5GAA TR A-200094

Working Group System Architecture and Solution Development

V2X Application Layer Reference Architecture

5GAA

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Contents

Foreword

This Technical Report has been produced by 5GAA.

The contents of the present document are subject to continuing work within the Working Groups (WG) and may change following formal WG approval. Should the WG modify the contents of the present document, it will be re-released by the WG with an identifying change of the consistent numbering that all WG meeting documents and files should follow (according to 5GAA Rules of Procedure):

x-nnzzzz

(1) This numbering system has six logical elements:

(a) x: a single letter corresponding to the working group:

where x =

T (Use cases and Technical Requirements)

A (System Architecture and Solution Development)

P (Evaluation, Testbed and Pilots)

S (Standards and Spectrum)

B (Business Models and Go-To-Market Strategies)

(b) nn: two digits to indicate the year. i.e. 17, 18, 19, etc.

(c) zzzz: unique number of the document

(2) No provision is made for the use of revision numbers. Documents which are a revision of a previous version should indicate the document number of that previous version

(3) The file name of documents shall be the document number. For example, document S-160357 will be contained in file S-160357.doc

Introduction

This document addresses the 5GAA WG2 work item 'V2X Application Layer Reference Architecture (V2XSRA)'.

1 Scope

The scope of this document covers the deliverable 'WG2-00XX' as described in [5GAA V2XSRA] under 'Expected output and Time Scale'.

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.

[5GAA V2XSRA] 5GAA Work Item Description A-180236: 'V2X System Application Layer Reference Architecture'

[3GPP TS 23.285] 3GPP TS 23.285: 'Architecture Enhancements for V2X Services'

[3GPP TS 23.286] 3GPP TS 23.286: 'Application Layer Support for V2X Services'

[3GPP TS 23.434] 3GPP TS 23.434: 'Service Enabler Architecture Layer for Verticals (SEAL)'

[CAM] ETSI EN 302 637-2: 'ETSI ITS: Specification of Cooperative Awareness Basic Service'

[DENM] ETSI EN 302 637-3: 'ETSI ITS: Specifications of Decentralised Environmental Notification Basic Service'

[IVIM] ETSI TS 103 301: 'ETSI ITS: Facilities Layer and Communication Requirements for Infrastructure Services'

[SREM] ETSI ITS 103 301: 'ETSI ITS: Facilities Layer and Communication Requirements for Infrastructure Services'

[SSEM] ETSI ITS 103 301: 'ETSI ITS: Facilities Layer and Communication Requirements for Infrastructure Services'

[SPATEM] ETSI ITS 103 301: 'ETSI ITS: Facilities Layer and Communication Requirements for Infrastructure Services'

[MAPEM] ETSI ITS 103 301: 'ETSI ITS: Facilities Layer and Communication Requirements for Infrastructure Services'

[BSM] SAE J2735: 'Dedicated Short Range Communications (DSRC) Message Set Dictionary'

[PSM] SAE J2735: 'Dedicated Short Range Communications (DSRC) Message Set Dictionary'

[DATEX II] DATEX II: 'DATEX II Downloads'

[SENSORIS] SENSORIS: 'SENSORIS Specification'

[HTTP] IETF: 'IETF RFC 7230'

[MQTT] ISO/IEC: 'ISO/IEC PRF 20922'

[AMQP] OASIS: 'OASIS Advanced Message Queuing Protocol (AMQP) Version 1.0' or 'ISO/IEC 19464:2014 Advanced Message Queuing Protocol (AMQP) v1.0 Specification'

[C-Roads Platform] C-Roads Platform: 'Harmonised C-ITS Specifications for Europe – Release 1.5'

3 Abbreviations

3.1 Abbreviations

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

AMQP	Advanced Message Queuing Protocol
App	Application
AS	Application Server
BSM	Basic Safety Messages
HMI	Human-Machine-Interface
CAM	Cooperative Awareness Message
C-ITS	Cooperative Intelligent Transport System
DATEX II	Data Exchange II
DENM	Decentralised Environmental Notification Message
HMI	Human Machine Interface
HTTP	Hypertext Transfer Protocol
IF	Interchange Function
IOO	Infrastructure Owner Operator
IVIM	In-Vehicle Information Message
OEM	Original Equipment Manufacturer
MAPEM	Map (topology) Extended Message
MBMS	Multimedia Broadcast Multicast Service
MNO	Mobile Network Operator
MQTT	Message Queue Telemetry Transport
PSM	Personal Safety Message
RTA	Road Traffic Authority
RTO	Road Traffic Operator
SDO	Standards Development Organisation
SENSORIS	SENSOR Interface Specification
SP	Service Provider
SPATEM	Signal Phase and Timing Extended Message
SREM	Signal Request Extended Message
SSEM	Signal request Status Extended Message
V2X	Vehicle-to-Everything
VRU	Vulnerable Road User

4 Overview

This technical report begins with an introduction to interoperability in chapter 5. In chapter 6, the application layer reference architecture is specified, including description of functional components and reference points.

5 Requirement of interoperability

5.1 Introduction to interoperability

Interoperability is a characteristic of a product or system to work with other products or systems, present or future, without any restrictions.

This technical report is about interoperability between functions on the application layer. Given the large ecosystem and extensive amount of services for connected vehicles, many diverse application layer protocols are needed. The requirements for interoperability vary depending on the endpoints of the application layer protocols.

