the interactions between the V2X AS and the PCRF and is specified in 3GPP TS 29.214 [22]. The functions for Rx reference point are supported by VAE server.

##### 7.1.1.5.4 MB2

The reference point MB2 supports the interactions between the V2X AS and the BM-SC and is specified in 3GPP TS 29.468 [23]. The functions for MB2 reference point are supported by VAE server.

##### 7.1.1.5.5 xMB

The reference point xMB supports the interactions between the V2X AS and the BM-SC and is specified in 3GPP TS 26.346 [18]. The functions for xMB reference point are supported by VAE server.

##### 7.1.1.5.6 T8

The reference point T8 supports the interactions between the V2X AS and the SCEF and is specified in 3GPP TS 23.682 [13]. The functions of T8 interface are supported by VAE server.

#### 7.1.1.6 Deployment models for the V2X application layer functional model

##### 7.1.1.6.1 General

The V2X AS may reside within the PLMN domain or outside the PLMN domain as per the PLMN operator agreement with the V2X service provider. The VAE client and VAE server may be offered by the PLMN operators or a 3rd party V2X service provider.

The following deployment models are illustrated in this subclause:

- Centralized deployments where the VAE server is co-located with V2X application specific server in the same physical entity.

- Distributed deployments where the VAE server and V2X application specific server are deployed in different physical entities.

NOTE: The deployment models illustrated in this subclause are not exhaustive.

The VAE server may be co-located with the V2X application specific server in some deployment scenarios and so Vs reference point is not required in such deployments. The Vs reference point may be specified for distributed deployments.

Editor's note: The functionality of Vs is FFS.

The following cardinality relationship between the V2X application specific server and the VAE server can be supported:

- A single V2X application specific server can interact with one or more VAE servers.

- One or more V2X application specific servers can interact with a single VAE server.

For simplicity, all entities of the V2X application layer functional model are not shown in the deployment models.

##### 7.1.1.6.2 Centralized deployment

Figure 7.1.1.6.2‑1 illustrates the centralized deployment where the V2X application specific server and the VAE server are co-located in a single physical entity. This physical entity can be deployed either in the PLMN operator domain or deployed in 3rd party V2X service provider domain. This physical entity connects with the 3GPP network systems in the PLMN operator domain. The Vs reference point between the VAE server and the V2X application enabler server may not be used in this deployment.



Figure 7.1.1.6.2-1: Centralized deployment

Figure 7.1.1.6.2‑2 illustrates the centralized deployment where the V2X application specific server and the VAE server are co-located in a single physical entity. This physical entity is deployed in the 3rd party V2X service provider domain. This physical entity connects with the 3GPP network systems in multiple PLMN operator domain.



Figure 7.1.1.6.2-2: Centralized deployment with connections to 3GPP network systems from multiple PLMN operator domains

##### 7.1.1.6.3 Distributed deployment

The VAE server and the V2X application specific server can be co-located in different physical entities.

Figure 7.1.1.6.3-1 illustrates the distributed deployment where the V2X application specific server is deployed in the 3rd party V2X service provider domain and the VAE server is deployed in the PLMN operator domain. The VAE server connects to the 3GPP network system of the PLMN operator domain. The Vs reference point is used for interaction between V2X application specific server and the VAE server.



Figure 7.1.1.6.3-1: Distributed deployment of V2X application layer entities in PLMN operator domain and 3rd party V2X service provider domain

Figure 7.1.1.6.3-2 illustrates the distributed deployment where both the VAE server and the V2X application specific server are deployed in the 3rd party V2X service provider domain and the VAE server connects to 3GPP network systems belonging to multiple PLMN operator domains.



Figure 7.1.1.6.3-2: Distributed deployment with connections to 3GPP network   
systems from multiple PLMN operator domains

Figure 7.1.1.6.3-3 illustrates the distributed deployment where the V2X application specific server is deployed in the 3rd party V2X service provider domain and connects via Vs to the VAE servers deployed in multiple PLMN operator domains.



Figure 7.1.1.6.3-3: Distributed deployment with connections to VAE servers deployed in multiple PLMN operator domain

### 7.1.2 Solution evaluation

This solution provides a viable functional model for V2X application architecture illustrating the VAE capabilities.

The deployment aspects are specified in subclause 7.1.1.6 and allows for VAE capabilities to be deployed in PLMN network and 3rd party V2X service provider.

## 7.2 Solution #2: UE location report over V1

### 7.2.1 Solution description

#### 7.2.1.1 General

This solution addresses key issue 10 and describes how to report the UE location (e.g., MBMS SAI(s), ECGI(s)) in the signalling to the VAE server via V1-AE to support MBMS-based communication.

#### 7.2.1.2 Location reporting event triggers configuration procedure

The procedure for configuring the location reporting event triggers from the VAE server to the VAE client is illustrated in figure 7.2.1.2-1. This procedure is also applied for the location reporting event triggers update.

Pre-condition:

- If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.



Figure 7.2.1.2-1: Location reporting event triggers configuration

1. VAE server sends the location reporting configuration request to the VAE client including the initial location reporting event triggers configuration (or a subsequent update), e.g., minimum time between consecutive reports, SAI changes, or ECGI changes. This message can be sent via unicast or multicast.

2. VAE client stores or updates the location reporting event triggers configuration.

3. VAE client sends the location reporting configuration response to the VAE server.

#### 7.2.1.3 Location reporting event triggers configuration cancel procedure

The procedure for cancelling the location reporting event triggers configuration at the VAE client is illustrated in figure 7.2.1.3-1.

Pre-conditions:

1. The VAE server has subscribed the VAE client location with the location reporting event triggers.

2. If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.



Figure 7.2.1.3-1: Location reporting event triggers configuration cancel

1. VAE server sends the location reporting configuration cancel request to the VAE client to stop receiving the UE location information. This message can be sent via unicast or multicast.

2. VAE client invalidates the location reporting event triggers configuration and no longer reports its location to the VAE server.

3. VAE client sends the location reporting configuration cancel response to the VAE server.

#### 7.2.1.4 Location reporting procedure

The procedure for UE location report over V1-AE reference point is illustrated in figure 7.2.1.4-1.

Pre-condition:

- UE is configured to report location based on event trigger or periodically.



Figure 7.2.1.4-1: UE location report over V1

1. VAE client sends UE location report with UE location information to VAE server when the configured location reporting events occurs.

2. VAE server may return a UE location report response if requested in UE location report message.

### 7.2.2 Solution evaluation

This solution enables the reporting of the UE location (e.g., MBMS SAI(s), ECGI(s)) in the signalling to the VAE server via V1-AE to support MBMS-based communication.

## 7.3 Solution #3: Handling MBMS bearer suspension via V1

### 7.3.1 Solution description

#### 7.3.1.1 General

This solution addresses the key issue 6 to allow the VAE server to acquire the MBMS bearer suspension event. In this solution, the VAE client reports the MBMS bearer suspension to the VAE server. The VAE server takes actions corresponding to the MBMS bearer suspension event, e.g. switching all the VAE clients associated to this MBMS bearer to unicast bearer.

#### 7.3.1.2 Procedure

The information flow below defines a procedure in which the VAE client notifies the VAE server about an MBMS suspension decision in RAN.

Pre-condition:

- It is assumed that there is at least one active MBMS bearer detected by VAE client.



Figure 7.3.1.2-1: MBMS suspension notification from VAE client

1. RAN decides to suspend the MBMS bearer, according to existing procedures in 3GPP TS 36.300 [24].

2. An MBMS suspension indication is sent in the MSI (MCH Scheduling Information), according to existing procedures in 3GPP TS 36.300 [24].

3. The VAE client detects the MBMS suspension and sends an MBMS suspension report to the VAE server.

The same procedure can be applied at MBMS resumption or other MBMS events that may be detected by the VAE client.

### 7.3.2 Solution evaluation

This solution enables VAE server to handle the MBMS bearer suspension event, e.g. switching all the VAE clients associated to this MBMS bearer to unicast bearer. This solution addresses the aspect of VAE server acquiring the information of MBMS bearer suspension of the key issue 6.

## 7.4 Solution #4: V2X USD provisioning via V1 reference point

### 7.4.1 Solution description

#### 7.4.1.1 General

This solution corresponds to key issue 3. The V2X application server can provision the V2X USD information to V2X UE via V1 reference point for V2X communication using MBMS.

#### 7.4.1.2 Procedure

Figure 7.4.1.2-1 illustrates the procedure for provisioning V2X USD to the V2X UE via V1 reference point.

Pre-conditions:

1. The V2X UE has connected to the V2X application server.

2. If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.



Figure 7.4.1.2-1: V2X USD provisioning via V1 reference point

1. The VAE server of the V2X AS is triggered for providing V2X USD to V2X UE.

2. The VAE server of the V2X AS 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 [8]. 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.

Editor's notes: Defining 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 reference point) is FFS.

4. The VAE client of the V2X UE provides an acknowledgement to the VAE server of the V2X AS.

### 7.4.2 Solution evaluation

This solution enables the V2X application server to provision the V2X USDs to the V2X UE via V1 reference point for V2X communication using MBMS. This solution supports the scenario where the V2X application is deployed by 3rd party like OEM, and the OEM prefers to provision the service provisioning data directly to its V2X UE, rather than provisioning by the PLMN operator.

This solution provides a mechanism for the option specified in 3GPP TS 23.285 [8] for V2X USD provisioning from the V2X application server via V1 reference point.

## 7.5 Solution #5: V2X UE obtaining the local service information

### 7.5.1 Solution description

#### 7.5.1.1 General

This solution corresponds to key issue 4. 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 solution describes the procedure for obtaining the local service information by the V2X UE via V1.

#### 7.5.1.2 Procedure

Figure 7.5.1.2-1 illustrates the procedure for obtaining the local service information by the V2X UE via V1.

Pre-conditions:

1. The V2X UE is connected to the V2X 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 7.5.1.2-1: Obtaining local service information by V2X UE via V1

1. The VAE client sends a V2X server USD 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 V2X server USD(s) information corresponding to the geographic locations information received in step 1.

3. The VAE server provides the V2X server USD(s) with the corresponding geographic locations information to the VAE client via a V2X server USD 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 [8]. This message can be sent via unicast or multicast.

4. Upon receiving the V2X server USD(s) in step 3, the VAE client stores the V2X server USD(s) information to be used to receive the local service information in the specific geographic location.

### 7.5.2 Solution evaluation

This solution proposes a new procedure to allow the V2X UE to get the V2X server USD from the V2X application server via V1 reference point for some geographic locations for which the V2X UE has no V2X server USDs before entering those geographic locations.

This solution also provides a mechanism for dynamic provisioning of V2X server USD for a newly deployed local V2X application server to cater to a geographical area.

This solution is complementary to the mechanims specified in subclause 4.4.1.2.2 of 3GPP TS 23.285 [8] for providing the local service information to the V2X UE.

There is no solution by 3GPP SA WG4 for local service information provisioning from V2X application server.

## 7.6 Solution #6: PC5 parameters provisioning via V1 reference point

### 7.6.1 Solution description

#### 7.6.1.1 General

This solution corresponds to key issue 8. The Vehicle OEMs' may operate their own V2X application server which are responsible to provide over the air (OTA) configuration to the V2X UE.

#### 7.6.1.2 Procedure

Figure 7.6.1.2-1 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 V2X application server.

2. If multicast delivery mode is used, the MBMS bearer being used is activated by the VAE server.



Figure 7.6.1.2-1: PC5 parameters provisioning via V1 reference point

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 [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.

### 7.6.2 Solution evaluation

This solution enables the over the air (OTA) configuration of PC5 parameters from V2X application server to the V2X UE over V1 reference point.

This solution provides a mechanism to the option specified in 3GPP TS 23.285 [8] for provisioning the PC5 parameters to the V2X UE via V1 reference point.

## 7.7 Solution #7: Network situation and QoS monitoring

### 7.7.1 Solution description

#### 7.7.1.1 General

This solution corresponds to key issue 2. The VAE server shall support monitoring of 3GPP systems' network situation for V2X services (on top of the monitoring events proposed in 3GPP TS 23.502 [12]):

- The VAE server should receive and process access network-related monitoring events/reports from 3GPP network system. The AN-related monitoring events/report may include RAN-related resource/traffic situation statistics and context to perform granular resource and QoS management.

- The VAE server should be able to initiate monitoring of the QoS for single or aggregately for groups of vehicles (supporting a V2X service and being in proximity) having ongoing sessions.

Editor's note: The role of V2X UE in providing the information related to monitoring events to the VAE server is FFS.

#### 7.7.1.2 Network situation and QoS monitoring events

Table 7.7.1.2-1 describes the list of network situation and QoS monitoring events relevant for V2X applications. The information for "Involved EPS entity" and "Involved 5GS entity" represents the current status of support for the monitoring events to the V2X application layer. If the monitoring events are currently supported, the entities involved in EPS and 5GS are indicated in the table. If the monitoring events are currently not supported, a note is captured to indicate that support may be required by the relevant 3GPP network system.

Table 7.7.1.2-1: Network situation and QoS monitoring events

|  |  |  |  |
| --- | --- | --- | --- |
| **Monitoring event** | **Description** | **Involved EPS entity** | **Involved 5GS entity** |
| Loss of connectivity | Network detects that the UE is no longer reachable for either signalling or user plane communication. | SCEF, MME | NEF, AMF |
| Communication failure | Network detects a communication failure at a network entity | SCEF, MME | NEF, AMF |
| Number of UEs present in a geographical area | Network captures the UE density level per cell area or tracking area | SCEF, MME | NEF, AMF |
| Access network congestion Level | A RAN congestion awareness function detects the congestion situation in access network. | Not supported (see NOTE 1) | Not supported (see NOTE 1) |
| Access network overload indication | Traffic and processing load of access network nodes can be detected by network | Not supported (see NOTE 2) | Not supported (see NOTE 2) |
| Network analytics | PDU session analytics (location, network traffic condition, QoS flow measured parameter values), non PDU Session information (e.g. RAN resource analytics, slice congestion levels, coverage) | Not supported | Not supported (see NOTE 3) |
| QoS notification control per UE or UEs | E2E (including access network and core network) traffic real-time QoS monitoring information. | Not supported (see NOTE 4) | Not supported (see NOTE 4) |
| NOTE 1: The support for access network congestion level monitoring event is the responsibility of SA2.  NOTE 2: The support for access network overload indication monitoring event is the responsibility of SA2.  NOTE 3: The support for network analytics monitoring event is the responsibility of SA2.  NOTE 4: The support for QoS notification control per UE or UEs monitoring event is the responsibility of SA2. | | | |

#### 7.7.1.3 Procedure for network situation and QoS monitoring

Figure 7.7.1.3-1 illustrates the procedure for network situation monitoring by VAE server.



Figure 7.7.1.3-1: Network situation and QoS monitoring

1. The VAE server sends a monitoring request to the underlying 3GPP network system by including the V2X application information optionally the mobility and location(s) information corresponding to one or many V2X UEs.

2. The 3GPP network system provides a monitoring response to the VAE server indicating the success or failure for initiating monitoring of network situation and QoS for the requested information.

3. The 3GPP network system monitors the network situation for the V2X application and the V2X UEs.

NOTE: The details of how the 3GPP network system monitors the network situation and determines the monitoring information is out of scope of the present document.

#### 7.7.1.4 Procedure for network situation and QoS monitor reporting

Figure 7.7.1.4-1 illustrates the procedure for network situation monitor reporting by VAE server.

Pre-condition:

- The network situation and QoS monitoring has been initiated as specified in subclause 7.7.1.2.



Figure 7.7.1.4-1: Network situation and QoS monitor reporting

1. The 3GPP network system sends a monitoring report (event driven or based on rules configured at the 3GPP network system) to the VAE server including the RAN and core network information (e.g. resource availability, RAN failure, RAN overload, Loss of connectivity, change in QoS level) with the corresponding information for the V2X application, V2X UE or group of V2X UEs.

Editor's note: Whether and how the monitoring information is provided to the V2X application specific server by VAE server is FFS.

Editor's note: The granularity of monitoring report provided to VAE server is FFS.

### 7.7.2 Solution evaluation

This is a viable technical solution and addresses key issue 2 for VAE server to support monitoring of 3GPP systems' network situation for V2X services. The VAE server communicates with 3GPP EPS and 3GPP 5GS for monitoring the network situation.

The list of monitoring events specified in subclause 7.7.1.2 are not exhaustive. The support for these monitoring events by 3GPP EPS and 3GPP 5GS are responsibility of SA2.

The aspect of communicating the change of LoA to the V2X UE is out of scope of the present document.

## 7.8 Solution #8: V2X USD provisioning using SACH

### 7.8.1 Solution description

#### 7.8.1.1 General

This solution corresponds to key issue 15. The V2X application server can provision the V2X USD information to V2X UE using MBMS. The current solution proposes to use the Service Announcement Channel (SACH) as defined in 3GPP TS 26.346 [18] Annex L.2 / L.3.

#### 7.8.1.2 Procedure

Figure 7.8.1.2-1 illustrates the procedure for provisioning V2X USD to the V2X UE.

Pre-conditions:

1. The V2X UE includes an MBMS client as defined in 3GPP TS 26.347 [19].

2. The VAE client is aware about usage of MBMS and can receive service announcement via SACH.

Editor's note: It is FFS how the VAE server informs the client about MBMS usage.



Figure 7.8.1.2-1: V2X USD provisioning using SACH

1. The VAE server desires to send data over MBMS. It triggers the creation of an MBMS service from the V2X application enabling server and the BM-SC.

2. The BM-SC sends the V2X USD information using the Service Announcement Channel (SACH) to the VAE client. The V2X USD information consists of serviceIds, TMGI, list of SAIs, frequency and SDP information for V2X applications' communication using MBMS. Each USD is uniquely identified by the serviceId. The V2X USD can include USDs which are identified by their serviceIds.

3. Upon receiving the V2X USD announcement, the VAE client stores the received V2X USD. Note, the VAE client may have stored already several other USDs.