5.2 Reference architecture and interoperability

The reference architecture facilitates identification of application layer protocols and understanding of the need for new standardisation. One example is that if the two endpoints of the application layer protocol are governed by different stakeholders, the need for standardisation of the application layer protocol is higher.

6 Application Layer Reference Architecture

6.1 Introduction

This section comprises the application layer reference architecture, description of all functional components and finally description of all reference points between the functional components in the architecture.

The objective of defining this application layer reference architecture is to identify application layer protocols in the automotive ecosystem, and to identify the lack of suitable application layer protocols and the need for new standardisation.

6.2 Stakeholders and their relationships

The automotive ecosystem has several stakeholders. The major stakeholders in the *operational part* of the automotive ecosystem are:

- Vehicle owners
- Vehicle Original Equipment Manufacturers (OEMs)
- Mobile Network Operators (MNOs)

- Road Traffic Authorities (RTAs)[1]
- Service Providers (SPs), e.g. navigation service providers and infotainment service providers

Beyond the operational part of the automotive ecosystem, many other stakeholders contribute to the entire automotive ecosystem, e.g. suppliers to Vehicle OEMs, MNOs, RTAs and SPs. These stakeholders are not included in this report.

The high-level business relationships between the major stakeholders are illustrated in Figure 1 below.

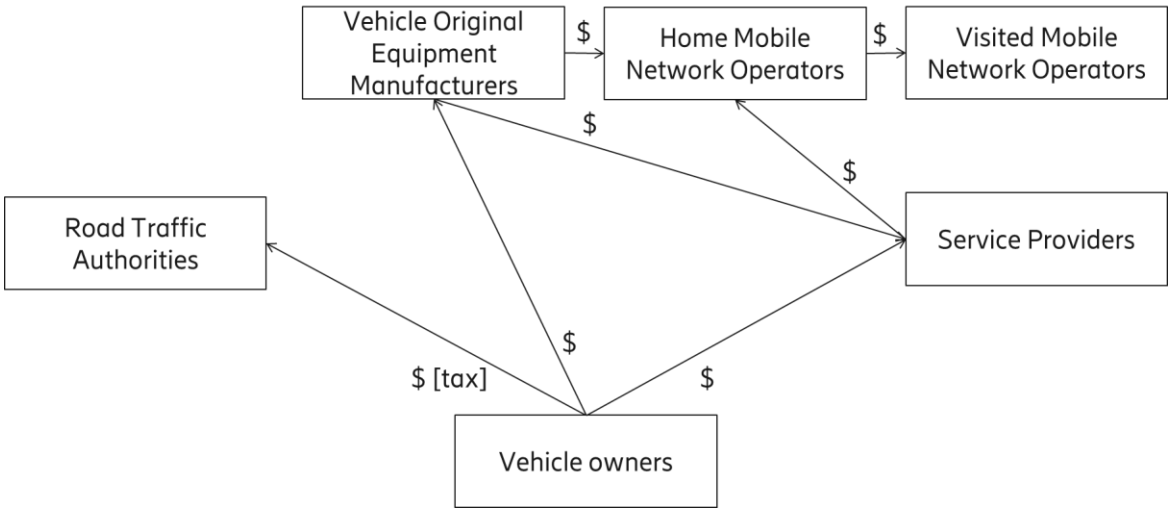

Figure 1: **Business relationships between stakeholders**

Vehicle owners are the primary source of revenue for the automotive ecosystem. They pay Vehicle Original Equipment Manufacturers for products and services and Service Providers for various services. Furthermore, they pay Road Traffic Authorities in their capacity as taxpayers.

Vehicle Original Equipment Manufacturers also pay Service Providers for various services. Furthermore, they have business relationships with a limited number of different Mobile Network Operators that provide connectivity to the vehicles.

Some Service Providers have business relationships with Mobile Network Operators for content distribution.

In order to offer global connectivity, Home Mobile Network Operators have roaming agreements with many Visited Mobile Network Operators.

6.3 Reference architecture

The application layer reference architecture is described from three different viewpoints:

- Functional view
- Deployment view

[1] Other terms are used in some regions, e.g. Road Traffic Operator (RTO) or Infrastructure Owner Operator (IOO)

- Implementation view

The functional view is described in section 6.3.1 and includes all automotive services. Several deployment views are described in section 6.3.2. Although several deployment views are provided, the views are only examples and the list of views is not exhaustive. The implementation view is described in section 6.3.3. The implementation view is only an example and many other implementations views are possible.

6.3.1 Functional view

The generic functional view is described in Figure 2 below. It consists of several functions (boxes) that are connected via different reference points (dotted lines). The generic functional view consists of pairs of Applications (Apps) and Application Servers (ASs). There are two ways to connect Application Servers, either directly (AS to AS) or indirectly via the Interchange Function (IF). The reference points are indicated by a capital letter G, followed by the two endpoints.

The generic functional view serves as a pattern to introduce functions in the functional view.