### 7.8.2 Solution evaluation

This solution enables the V2X application server to provision the V2X USDs to the V2X UE. Either the full USD or a handle for the USD (i.e. a serviceId) is sent using MBMS SACH.

## 7.9 Solution #9: Abstraction of network QoS aspects for V2X communications

### 7.9.1 Solution description

#### 7.9.1.1 General

This solution corresponds to the key issue 1a. The VAE server abstracts from the V2X application specific server the details of network QoS information and stores the mapping information of the LoA and network QoS information to enable communication of appropriate network QoS requirements with the underlying 3GPP network systems.

The VAE server communicates with SCEF or PCEF in EPS and NEF or PCF in 5GS for network QoS aspects.

#### 7.9.1.2 Procedure

The solution is described in the high-level procedure illustrated in figure 7.9.1.2-1.

Pre-conditions:

1. The VAE server has the mapping relationship of LoA information and network QoS information (QCIs) corresponding to the V2X services.

2. The network situation and QoS monitoring procedure specified in subclause 7.7.1.3 has been initiated by VAE server.



Figure 7.9.1.2-1: Abstraction of network QoS aspects for V2X communications

0. The network situation and QoS monitor reporting is performed as specified in subclause 7.7.1.4.

Editor's note: How the SA2 work on eV2X impacts this solution is FFS.

1. The VAE server sends a monitoring report to the V2X application specific server which has impact on the V2X application provided by the V2X application specific server which includes information related to the UEs identification and the LoA levels that can be supported for the V2X application.

2. Based on monitoring information received and other V2X application context, a trigger for LoA change may be initiated at the V2X application specific server.

3. The V2X application specific server sends an LoA resource modification request including the information of the V2X UE(s) or V2X application group ID, the current operating LoA per UE and the target operating LoA per UE.

4. The VAE server translates the service adaptation information to the corresponding network QoS requirements based on the mapping information applicable for one or more sessions involving one or more V2X UEs.

5. The VAE server communicates with the appropriate entity (e.g. SCEF or PCRF) of the underlying 3GPP network systems (EPS or 5GS) to modify the QoS levels for the resources involved in the V2X communications with the information of V2X UEs and the new QoS level per UE.

6. The VAE server provides a LoA resource modification response to the V2X application specific server.

7. The VAE server notifies about the change of QoS related to the adapted LoA to the VAE client of the V2X UEs.

8. The 3GPP network system applies the PDN/PDU session modification on the V2X UE(s).

### 7.9.2 Solution evaluation

This solution enables VAE server to provide the abstraction of network aspects for V2X communications and supports the translation of LoA resource modification request to corresponding network QoS aspects and communicates with the underlying 3GPP network system(s).

## 7.10 Solution #10: Communication of V2X application PC5 QoS requirements with 3GPP systems

### 7.10.1 Solution description

#### 7.10.1.1 General

This solution corresponds to key issue 1b and describes the ProSe Per-Packet Priority values to be applied for the multicast packets relayed to a UE over PC5.

#### 7.10.1.2 ProSe Per-Packet Priority values

The needed quality of service (on a per message basis) as determined by the V2X application (i.e. KPI) must be mapped to the available list of ProSe Per-Packet Priority values.

#### 7.10.1.3 Procedure

VAE client includes ProSe Per-Packet Priority value corresponding to the V2X application layer functional requirements, to be applied for the multicast packets relayed to a UE over PC5.

### 7.10.2 Solution evaluation

This solution enables QoS handling over PC5 according to application layer QoS needs by selecting an appropriate ProSe Per-Packet Priority value.

## 7.11 Solution #11: Switching from MBMS delivery to unicast delivery

### 7.11.1 Solution description

This solution addresses scenario 2 and 3a as described in key issue 5 in subclause 5.5. The V2X communication has to be switched to unicast for service continuity when the V2X UE suffers from bad MBMS bearer condition. This solution is similar to the procedure in subclause 10.7.3.3 in 3GPP TS 23.280 [7], which is currently used for mission critical service between UE and MC service server.

Figure 7.11.1-1 shows the procedure for service continuity when a V2X UE is about to move out of MBMS coverage by switching from MBMS bearer to unicast bearer.

Pre-condition:

- It is assumed that the MBMS bearer has been activated by V2X application enabler server for downlink delivery.



Figure 7.11.1-1: Switching from MBMS delivery to unicast delivery

1. The V2X UE detects that it suffers from bad MBMS bearer condition for the corresponding MBMS service. The method to detect is implementation specific.

2. The VAE client notifies the VAE server that it suffers from bad MBMS bearer condition for the corresponding MBMS service by sending the MBMS listening status report.

3. The VAE server sends the downlink data by unicast delivery to the VAE client.

NOTE: The unicast bearer may be set up on demand after step 2 or before.

4. During the switching, the V2X UE simultaneously receives downlink data through both unicast bearer and MBMS bearer. If there is no downlink data to the VAE client, this step can be skipped.

5. The V2X UE ceases to receive the downlink data through MBMS bearer but continues receiving data through unicast bearer.

### 7.11.2 Solution evaluation

The solution allows the VAE client to report the MBMS listening status to the VAE server to trigger the switching from multicast delivery to unicast delivery. This solutions provides a mechanism to maintain the service continuity in V2X communication with MBMS.

## 7.12 Solution #12: Supporting for V2X group communication

### 7.12.1 Solution description

#### 7.12.1.1 General

This solution addresses the key issue 9 to support the V2X group communication over ProSe. 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).

In this solution, the V2X application group management (e.g. group creation, membership management) is the responsibility of the V2X application specific server. The V2X group information is provided to the VAE server. The VAE server assigns a ProSe Layer-2 Group ID from the ProSe Layer-2 Group ID pool to a V2X application group ID. The VAE server then delivers the assigment of the ProSe Layer-2 Group ID and the V2X application group ID to the VAE client.

#### 7.12.1.2 VAE server pushes ProSe group communication parameters procedure

The VAE server pushes the assignment of V2X application group IDs with ProSe Layer 2 IDs to the UEs belonging to the same or different PLMNs.

The procedure for pushing V2X ProSe group communication parameters to VAE client over V1 reference point is illustrated in figure 7.12.1.2-1.

Editor's note: Handling the case where the VAE clients in a single V2X application group are from multiple VAE servers is FFS.

Pre-conditions:

1. V2X application group information is available at the VAE server.

2. VAE server has a pool of the ProSe Layer-2 Group IDs to be assigned.

3. VAE server is able to provide to assignment to the VAE client from multiple PLMNs.

NOTE 1: For a single V2X application group, only one single VAE server is responsible for pushing the parameters for the V2X group communication over ProSe.

NOTE 2: When a single V2X application specific server connects multiple VAE servers, how to determine the VAE server for pushing the parameters for V2X group communication over ProSe is implementation.



Figure 7.12.1.2-1: VAE server pushes the parameters for V2X group communication over ProSe

1. The VAE server assigns the ProSe Layer-2 Group ID to a V2X application group ID when triggered by V2X application specific server.

2. The VAE server pushes the mapping relationship of the ProSe Layer-2 Group ID and V2X application group ID in a ProSe group parameters push request to the VAE client(s) who are members of the V2X application group.

3. The VAE client(s) provide an acknowledgement to the VAE server via a ProSe group parameters push response.

### 7.12.2 Solution evaluation

This solution enables the VAE server to provision the ProSe parameters for V2X group communication over ProSe to the V2X UE within the group members via V1 reference point. This solution requires the V2X application group related information from V2X application specific server. This solution facilitates the the V2X application specific server better use the ProSe feature for V2X group communication.

## 7.13 Solution #13: Group communication parameters provisioning via V5

### 7.13.1 Solution description

#### 7.13.1.1 General

This solution addresses the key issue 9 to support the V2X group communication over ProSe. In this solution, an authorized V2X UE broadcasts the available ProSe Layer-2 Group ID(s) being used for platooning and the related destination information.

As a use case showing the value of this solution, in Figure 7.13.1.1-1, UE A and UE B are going to destination A and destination B, respectively. To go their destinations, they should pass by IC#12 on the highway. RSU as an authorized V2X UE, sends platooning service information messages via PC5. The destination Layer-2 ID of the message is pre-configured ProSe Layer-2 Group ID for V2X platooning service. The vehicles who are authorized to use the V2X platooning service can interpret the message. UE A and UE B determine to select ProSe Layer2 Group ID which is mapped to IC#12 based upon the platooning information broadcasted by the RSU.



Figure 7.13.1.1-1: RSU assisted dynamic platoon communication

#### 7.13.1.2 Procedure

Figure 7.13.1.2-1 illustrates the procedure for providing group information to the V2X UE via V5-AE reference point.

Pre-condition:

- The VAE client 1 (e.g. RSU) has been provisioned with the ProSe Layer-2 Group ID(s) assigned to group(s).



Figure 7.13.1.2-1: Group communication parameters provisioning via V5

1. VAE client 1 (e.g. RSU) sends periodic group communication parameters announcement message corresponding to each group over ProSe Layer-2 ID. This message contains the PC5 parameters information as specified in subclause 4.4.1.1.2 in 3GPP TS 23.285 [8] and the relevant group selection criteria.

NOTE: Due to the movement of the participants (in and out of the VAE client 1's radio coverage) during the V5 group communication, the group communication parameters announcement message is periodically sent.

2. The VAE client 2 selects the appropriate ProSe Layer-2 Group ID corresponding to its group needs.

### 7.13.2 Solution evaluation

This solution enables an authorized V2X UE to broadcast the ProSe Layer-2 Group ID to be used for PC5 group communication and corresponding group selection criteria information via V5 reference point.

## 7.14 Solution #14: Autonomous decision for assigning ProSe Layer-2 Group ID

### 7.14.1 Solution description

#### 7.14.1.1 General

This solution addresses the key issue 9 to support the V2X group communication over ProSe. In this solution, the UE is configured with rules to be able to generate an appropriate ProSe Layer-2 Group ID for platooning by the V2X Application Server. When the V2X client decides to start platooning, it generates ProSe Layer-2 Group ID based on the configured rules corresponding to V2X UE's destination.



Figure 7.14.1.1-1: Unassisted dynamic platoon communication

#### 7.14.1.2 Procedure

Figure 7.14.1.2-1 illustrates the procedure for generating a ProSe Layer-2 Group ID based on configured rules, by the V2X UE corresponding to a group criteria.

Pre-condition:

- VAE client 1, 2, 3, 4 have been provided with the ProSe Layer-2 Group ID generation rules.



Figure 7.14.1.2-1: Autonomous decision for assigning ProSe Layer-2 Group ID

1. VAE clients 1, 2, 3, 4 generate ProSe Layer-2 Group ID independently based on the provisioned ProSe Layer-2 Group ID(s) generation rules for its group criteria.

NOTE: Ensuring that the ProSe Layer-2 Group IDs generated independently are not clashing is out of scope of the present document.

2. The VAE clients send communication only to the generated ProSe Layer-2 Group ID.

### 7.14.2 Solution evaluation

This solution provides a mechanism for VAE clients to autonomously generate and assign ProSe Layer-2 Group ID for its group criteria. This solution requires the ProSe Layer-2 Group ID generation rules to be provisioned in each of the V2X UEs. Within the solution, how to avoid clashing of ProSe Layer-2 Group IDs generated independently is not detailed.

## 7.15 Solution #15: Support for uplink video streaming using FLUS framework

### 7.15.1 Solution description

#### 7.15.1.1 General

This solution corresponds to key issue #11. Multiple V2X UEs are communicating with a V2X application server for uplink streaming of captured videos. The FLUS source and FLUS sink provide enabler functions as specified in 3GPP TS 26.238 [15] to support uplink video streaming. The VAE client and the VAE server act as a FLUS source enabler function and a FLUS sink enabler function, respectively.

#### 7.15.1.2 Procedure

Pre-conditions:

1. The V2X application specific client triggers the VAE client to start sending video.

2. The VAE client (FLUS source) is pre-provisioned with the URI of the VAE server (FLUS sink) as specified in subclause 5.2.1.2 of 3GPP TS 26.238 [15].



Figure 7.15.1.2-1: Solution for support for uplink video streaming between V2X UEs and V2X application server

1. The VAE client creates a FLUS session (according to subclause 5.3.2 of 3GPP TS 26.238 [15]) with a VAE server. The session establishment is carried over V1 reference point. The VAE server returns a session identifier for the FLUS session.

2. Once the session is established, the VAE client starts sending the captured video to the VAE server.

3. The VAE server may provide the received video for post-processing to the V2X application specific server.

The VAE server may receive multiple videos from multiple FLUS sources via the same procedure and may provide the received videos for post-processing.

### 7.15.2 Solution evaluation

The solution supports the uplink video streaming from multiple V2X UEs to a V2X application server based on the FLUS framework. The solution provides a framework for uplink video streaming which can be carried over HTTP, RTP, or other protocol depending on the FLUS source and sink capabilities.

## 7.16 Solution #16: Communicating application requirements from the V2X application server

### 7.16.1 Solution description

#### 7.16.1.1 General

This solution corresponds to key issue 13. The V2X application server provides application and timing requirements to the 3GPP network system.

#### 7.16.1.2 Procedure for subscription to the 3GPP network system



Figure 7.16.1.2-1: Subscription for communicating application requirements from the V2X application server

1. The VAE server sends the subscription request message to the 3GPP network system (e.g., PCF) in order to provide V2X application requirements to the network and to receive related notifications.

2. The 3GPP network system sends the subscription response message to the VAE server with the result of the request.

#### 7.16.1.3 Procedure for communication of application requirements



Figure 7.16.1.3-1: Communication of application requirements from the V2X application server

1. The VAE server provides the 3GPP network system with the application requirements relevant to the service including amount of data to be transferred, time window for transfers, key performance indicators affecting application behaviour, time constraints for interaction with the network.

2. The 3GPP network system provides a response to the VAE server indicating whether the communicated requirements are supported by the network.

NOTE: The above procedure can be also used by the VAE server to update the information related to an ongoing session.

#### 7.16.1.4 Procedure for notification generation



Figure 7.16.1.4-1: Notification for communicating application requirements

1. The 3GPP network system takes into consideration the information received from the VAE server according to the procedure specified in the subclause 7.16.1.3 and generates a notification. The notification includes information comprising whether the application demand can/cannot be satisfied in a certain time range. The notification might also include an updated list of application demand supported by the network according to current or expected network capabilities.

2. The 3GPP network system provides a notification to the VAE server.

NOTE: The above procedure can be also used by the network to provide a new notification, e.g., to notify an updated list of network capabilities.

### 7.16.2 Solution evaluation

The solution enables the VAE server to communicate application requirements to the 3GPP network system. The solution provides the 3GPP network system with application-specific information including timing information about the V2X application which allows the 3GPP network to increase the level of knowledge about the application requirements. This can be used to help the network satisfy the application demands.

## 7.17 Solution #17: Network assistance for enhancing QoE in V2X applications using SAND framework

### 7.17.1 Solution description

#### 7.17.1.1 General

This solution corresponds to key issue 14. The SAND framework is specified in 3GPP TS 26.247 [17] to provide network support for video streaming clients. The VAE client and the VAE server act as a DASH Client and a DANE server, respectively.

#### 7.17.1.2 Procedure

Pre-condition:

- The VAE client is aware of the location of the VAE servers.



Figure 7.17.1.2-1: Solution for network assistance for enhancing the QoE in V2X applications

1. The VAE client establishes a Network Assistance session with a VAE server (DANE) (according to subclause 13.6.6 of 3GPP TS 26.247 [17]). The session establishment is carried over V1 reference point. The VAE server (DANE) returns a network assistance session identifier to the VAE client.

2. The VAE client issues a network assistance request to the VAE server (DANE) indicating the video file index and the available bitrates. The VAE server (DANE) responds by indicating the recommended bitrate to the VAE client.

3. The VAE client issues a request to the VAE server (content server) to get the video file.

4. The VAE server (content server) gets the video file from the application-specific server.

5. The VAE server (content server) delivers the requested video file to the VAE client.

6. The VAE client provides the video file to the application-specific client.

NOTE: Steps 2, 3, 4, 5 and 6 are repeated until the video file transaction is complete.

### 7.17.2 Solution evaluation

This is a viable solution to provide network support to V2X UEs in video streaming applications in V2X. The solution uses the SAND framework to exchange messages between the VAE server and the VAE client. The solution enables the V2X UEs receiving video streams from the V2X application server to maintain a sustainable QoE.

## 7.18 Solution #18: Support for QoE reporting

### 7.18.1 Solution description

#### 7.18.1.1 General

This solution partially addresses the key issue 14. The VAE client provides the V2X application QoE information and the VAE server receives the network information from the 3GPP system(s). This information are required to be analyzed and decisions to be taken for enhancing the QoE.

#### 7.18.1.2 Procedure

Figure 7.18.1.2-1 illustrates the solution for supporting QoE reporting

Pre-condition:

- The network situation and QoS monitoring procedure specified in subclause 7.7.1.3 has been initiated by VAE server.



Figure 7.18.1.2-1: Solution for supporting QoE reporting

1. The VAE server receives periodically network and QoS monitoring events (e.g. congestion, overload) as specified in subclause 7.7.1.4.

2. The VAE client(s) sends periodic V2X application QoE information (e.g. average throughput) as specified in 3GPP TS 26.247 [17] to the VAE server.

The VAE server correlates the received information in step 1 to corresponding QoE information and stores the correlated QoE information. The correlated QoE information may be retrieved from the VAE server by the V2X application specific server.

### 7.18.2 Solution evaluation

This solution enables support for the QoE reporting to the VAE server.

## 7.19 Solution #19: Support for larger files using MBMS non-Transparent xMB Session Types

### 7.19.1 Solution description

#### 7.19.1.1 General

This solution corresponds to key issue 16. A V2X application server wants to send a large file to V2X clients. The VAE server leverages the xMB interface for file delivery (subclause 5.4a of 3GPP TS 26.346 [18]).