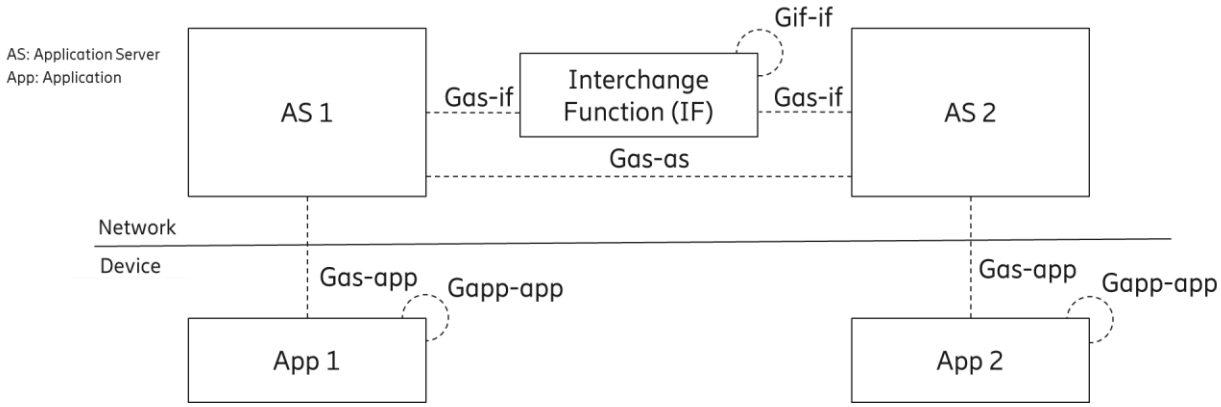

Figure 2: Generic functional view

The functional view of the V2X Application Layer Reference Architecture is described in Figure 3 below. It is based on the pattern of the generic functional view described above. Every reference point represents an application layer connection between the two functions. The transport, network and access layers are not part of this reference architecture.

The circular dotted lines indicate reference points between different instances of the same function. For example, the V0 is the reference point between two instances of V2X AS.

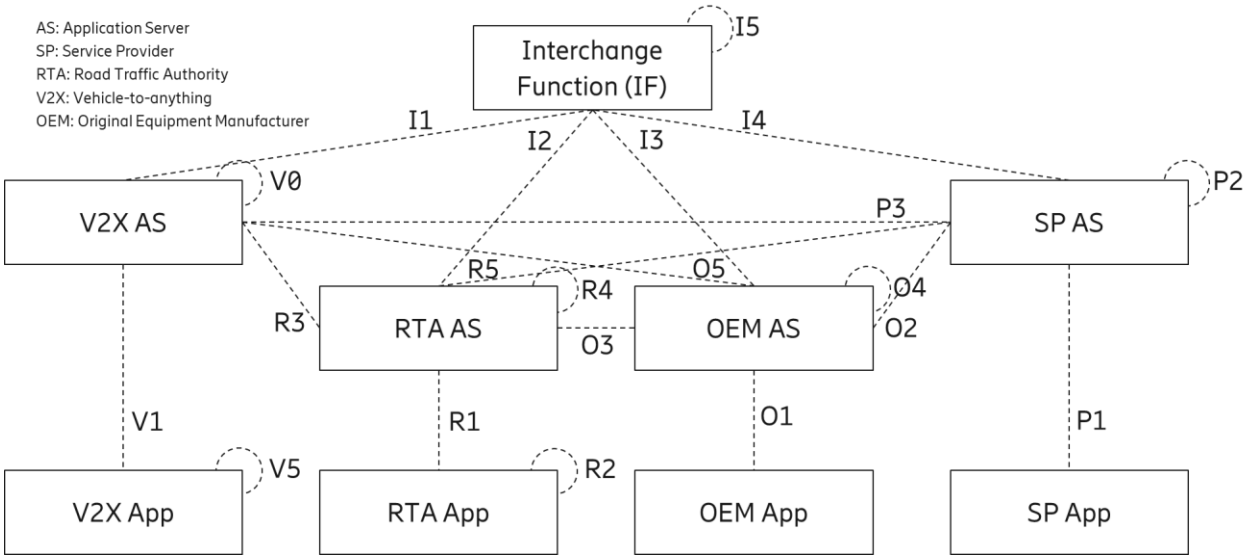

Figure 3: **Functional view with functional components and reference points based on the generic functional view**

Every AS may provide several services to the App.

The functions are described in section 6.4 and the reference points are described in section 6.5 below.

6.3.2 Deployment views

The functional components in the functional view may be deployed in many ways. In some deployment views all functional components are used, in other deployment views only a part of the functional components is used. In some deployment views, the geographical deployment is relevant, whereas in other deployment views the deployment according to different stakeholders is of interest. The content in the deployment view depends on what is being described.

In this document, the deployment views describe the different stakeholders' roles. The Application Servers and the Interchange Function are deployed in cloud systems, selected by different stakeholders, see section 6.4.2. The Apps are deployed in vehicles, in roadside infrastructure and in devices for Vulnerable Road Users (VRUs).

In the deployment view in Figure 4 below, the RTA is the stakeholder for RTA AS and the RTA AS is deployed in an RTA Cloud, i.e. a cloud system selected by the RTA. In the same way, the OEM is the stakeholder for OEM AS and the OEM AS is deployed in an OEM Cloud. Finally, the SP is the stakeholder for SP AS and the SP AS is deployed in an SP Cloud.

The V2X AS may have different stakeholders, in this case the MNO is the stakeholder for V2X AS and the V2X AS is deployed in an MNO Cloud.

In this deployment view, no Interchange Function is deployed. A deployment without Interchange Function can apply to deployments with a limited number of stakeholders.

The applications are deployed in different devices that make use of the services. The device for Vulnerable Road Users (VRUs) has a deployment of a V2X App and RTA App. The roadside

infrastructure has a deployment of an RTA App. Finally, the vehicle has a deployment of an OEM App, SP App, RTA App and V2X App.

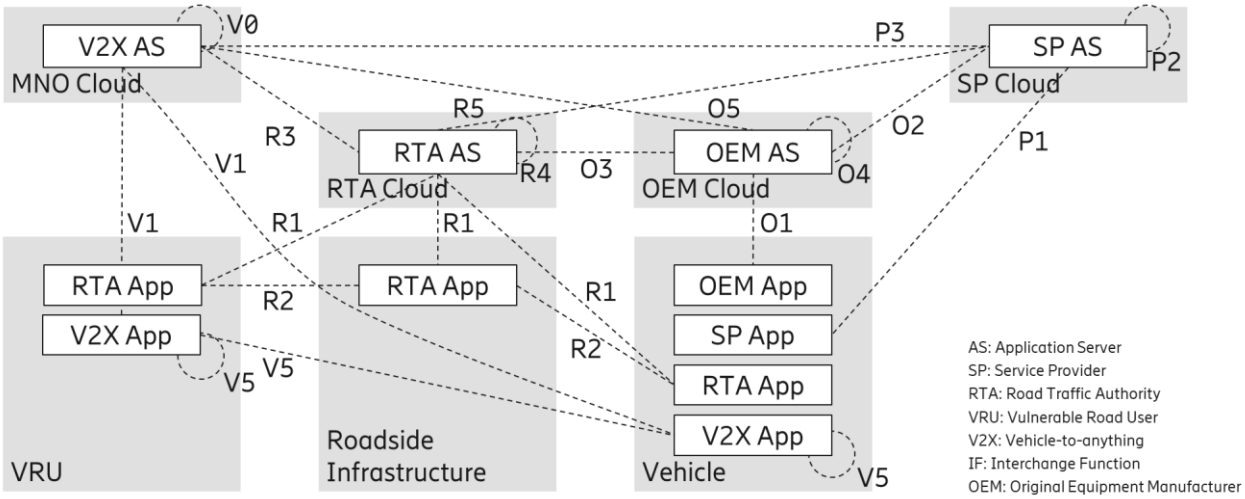

Figure 4: Deployment view with MNO stakeholder for V2X AS, no Interchange Function

The deployment view in Figure 5 below is similar to the deployment in Figure 4. The difference is that the IF is deployed. In this case, the MNO is the stakeholder for IF which is deployed in an MNO Cloud.

There is a large number of different RTAs in the world, in the order of thousands. The number of different OEMs in the world is in the order of tens. The RTAs are local, but the OEMs are global actors. It is a major challenge for OEMs to negotiate contract and setup communication for every RTA. The Interchange Function is needed to scale up traffic information message exchanges, primarily between RTA ASs and OEM ASs, but also SP ASs. The Interchange Function acts a message broker between the Application Servers. RTAs publish road traffic information to the Interchange Function, e.g. in DATEX II format, and OEMs subscribe to road traffic information from the Interchange Function, for all geographical areas where the OEMs' vehicles are located.

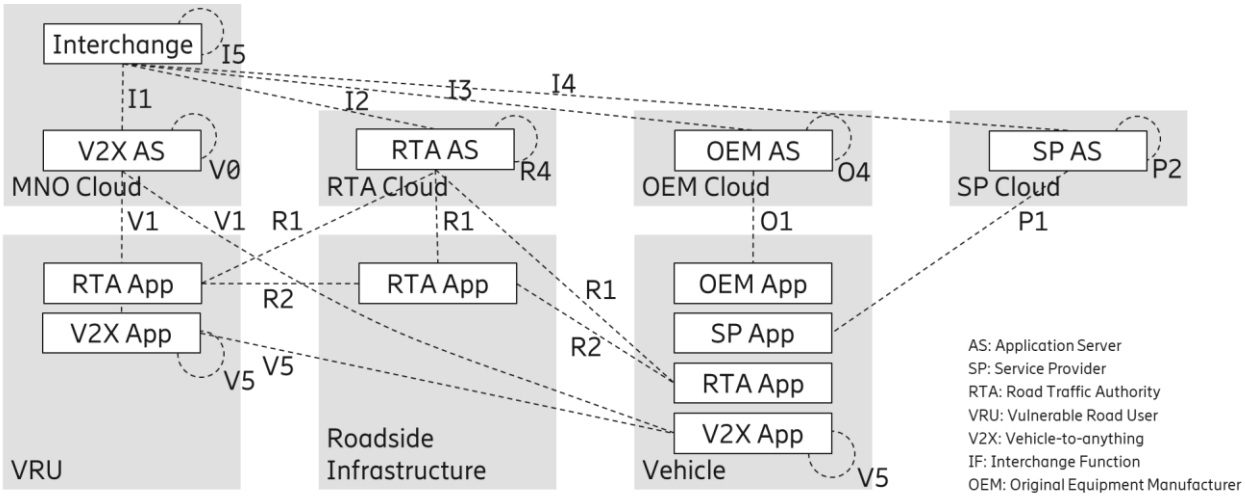

Figure 5: Deployment view with MNO stakeholder for V2X AS and Interchange Function

The deployment view in Figure 6 below is similar to the deployment in Figure 5. The difference is that the Interchange Function is deployed by a Service Provider who provides navigation services, for example. In this case the SP is the stakeholder for Interchange Function and the IF is deployed in an SP Cloud.