#### 7.19.1.2 Procedure

Pre-conditions:

1. The VAE server has discovered the xMB-C interface of a BM-SC and is authorized to use it;

2. The VAE client has acquired the V2X USD for the file delivery session and is aware about the upcoming MBMS transmission; and

3. The VAE client acts as an MBMS client as defined in 3GPP TS 26.347 [19].



Figure 7.19.1.2-1: Solution for support for non-Transparent xMB session type for file delivery

1. The VAE server creates an xMB Service for the large file delivery session.

2. The VAE server creates an xMB Session for large file delivery and configures it as Session Type *File*.

3. The VAE server provides the file (optionally encrypted) using xMB-U to the 3GPP network system (BM-SC).

4. The 3GPP network system sends the file including appropriate methods to provide reception reliability (e.g. addition of FEC redundancy and / or unicast file repair). When activated via the V2X USD, the VAE client provides reception feedback such as reception acknowledgement to the 3GPP network system.

5. When activated via xMB Session procedures, the 3GPP network system provides feedback or notification, optionally containing information from receivers to the VAE server.

### 7.19.2 Solution evaluation

The solution supports the usage of xMB Non-Transparent Session Types. The VAE server makes use of 3GPP network system (BM-SC) for delivering large files or V2X messages to the VAE client.

## 7.20 Solution #20: Support for file transfer

### 7.20.1 Solution description

#### 7.20.1.1 General

This solution addresses the key issue 16 on large file transfer. The VAE client and the VAE server supports the file upload and download services for the V2X applications.

#### 7.20.1.2 Procedure for file upload using HTTP

The procedure in figure 7.20.1.2-1 describes the case where the user at V2X UE is uploading a file to the V2X application server.

Pre-condition:

- The V2X UE is authorized to upload file to the V2X application specific server.



Figure 7.20.1.2-1: File upload using HTTP

1. The V2X application specific client triggers a file upload with the VAE client. The information (e.g. target destination) of the file is made available to the VAE client.

2. The VAE client sends the file information to the VAE server for storing using the file upload request.

3. The VAE client performs HTTP based file upload to the VAE server.

4. The VAE server stores the received file and provides a file upload response indicating success (along with file URL to the VAE client) or failure.

5. The VAE client provides the uploaded file information (obtained in step 4) to the V2X application specific client.

6. The VAE server provides the file to the V2X application specific server.

#### 7.20.1.3 Procedure for file download using HTTP

The procedure in figure 7.20.1.3-1 describes the case where the user at V2X UE is downloading a file from the V2X application specific server.

Pre-conditions:

1. The V2X UE is authorized to download file (e.g. HD map) from the V2X application specific server; and

2. The V2X application specific client has the file URI that is to be downloaded.

3. The VAE server provides the file corresponding to the file URI available with V2X application specific client.



Figure 7.20.1.3-1: File download using HTTP

1. The V2X application specific client triggers a file download with the VAE client. The information (e.g. file URI) of the file is made available to the VAE client.

2. The VAE client sends a file download request to the VAE server based on the information in the file URI.

3. The VAE server performs HTTP based file download to the VAE client.

4. The VAE server provides a file download response indicating success or failure to the VAE client.

5. The VAE client provides the downloaded file to the V2X application specific client.

### 7.20.2 Solution evaluation

This is a viable technical solution that addresses key issue 16 where the VAE client and VAE server can provide file upload and file download capabilities to support handling large files for the V2X application layer.

## 7.21 Solution #21: Resolving UE address for ETSI ITS facility layer messages

### 7.21.1 Solution description

#### 7.21.1.1 General

This solution corresponds to key issue 18. The solution relies on the V2X UE providing geographical location/area information to the VAE server. This information is used by the VAE server to create a mapping between the geographical location and the identification of the V2X UE. The solution focuses on unicast scenarios.

#### 7.21.1.2 Procedure for tracking geographical location at the VAE server

Pre-conditions:

1. The address of the VAE server is known to the VAE client; and

2. The VAE client has established a relation with a specific geographical area (e.g., by subscribing to a certain URL which corresponds to a geographical area, or through a tile identifier that represents a certain geographical area, or geo-fence tile identifier).

NOTE: How the VAE client retrieves the geographical area information (e.g., calculating locally at the client or through a geo-lookup) is for further study.



Figure 7.21.1.2-1: Solution for tracking the client geographical area/location at the VAE server

1. The VAE client provides geographic location/area information (e.g., subscription URL, tile identifier) to the VAE server. Upon entering a new geographical area, the client updates the geographic location/area information by reporting a new tile identifier or subscribing to a new content URL or geo-fence tile identifier.

2. The VAE server considers the geographical area information (e.g., subscription URL or tile identifier or geo-fence tile identifier) with the client identification information to create a mapping. Note that the identification information of the client can be extracted from the reporting/subscription message in step 1.

#### 7.21.1.3 Procedure for message delivery to target geographical locations from the VAE server

Pre-condition:

- The VAE server has created a mapping between geographical location/area information and client identification.



Figure 7.21.1.3-1: Solution for delivering messages to target geographical locations from the VAE server

1. The application-specific server sends an ETSI ITS message (e.g., DENM, CAM) with target geographical locations.

2. The VAE server determines the client identification for the intended clients in the target geographic locations using the mapping as specified in subclause 7.21.1.2.

3. The VAE server transmits the message to each VAE client using the client identification.

4. The VAE client provides the ETSI ITS message to the application-specific client.

NOTE: The procedures for message delivery are not limited to ETSI ITS messages.

### 7.21.2 Solution evaluation

This is a viable solution to enable unicast delivery of ETSI ITS facility layer messages over 3GPP Uu. The solution is independent of the geographical area identification (e.g., tile identifier or content subscription) and exploits the VAE capabilities to create the mapping between geographical area/location and client identification.

## 7.22 Solution #22: Resolving security issues for ETSI ITS distribution

### 7.22.1 Solution description

#### 7.22.1.1 General

This solution partially corresponds to key issue 19 and provides a generic capability filtering mechanism at the VAE server and the VAE client. The key issue 19 is such an example in the security context, where two incompatible versions of ITS security protocol stack in the ETSI ITS communication architecture exist.

#### 7.22.1.2 Procedure for V2X UE to V2X application server communication scenario

Pre-condition:

- The VAE server maintains lists of V2X application specific servers that support different capabilities.



Figure 7.22.1.2-1: Solution for delivering messages from V2X UE to V2X application server

1. The V2X application specific client identifies the supported capability for the message.

2. The V2X application specific client sends the processed message to the VAE client with an identification of the capability used for this message.

3. The VAE client forwards the processed message to the VAE server with the identification of the capability.

4. According to the pre-condition, the VAE server identifies the V2X application-specific server supporting the indicated capability.

Editor's note: The impact on network-based addressing of the V2X application server is FFS.

5. The VAE server sends the processed message to the V2X application-specific server supporting the correct capability.

6. The V2X application specific server processes the message.

#### 7.22.1.3 Procedure for V2X application server to V2X UE communication scenario

Pre-conditions:

1. The VAE server maintains respective lists of UEs supporting different capabilities; and

2. The VAE client maintains respective lists of V2X application clients in the same UE supporting different capabilities.



Figure 7.22.1.3-1: Solution for delivering messages from V2X application server to V2X UEs

1. The V2X application specific server identifies the supported capability for the message.

2. The V2X application specific server sends the processed message to the VAE server with an indication of the capability used for this message.

3. According to the pre-condition 1, the VAE server finds out V2X UEs supporting the identified capability.

4. The VAE server sends the processed message to the VAE clients of identified V2X UEs in step 3.

5. According to the pre-condition 2, the VAE client finds out the V2X application specific client supporting the identified capability.

6. The VAE client sends the processed message the V2X application specific client supporting the indicated capability.

7. The V2X application specific client processes the message.

### 7.22.2 Solution evaluation

The solution provides a generic mechanism at the VAE to support interoperability between V2X application clients and V2X application services supporting multiple capabilities. This solution enables the V2X applications using the same version of ETSI ITS security protocol stack to communicate with each other over the Uu interface.

## 7.23 Solution #23: Supporting V2X dynamic group communication over Uu

### 7.23.1 Solution description

#### 7.23.1.1 General

This solution addresses the key issue 20 where enabling layer supports V2X UEs in the Uu communication range, with application layer V2X dynamic group formation and communication.

In this solution, 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), checking if there is an existing dynamic group for the group definiton and delivery of dynamic group communication over Uu interface. The VAE server is responsible for assigning a ProSe Layer-2 Group ID from the ProSe Layer-2 Group ID pool corresponding to the V2X application specific server provided dynamic group formation and then delivering the assignment of the ProSe Layer-2 Group ID and the V2X dynamic group formation to the VAE client over V1 reference point.

VAE client may further broadcast the dynamic group formation including corresponding ProSe Layer-2 Group ID to other VAE clients within the PC5 communication proximity, enabling more V2X UEs to join the dynamic group.

When there is loss of connectivity at the V2X UEs with the network, 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.

#### 7.23.1.2 VAE server configuring dynamic group parameters procedure

The VAE server pushes the assignment of V2X dynamic group IDs with ProSe Layer 2 IDs to the V2X UE, requesting to form dynamic group.

The procedure for pushing V2X ProSe dynamic group communication parameters to VAE client over V1 reference point is illustrated in figure 7.23.1.2-1.