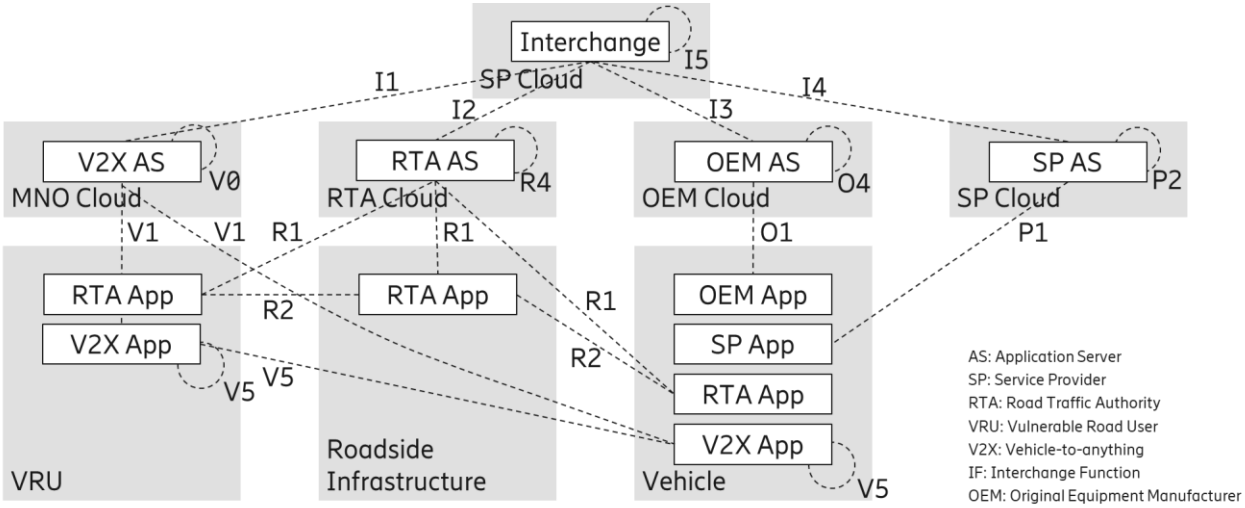

Figure 6: Deployment view with MNO stakeholder for V2X AS, SP stakeholder for Interchange Function

The deployment view in Figure 7 below is similar to the deployment in Figure 6. The difference is that the Interchange Function is deployed by a Road Traffic Authority (RTA). In this case the RTA is the stakeholder for Interchange Function and the IF is deployed in an RTA Cloud.

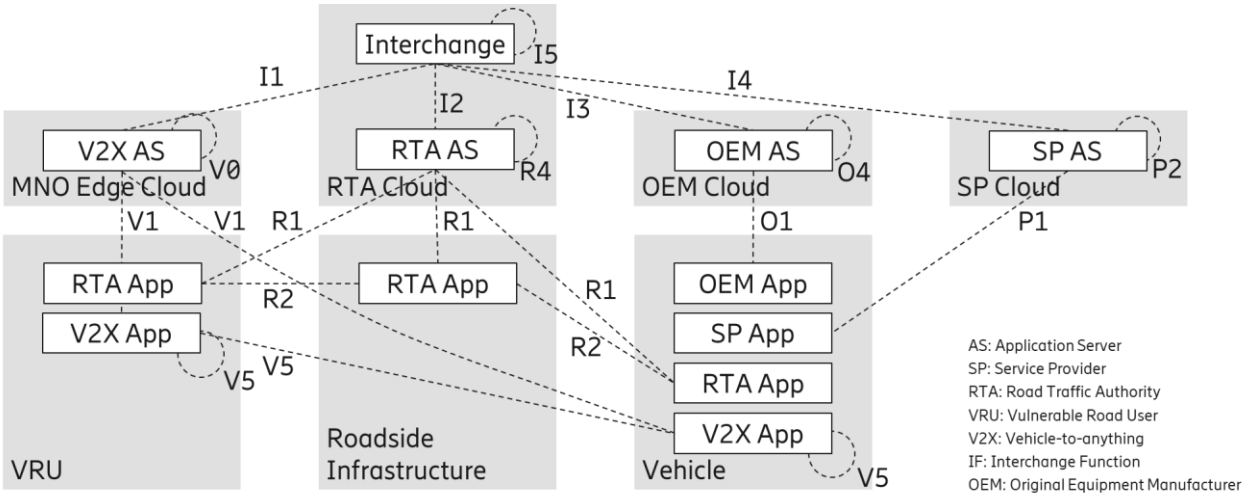

Figure 7: Deployment view with MNO stakeholder for V2X AS, RTA stakeholder for Interchange Function

The deployment view in Figure 8 below is similar to the deployment in Figure 7. The difference is that the Vehicle-to-anything Application Server (V2X AS) is deployed by a Road Traffic Authority. In this case the RTA is the stakeholder for V2X AS and the V2X AS is deployed in an RTA Cloud.

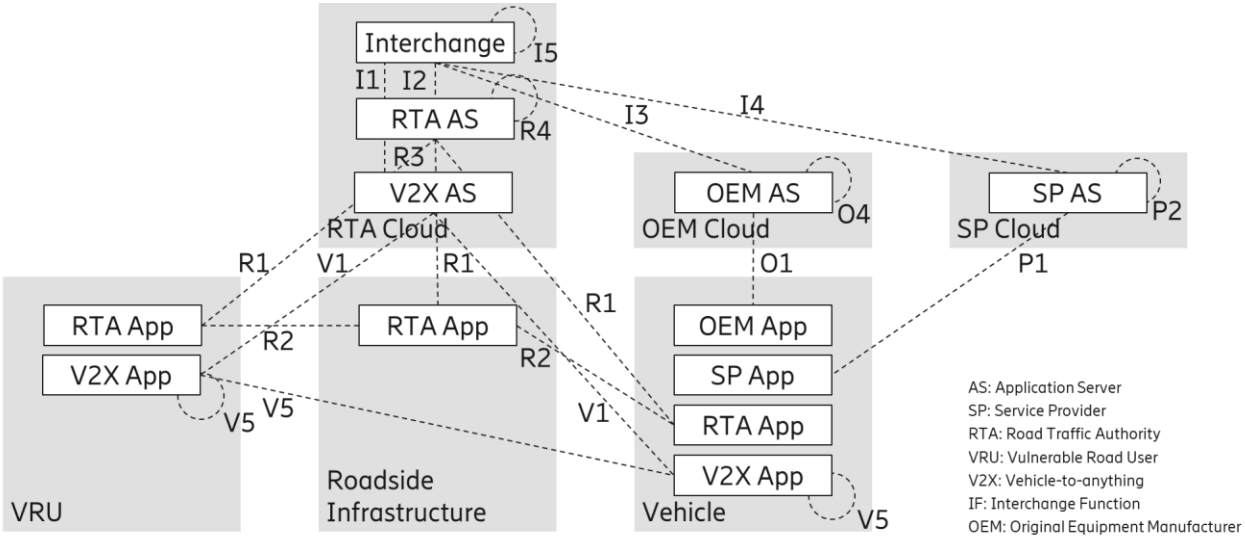

Figure 8: Deployment view with RTA stakeholder for V2X AS and Interchange Function

NOTE: Many more deployment views are possible.

6.3.3 Implementation views

The functional components in the V2X Application Layer Reference Architecture may be implemented in various ways. There are several platforms that can be used as a base for implementing the various functions. Platforms are available for both ASs and Apps. There are platforms based on both open source software and commercial software.

6.3.3.1 3GPP V2X Application Enabler (VAE) functional model

3GPP has specified a V2X application enabler in [3GPP TS 23.286]. The V2X application enabler can be common to all stakeholder functions. The V2X application enabler is specified in order to overcome the following limitations:

- High cost for the OEM, SP, RTA to understand and utilise the network capabilities, e.g. how to establish connections with Quality of Service, MBMS capability, network information/notification, network status and events.
- High cost and long lead-time for V2X application development and commercial deployment, as each V2X application has to implement the common basic functionalities, e.g. network situation, QoS monitoring, communication parameters provisioning (e.g. PC5 communication parameters), and network resource management.
- High cost and poor scalability for interworking, interoperation, and interchange among different AS stakeholders that may be using proprietary interfaces between different stakeholders.

To overcome the above limitations, the V2X application enabler layer provides the following enhancements and benefits:

- The underlying network capabilities are abstracted such that the OEM, SP, RTA can easily utilise them (e.g. easy to establish connections with Quality of Service, use MBMS capability, receive network notifications, network status and events).
- Common functionalities can be utilised by different V2X applications including the network situation and QoS monitoring, communication parameter (e.g. PC5), and network resource management.
- Interworking, interoperation, and interchange among different stakeholders is simplified via a unified enabler layer.
- Time to market for the V2X applications may be reduced.

The relationship between the 3GPP V2X application enabler (VAE), and the functional components V2X App and V2X AS in this Technical Report are described in Figure 9 below.