Pre-conditions:

1. V2X application dynamic group is defined at the V2X application specific server with V2X UE 2 assigned as dynamic group leader; and

2. VAE server has a pool of the ProSe Layer-2 Group IDs to be assigned.



Figure 7.23.1.2-1: VAE server configuring dynamic group parameters

1. The V2X application specific server requests the VAE server to configure dynamic group including dynamic group information (e.g. dynamic group ID, V2X group member, group definition).

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 triggers a push request including PC5 parameters and dynamic group information to the VAE client 2.

4. The VAE client 2 stores the received dynamic group parameters from the VAE server.

NOTE: The VAE client 2 can engage in the group communication over Uu interface.

#### 7.23.1.3 Enabling V2X UEs to join V2X dynamic group procedure

The procedure for VAE client broadcasting the dynamic group formation to the V2X UEs in the PC5 communication proximity is illustrated in figure 7.23.1.3-1.

Pre-conditions:

1. The dynamic group parameters received from the VAE server are available at VAE client 2 as per the procedure in subclause 7.23.1.2; and

2. VAE client 1 is in PC5 communication proximity to VAE client 2 (dynamic group leader) and is listening on a PC5 channel dedicated for V5-AE communications.



Figure 7.23.1.3-1: Enabling V2X UEs to join V2X dynamic group

1. The VAE client 2 broadcasts PC5 parameters and the dynamic group information using PC5 channel dedicated for V5-AE communications and received by the VAE client 1 which is in the PC5 communication proximity.

2. The VAE client 1 stores the received PC5 parameters and the dynamic group formation in the V2X UE 1.

3. The V2X UE 1 may join the dynamic group and engage in the group communication over Uu interface.

NOTE: The VAE client 1 can discard the received information in step 1, if the V2X application specific client does not join the dynamic group.

#### 7.23.1.4 Switching from Uu to PC5 V2X communications controlled by UE procedure

The procedure for V2X dynamic group communication switching from Uu communication to PC5 communication is illustrated in figure 7.23.1.4-1.

Pre-conditions:

1. V2X dynamic group PC5 parameters are already configured on both the V2X UEs, as per the procedures in subclause 7.23.1.2 or subclause 7.23.1.3; and

2. V2X UE 1 and V2X UE2 are engaged in dynamic group communication over Uu interface.



Figure 7.23.1.4-1: Switching from Uu to PC5 V2X communications controlled by UE

1. V2X UEs engaged in dynamic group communication over Uu interface, moved to an area where they have lost connectivity with the network.

2. The VAE UEs engaged in dynamic group communication switch to ProSe direct communication using the PC5 parameters already configured for the dynamic group.

3. The V2X UEs continue their dynamic group communication over PC5 interface.

### 7.23.2 Solution evaluation

This solution supports the VAE server to configure dynamic group parameters including PC5 parameters and dynamic group formation information corresponding to the dynamic group created by the V2X application specific server. Further this solution enables V2X UEs to join an existing V2X dynamic group. This solution also supports V2X dynamic group communication by switching from Uu communication to PC5 communication. Switching from PC5 to Uu V2X communications controlled by UE procedure is required.

## 7.24 Solution #24: Supporting V2X dynamic group communication over PC5

### 7.24.1 Solution description

#### 7.24.1.1 General

This solution addresses the key issue 20 where enabling layer supports V2X UEs in the PC5 communication range, with application layer V2X dynamic group formation and communication.

In this solution, the V2X application specific client is responsible for V2X dynamic group information (including information like group ID assignment, group definition) and checking if there is an existing dynamic group for the group definition. VAE client may further broadcast the dynamic group formation to other VAE clients within the PC5 communication proximity, enabling more V2X UEs to join the dynamic group.

#### 7.24.1.2 Enabling dynamic group formation procedure

The procedure for enabling layer supporting V2X UEs in the PC5 communication range, with the application layer V2X dynamic group formation and communication is illustrated in figure 7.24.1.2-1.

Pre-conditions:

1. V2X UE 1 has received request to form a dynamic group; and

2. VAE client 2 is in the PC5 communication proximity of VAE client 1 and is listening on a PC5 channel dedicated for V5-AE communications.



Figure 7.24.1.2-1: Enabling dynamic group formation procedure

1. Each V2X UE is configured with unique pool of ProSe Layer 2 IDs, when they are still in the coverage area of the VAE server.

2. Uu connection is lost at the VAE client 1 and VAE client 2.

3. Upon receiving a request from the application specific client to create a dynamic group, the VAE client 1 assigns ProSe Layer-2 Group ID from the available ProSe Layer-2 Group ID pool (obtained from step 1) corresponding to the dynamic group formation information.

NOTE 1: If the dynamic group formation information matches with an existing dynamic group, the VAE client 1 joins the corresponding dynamic group and does not create a new dynamic group.

4. The VAE client 1 triggers a broadcast request including PC5 parameters and dynamic group formation information as per step 3, using PC5 channel dedicated for V5-AE communications.

5. Upon receiving the broadcast, the VAE client 2 stores the received PC5 parameters and the dynamic group formation information in the V2X UE.

NOTE 2: The VAE client 2 can discard the received information in step 5, if the V2X application specific client does not join the dynamic group.

NOTE 3: The VAE client 2 receiving the PC5 parameters and the dynamic group formation information can engage in the group communication over PC5 interface.

### 7.24.2 Solution evaluation

This solution supports the VAE client to form a dynamic group by assigning a ProSe Layer-2 Group ID from the ProSe Layer-2 Group ID pool to the V2X user provided dynamic group information.

## 7.25 Solution #25: Dynamic group management

### 7.25.1 Solution description

This solution addresses the dynamic group management in key issue 20. The VAE capabilities provides support for dynamic group management (e.g. creation, join, leave) based on the group configuration information (e.g. group join policy, dynamic group leader) provided by the V2X application layer. The decisions and corresponding triggers (e.g. group creation, join, leave) for group management are responsibility of the V2X application layer and the details of the group management are abstracted by the VAE capabilities. The V2X application layer mainly focuses on group communication over the dynamic groups.

#### 7.25.1.1 Group creation

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.

The procedure for group creation is illustrated in figure 7.25.1.1-1.

Pre-condition:

- The VAE client 1 has received a trigger for group creation from the V2X application specific client 1.



Figure 7.25.1.1-1: Group creation

1. The VAE client 1 sends group creation request to the VAE server.

2. The VAE server checks whether VAE client 1 is authorized. If authorized, the VAE server checks the group policy (e.g. limit for the maximum number of members allowed for the group if a VAE client list is included in step 1, limit for maximum number of groups that the VAE client 1 can create). If allowed, the VAE server allocates a unique group identity, creates and stores the information of the group including the group member if included, the dynamic group leader information, the group join policy, the associated ProSe layer-2 group identity used for ProSe direct communication within the group.

3. The VAE server sends the group creation response to the VAE client 1 with the group information and the associated ProSe layer-2 group identity. The VAE server provides the group information (e.g. group identity) to the corresponding V2X application specific server. Upon receiving the group information from the VAE server, the VAE client provides the group information to the corresponding V2X application specific client.

4. If VAE clients (group member) information is available, the VAE server sends the group creation notify to the VAE clients (group members).

#### 7.25.1.2 Group join controlled by the VAE server

The procedure for group joining controlled by the VAE server is illustrated in figure 7.25.1.2-1.

Pre-conditions:

1. The VAE server has the group information and broadcasts the group information to the geographical areas where it is relevant;

2. The VAE client 1 has discovered the group information from the VAE server and provided to the V2X application client 1; and

3. The VAE client 2 is the dynamic group leader.



Figure 7.25.1.2-1: Group join controlled by the VAE server

1. When triggered by the V2X application specific client 1 to join a group, the VAE client 1 sends group join request to the VAE server.

2. The VAE server checks group join policy including the limit for the maximum number of members allowed for the group.

3. If confirmation by dynamic group leader is required, the VAE server gets the group joining confirmation from the VAE client 2 (dynamic group leader).

4. If the VAE client 1 satisfies the group join policy, the VAE server adds the requesting VAE client 1 to the group and updates the group information.

5. The VAE server sends the group join response to the VAE client 1 with the group information and the associated ProSe layer-2 group identity.

6. The VAE clients of the group are notified about the joining of the VAE client 1.

#### 7.25.1.3 Group join over PC5 controlled by the authorized VAE client

The procedure for group joining over PC5 controlled by the authorized VAE client is illustrated in figure 7.25.1.3-1.

Pre-conditions:

1. The VAE server has the group information and broadcasts the group information to the geographical areas where it is relevant along with the dynamic group leader information;

2. The VAE client 1 has discovered the group information from the VAE server; and

3. The VAE client 2 is the dynamic group leader and can operate both on Uu and PC5.



Figure 7.25.1.3-1 Group join over PC5 controlled by the authorized VAE client

1. When triggered by the V2X application specific client 1 to join a group, the VAE client 1 sends group join request to the VAE client 2 (dynamic group leader) over PC5.

2. The VAE client 2 checks the group join policy including the limit for the maximum number of members allowed for the group.

3. If allowed, the VAE client 2 adds the requesting VAE client 1 to the group and updates the group information.

4. Other VAE clients of the group are notified about the joining of the VAE client 1.

5. The VAE client 2 sends the group join response to the VAE client 1 with the group information and the associated ProSe layer-2 group identity.

6. The VAE client 2 sends the group update notify to the VAE server.

### 7.25.2 Solution evaluation

This solution enables the dynamic group management support for the V2X applications (e.g. platooning) to allow the V2X application layer to create and join the groups. The V2X applications can initiate group communications using the group identity while all the dynamic group management aspects are abstracted and controlled by the VAE client and the VAE server.

## 7.26 Solution #26: Abstraction and control of network slice instance for V2X communications

### 7.26.1 Solution description

#### 7.26.1.1 General

This solution addresses the key issue 21. The VAE capabilities abstracts the network slice information and its usage from the V2X applications. In this solution, LoA is an example and this procedure can be used for application triggers requiring resource modification.

A resource modification request for the LoA (e.g. triggered by V2X UE or by V2X application specific server) may trigger adjustment of the network resources (impacting network slice) for the affected V2X UEs corresponding to the V2X service. The result may be dynamic modification of resources of the network slice instance (scale in/out, resource management policies) if this change affects multiple V2X UEs.

The VAE Server has the capability to translate the information related to the LoA for which resource modification is requested to appropriate network resource adjustment information for the network slice instance and to further communicate with the control plane of the 5GS (via NEF) for adjusting network slice instance parameters.

#### 7.26.1.2 Procedure

The solution is described in the high-level procedure illustrated in figure 7.26.1.2-1.

Pre-conditions:

1. The VAE server has the mapping relationship of LoA information and network slice instance information corresponding to the V2X services and the VAE server has provided this mapping relationship information to the VAE client;

2. The UE is connected to a network slice (assuming URLLC slice type), and is mapped to a Network Slice Instance by the 5G system;

3. V2X UE is attached to a network slice instance using the communication procedures as specified in 3GPP TS 23.501 [11], subclause 5.15.1; and

4. The VAE server receives periodically network and QoS monitoring as specified in subclause 7.7.1.4, which includes network slice analytics and performance monitoring information (e.g. slice congestion, load).



Figure 7.26.1.2-1: Abstraction and control of network slice instance for V2X communications

1. The VAE server sends periodic monitoring information of actual and predicted network metrics (e.g. delay, error rate) to VAE client to ensure up-to-date network resource situation.

2. The V2X application layer at the V2X UE triggers a resource modification for the LoA based on the network metrics and V2X UE context information.

3. The VAE client translates the information related to the LoA for which the resource modification was requested to a network metric adjustment information (e.g. change in bandwidth) and further sends a network resource adjustment request to the VAE server.

4. The VAE server communicates with the appropriate entity (e.g. NEF) of the underlying 3GPP network system to modify the network slice instance parameters and the resources involved in the V2X communications with the information of affected V2X UEs.

NOTE: The details for interaction with the underlying network for network slice resource modification is the responsibility of SA2.

5. The VAE server provides a success or failure indication via the network resource adjustment response to the VAE client

6. If the network resource adjustment was successful, the V2X UE performs the application layer adaptation corresponding to the resource modification for the LoA in coordination with other affected V2X UEs with the support of the V2X application specific server.

### 7.26.2 Solution evaluation

This solution enables VAE server to abstract and control the network slice instance aspects for V2X communications by supporting the translation of the application requirements to the network slice requirements and communicating with the underlying 3GPP network system(s). The details for interaction with the underlying network for network slice resource modification is the responsibility of SA2.

## 7.27 Solution #27: Switching the mode of operation for V2V communications controlled by network

### 7.27.1 Solution description

#### 7.27.1.1 General

This solution corresponds to key issue 22. The V2X services need to support different modes of operation for V2V (PC5 and Uu) communications. The V2X application layer requires to control the operation modes selection considering the V2V service KPIs as specified in 3GPP TS 22.186 [3].

The modes of operations can be configured based on network capabilities information available at the V2X application layer, in order to ensure V2V service KPI fulfilment in the following scenarios:

- The VAE server triggers switching the user plane configuration from direct (PC5) to in-direct (Uu) V2V, when the side-link conditions/QoS are expected to downgrade for single or pre-defined group of V2X-UEs (e.g. based on information from V2X UEs or from V2X application specific server).

- The VAE server triggers switching the user plane configuration from indirect (Uu) to direct (PC5) V2V, when the resource situation or network QoS are expected to downgrade for single or pre-defined group of V2X-UEs (based on the received monitoring events and/or network analytics).

#### 7.27.1.2 Switching from Direct (PC5) to Indirect (Uu) V2V communications

Figure 7.27.1.2-1 illustrates the solution where the V2V communications are switched from direct (PC5) to indirect (Uu) mode.

Pre-conditions:

1. The network situation and QoS monitoring procedure specified in subclause 7.7.1.3 has been initiated by VAE server and the network situation and QoS monitor reporting (e.g. congestion, load) is performed as specified in subclause 7.7.1.4;

2. The VAE server is provided with the KPI information for the V2V services; and

3. V2X UE 1 and V2X UE2 are engaged in direct (PC5) V2V session.



Figure 7.27.1.2-1: Switching from direct (PC5) to indirect (Uu) V2V communications

1. The V2X UEs periodically provide PC5 monitoring reports to the VAE server which includes information of the V2V service KPIs as received by the V2X UEs.

2. The VAE server monitors the PC5 conditions corresponding to the direct V2V session(s) and further decides to switch the mode of operation from direct (PC5) to indirect (Uu) for the on-going V2V session(s), if the KPIs for the V2V service communication are degraded.

3. The VAE server communicates with the appropriate entity (e.g. SCEF or NEF) of the underlying 3GPP network systems (EPS or 5GS) to establish indirect (Uu) V2V connectivity (PDN/PDU session and user plane path) with the information of V2X UEs and the new mode of operation.

4. The VAE server notifies about the change of mode of operation (PC5 to Uu) to the affected V2X UEs.

5. The VAE server notifies about the change of mode of operation (PC5 to Uu) to the V2X application specific server with the information of the V2X UEs and the V2V service.

6. The 3GPP network system applies the PDN/PDU session establishment on the V2X UEs.

#### 7.27.1.3 Switching from Indirect (Uu) to Direct (PC5) V2V communications

Figure 7.27.1.3-1 illustrates the solution where the V2V communications are switched from indirect (Uu) to direct (PC5) mode.

Pre-conditions:

1. The network situation and QoS monitoring procedure specified in subclause 7.7.1.3 has been initiated by VAE server and the network situation and per UE or UEs QoS monitor reporting is performed as specified in subclause 7.7.1.4;

2. The VAE server is provided with the KPI information for the V2V services; and

3. V2X UE 1 and V2X UE2 are engaged in indirect (Uu) V2V session.



Figure 7.27.1.3-1: Switching from indirect (Uu) to direct (PC5) V2V communications

1. Based on monitoring information available at the VAE server about the on-going V2V session(s), the VAE server estimates a QoS downgrade for the V2V indirect communication (e.g. uplink or downlink link degradations, congestions, overload) and decides to switch the mode of operation from indirect (Uu) to direct (PC5) for the V2V session(s).

2. The VAE server sends a change mode of operation request to the affected V2X UEs with the PC5 provisioning parameters.

3. Upon receiving the request from the VAE server, the V2X UEs performs discovery and authentication of the V2V communication. If the V2X UEs have already established PC5 control signaling (PC5-C), the PC5 needs to be modified using PC5-C to support direct data plane traffic exchange.

NOTE 1: If the PC5 session establishment cannot be performed (e.g. due to unavailability, failure to meet requirements by side-link); the indirect (Uu) V2V session continues till the V2X application layer decides the Level of Automation (LoA) change to adapt the QoS requirements for the service (see solution to key issue 1 specified in subclause 7.9.1).

4. The involved V2X UEs send a change mode of operation response to the VAE server indicating success or failure of the direct V2V session establishment.

NOTE 2: If the V2X UE sends an acknowledgement message upon receiving the change mode of operation request, then at step 4, the V2X UE sends the change mode of operation response as a notification message.

5. The VAE server communicates with the appropriate entity (e.g. SCEF or NEF) of the underlying 3GPP network systems (EPS or 5GS) to release the indirect V2V session (PDN/PDU session) with the information of V2X UEs and the new mode of operation.

6. The VAE server notifies about the change of mode of operation (Uu to PC5) to the V2X application specific server with the information of the V2X UEs and the V2V service.

### 7.27.2 Solution evaluation

This solution addresses key issue 22 and provides mechanisms where the VAE server switches the modes of operation for the V2V sessions over indirect (Uu) or direct (PC5) communications based on monitoring information.

# 8 Overall evaluation

## 8.1 General

The following subclauses contain an overall evalation of the solutions presented in this technical report, and their applicability to the identified key issues.

- Subclause 8.2 provides an evaluation of the high level architecture specified in subclause 7.1; and

- Subclause 8.3 lists the solutions for the key issues including impact on other working groups that will need consideration.