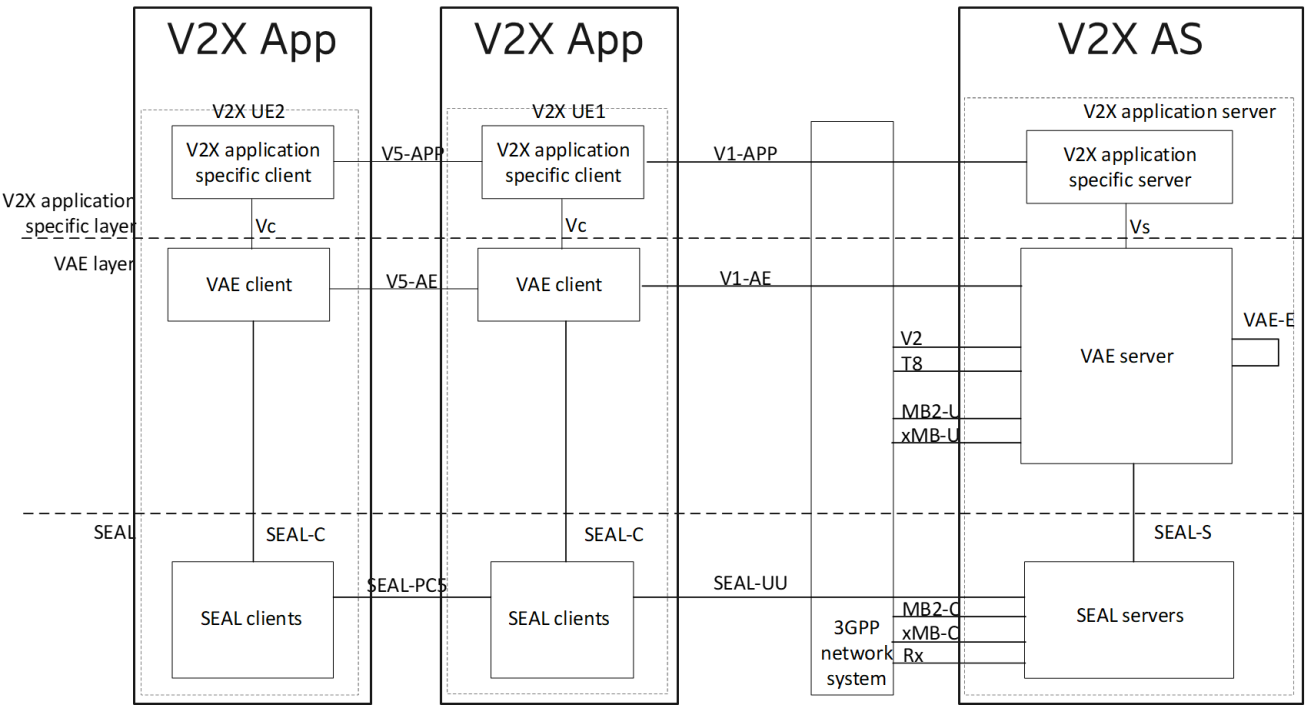

Figure 9: Relationship between 3GPP V2X Application Enabler [3GPP TS 23.286], Figure 6.2-2 and V2X AS and V2X App[2]

The V2X application enabler (VAE) is further composed of the following parts:

- **VAE client**: The VAE client provides client-side application support functions like messaging support, file transfer support, network monitoring events abstraction, communication mode switching of the underlying network, location augmentation, dynamic group management, etc. A more detailed list of such functionalities is specified for VAE client and SEAL client entities in [3GPP TS 23.286].
- **VAE server**: The VAE server provides server-side application support functions like abstracting the underlying network interactions for network resource management, tracking of location, message distribution, file transfer, network monitoring, group management, configuration management, identity management, etc. A more detailed list of such functionalities is specified for VAE server and SEAL server entities in [3GPP TS 23.286].

SEAL is a Service Enabler Architecture Layer operating over 3GPP networks which supports many vertical applications (e.g. V2X applications). SEAL services are specified in [3GPP TS 23.434].

The VAE may be provided by any of the stakeholders including MNOs, SPs, OEMs and RTAs.

The V2X application enabler also specifies the following reference points:

[2] The following reference points are defined in 3GPP TS 23.286: V2 (V2X AS - V2X control function), T8 (V2X AS - SCEF), MB2 (V2X AS - BM-SC), xMB (V2X AS - BM-SC) and Rx (V2X AS - PCRF).

- **V1-AE**: Interactions related to V2X application layer support functions between VAE client and VAE server are supported by the V1-AE reference point.
- **VAE-E**: Interactions related to V2X application layer support functions between one VAE server and another VAE server, supporting the same kind of V2X application specific server or different kinds of V2X application specific servers.
- **V5-AE**: Interactions related to V2X application layer support functions between the VAE clients are supported by the V5-AE reference point.

6.3.3.1.1 VAE server deployment models

The VAE server deployments can be centralised or distributed.

6.3.3.1.1.1 Centralised deployments

Centralised deployment is where a single VAE server is in place and offers its capabilities to one or more V2X application specific servers.

Among the different possibilities, the VAE server and the V2X application specific server may be co-located in a single physical entity, for instance in the V2X service provider domain. In this case, the Vs reference point between the VAE server and the V2X application enabler server may not be used.

Figure 10 illustrates such deployment options with only one MNO interacting with the VAE server located in the V2X service provider domain.

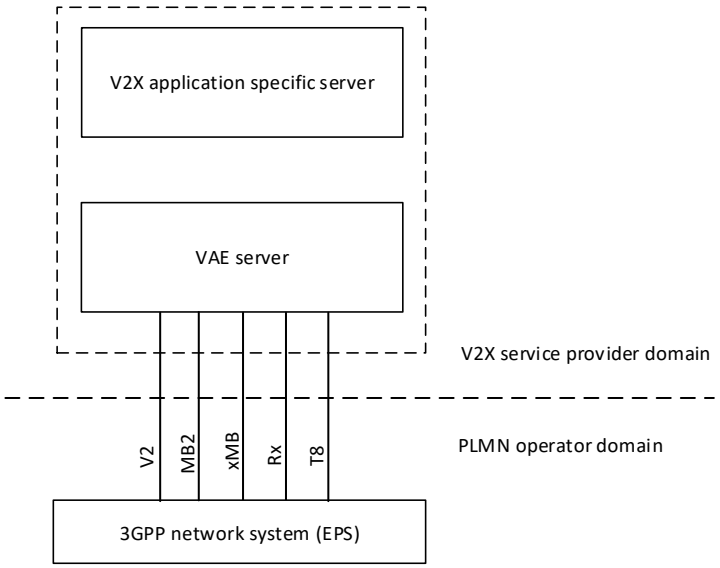

Figure 10: Centralised VAE server co-located with V2X application specific server with a single MNO, [3GPP TS 23.286], Figure 7.2.1-1

Similarly, multiple MNOs could be connected to the same centralised VAE server co-located with a V2X application specific server.

Figure 11 illustrates the VAE server and the V2X application specific server, co-located in a single entity and deployed in the V2X service provider domain and connected to the systems of multiple mobile network operators.