## 8.2 Architecture evaluation

The high level architecture solution in subclause 7.1.1 describes the baseline functional model for V2X application layer. A summary of the architecture and key issues specified in this technical report are listed in table 8.2-1.

Table 8.2-1: Architecture evaluation

| Architecture solution | Applicable key issues  (subclause reference) | Evaluation  (subclause reference) | Dependency on other working groups |
| --- | --- | --- | --- |
| Solution # 1: V2X application layer functional model | Supports all key issues specified in clause 5 | 7.1.2 | SA2 |

## 8.3 Key issue and solution evaluation

All the key issues and solutions specified in this technical report are listed in table 8.3-1. It includes the mapping of the key issues (clause 5) to the solutions and corresponding solution evaluations. Also it lists the impact on other working groups that will need consideration during the Release 16 normative phase.

Table 8.3-1: Key issue and solution evaluation

| Key issues | Solution | Evaluation  (subclause reference) | Dependency on other working groups |
| --- | --- | --- | --- |
| Key issue 1 - Communication of V2X application QoS requirements with 3GPP systems  Key issue 1a – Communication of V2X application network QoS requirements with 3GPP systems  Key issue 1b – Communication of V2X application PC5 QoS requirements with 3GPP systems | Solution #9: Abstraction of network QoS aspects for V2X communications (corresponds to Key issue 1a) | 7.9.2 | SA2 |
| Solution #10: Communication of V2X application PC5 QoS requirements with 3GPP systems  (corresponds to key issue 1b) | 7.10.2 | SA2 |
| Key issue 2 - Monitoring network situation of 3GPP systems by V2X application | Solution #7: Network situation and QoS monitoring | 7.7.2 | SA2 |
| Key issue 3 - V2X USD provisioning via V1 reference point | Solution #4: V2X USD provisioning via V1 reference point | 7.4.2 | None |
| Key issue 4 - Local service information | Solution #5: V2X UE obtaining the local service information | 7.5.2 | None |
| Key issue 5 - Service continuity during MBMS based V2X traffic | Solution #11: Switching from MBMS delivery to unicast | 7.11.2 | None |
| Key issue 6 - Handling MBMS bearer suspension | Solution #3: Handling MBMS bearer suspension via V1 | 7.3.2 | None |
| Key Issue 7 - V2X UE capabilities reporting | None | No solution is available. | None |
| Key issue 8 - PC5 parameters provisioning over V1 | Solution #6: PC5 parameters provisioning via V1 reference point | 7.6.2 | None |
| Key issue 9 – V2X group communication | Solution #12: Supporting for V2X group communication | 7.12.2 | None |
| Solution #13: Group communication parameters provisioning via V5 | 7.13.2 | None |
| Solution #14: Autonomous decision for assigning ProSe Layer-2 Group ID | 7.14.2 | None |
| Key issue 10 – UE location report over V1 | Solution #2: UE location report over V1 | 7.2.2 | None |
| Key issue 11 - Support for uplink video streaming | Solution #15: Support for uplink video streaming using FLUS framework | 7.15.2 | SA4 |
| Key issue 12 - Handling multiple V2X application priorities at the V2X UE | None | No solution is available | None |
| Key issue 13 - Communicating application requirements from the V2X application server | Solution #16: Communicating application requirements from the V2X application server | 7.16.2 | SA2 |
| Key issue 14 - Network assistance for enhancing QoE in V2X applications | Solution #17: Network assistance for enhancing QoE in V2X applications using SAND framework | 7.17.2 | SA4 |
| Solution #18: Support for QoE reporting | 7.18.2 | SA4 |
| Key issue 15 - V2X USD provisioning using existing MBMS service announcement mechanisms | Solution #8: V2X USD provisioning using SACH | 7.8.2 | None |
| Key issue 16 - Supporting larger files or V2X messages | Solution #19: Support for larger files using MBMS non-Transparent xMB Session Types | 7.19.2 | None |
| Solution #20: Support for file transfer | 7.20.2 | None |
| Key issue 17 - Determining UE location for a geographical area | None | No solution is available. | None |
| Key issue 18 - Resolving UE address for ETSI ITS facility layer messages | Solution #21: Resolving UE address for ETSI ITS facility layer messages | 7.21.2 | None |
| Key issue 19 - Resolving security issues for ETSI ITS distribution | Solution #22: Resolving security issues for ETSI ITS distribution | 7.22.2 | SA3 |
| Key issue 20 – V2X dynamic groups | Solution #23: Supporting V2X dynamic group communication over Uu | 7.23.2 | None |
| Solution #24: Supporting V2X dynamic group communication over PC5 | 7.24.2 | None |
| Solution #25: Dynamic group management | 7.25.2 | None |
| Key issue 21 – V2X application support for network slicing | Solution #26: Abstraction and control of network slice instance for V2X communications | 7.26.2 | SA2 |
| Key issue 22 – Support for operation modes selection for V2V communications | Solution #27: Switching the mode of operation for V2V communications controlled by network | 7.27.2 | None |
| Key issue 23 – Support for service continuity between Uu and UE-to-network relay for V2X communications | None | No solution is available. | None |

Apart from the key issue 21, all the key issues are applicable for EPS. The key issue 21 is only applicable for 5GS. As 5GS does not currently support functionalities (e.g. ProSe, MBMS) required for V2X communications, several key issues as listed in table 8.3-1 cannot be applicable for 5GS. Further study is required to complete these solutions to be enabled over 5GS.

The key issues and solutions which are enabled over EPS shall be considered for the normative phase.

# 9 Conclusions

This technical report fulfills the objectives of the study on application layer support for V2X services enabled on 3GPP systems (EPS, 5GS), including the following:

1) Identification of key issues (clause 5) and corresponding architecture requirements (subclause 6.2) for V2X application enabler capabilities.

2) Analysis of existing V2X standardization activities (clause 4) related to 3GPP V2X service requirements, 3GPP EPS architecture for V2X communications, ETSI ITS communication architecture and requirements and SAE and related standards communication architecture and requirements.

3) Individual solutions (clause 7) addressing the key issues including the solution for functional model for V2X application layer (subclause 7.1)

4) Overall evaluation (clause 8) of all the solutions

The results from the study will be considered for follow-up normative work in Release 16 as follows:

1) The architecture requirements (in clause 6) will be considered as the basis for technical specification with necessary enhancements and additions;

2) The solution for V2X application layer functional model (subclause 7.1) will be used as the baseline functional model with necessary enhancements as appropriate;

3) The key issues (clause 5) and individual solutions (clause 7) enabled over EPS are considered to be the candidate solutions with necessary enhancements as appropriate, according to the overall evaluation (clause 8) and the functional model (subclause 7.1).

There are dependencies on 3GPP groups identified in the overall evaluation (clause 8) which are required for fulfilling the solutions (clause 7).

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2018-01 | SA6#21 |  |  |  |  | TR skeleton | 0.0.0 |
| 2018-01 | SA6#21 |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-180150, S6-180153, S6-180159, S6-180202, S6-180203, S6-180204, S6-180205, S6-180207, S6-180208, S6-180227, S6-180228, S6-180229 | 0.1.0 |
| 2018-03 | SA6#22 |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-180304, S6-180332, S6-180407, S6-180413, S6-180414, S6-180469, S6-180474, S6-180475, S6-180476, S6-180482, S6-180494, S6-180499 | 0.2.0 |
| 2018-04 | SA6#23 |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-180553, S6-180641, S6-180645, S6-180646, S6-180647, S6-180656, S6-180657, S6-180696, S6-180697, S6-180698, S6-180699, S6-180701, S6-180703, S6-180712, S6-180713, S6-180725, S6-180742 | 0.3.0 |
| 2018-05 | SA6#24 |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-180833, S6-180834, S6-180884, S6-180891, S6-180893, S6-180895, S6-180922, S6-180924, S6-180925, S6-180926, S6-180931, S6-180932, S6-180934, S6-180936, S6-180945, S6-180946, S6-180947, S6-180949, S6-180952, S6-180955, S6-180956, S6-180957, S6-180958, S6-180959, S6-180960, S6-180961 | 0.4.0 |
| 2018-06 | SA#80 | SP-180377 |  |  |  | Submitted to SA#80 for information | 1.0.0 |
| 2018-07 | SA6#25 |  |  |  |  | Implementation of the following pCRs approved by SA6:  S6-181093, S6-181099, S6-181153, S6-181159, S6-181160, S6-181165, S6-181172, S6-181229, S6-181230, S6-181232, S6-181233, S6-181235, S6-181237, S6-181238, S6-181239, S6-181240, S6-181258, S6-181272, S6-181273, S6-181274, S6-181285, S6-181286 | 1.1.0 |
| 2018-09 | SA#81 | SP-180682 |  |  |  | Submitted to SA#81 for approval | 2.0.0 |
| 2018-09 | SA#81 | SP-180682 |  |  |  | MCC Editorial update for publication after TSG SA approval (SA#81) | 16.0.0 |
| 2018-12 | SA#82 | SP-181181 | 0001 |  | D | Proposal for Definitions clause | 16.1.0 |
| 2018-12 | SA#82 | SP-181181 | 0002 | 1 | F | Solution evaluation for the solution on support for QoE reporting | 16.1.0 |