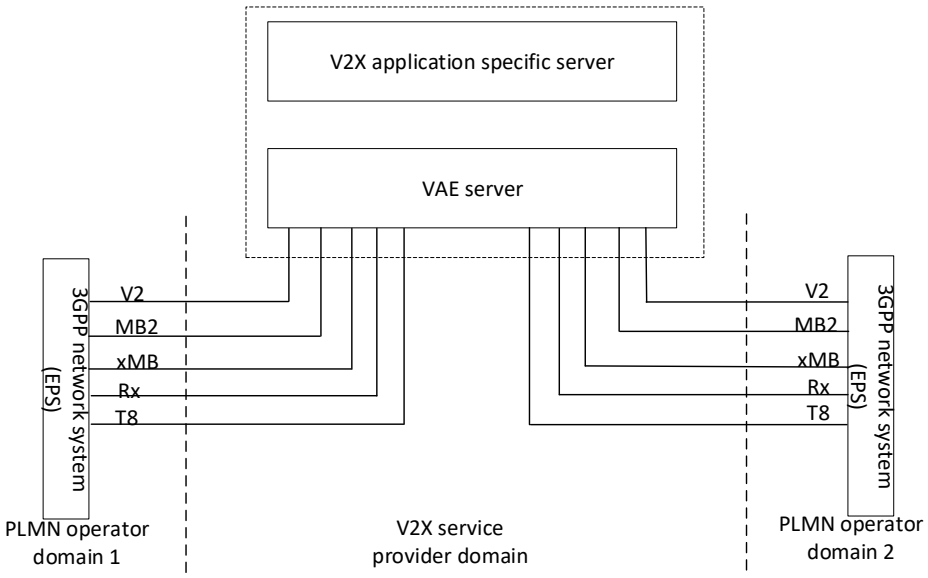

Figure 11: Centralised VAE server co-located with V2X application specific server with multiple MNOs, [3GPP TS 23.286], Figure 7.2.1-3

If necessary, the Vs reference point is used for communication between the VAE server and a V2X application specific server. The VAE server could eventually handle and support multiple V2X application specific servers.

This possibility offers two options:

- The VAE sever could be located in the PLMN operator domain while interacting with the V2X application specific server in the V2X service provider domain.
- The VAE server could provide VAE capabilities to multiple V2X application specific servers over the Vs reference points.

Figure 12 illustrates a deployment of the VAE server in the PLMN operator domain and the V2X application specific server in the V2X service provider domain.

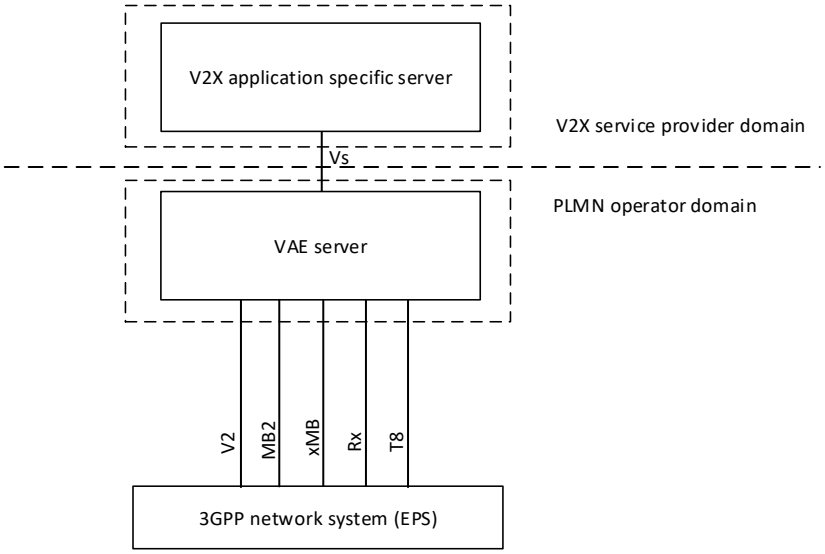

Figure 12: VAE server deployed in the PLMN operator domain, [3GPP TS 23.286], Figure 7.2.1-2

Figure 13 illustrates a deployment of the VAE server which provides VAE capabilities to multiple V2X application specific servers over Vs reference point.

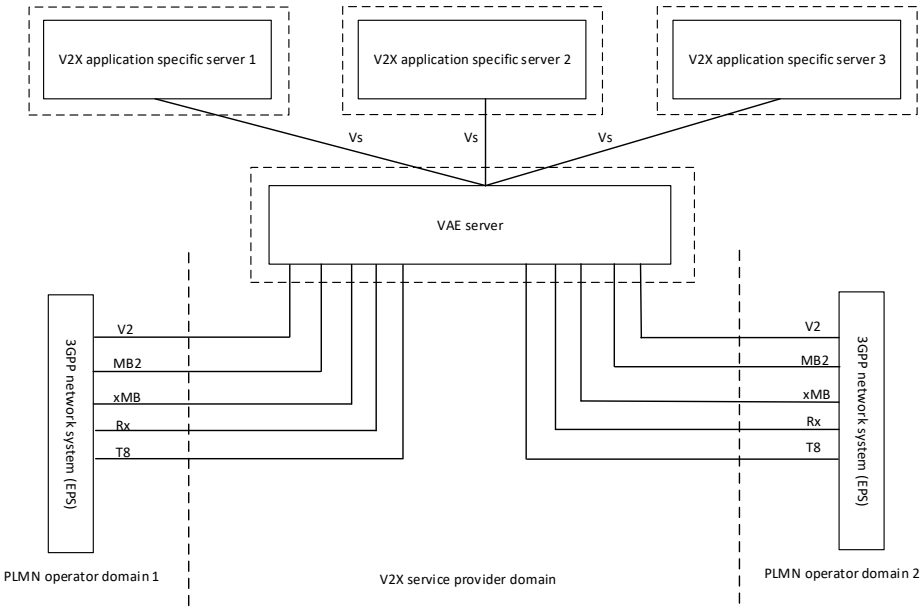

Figure 13: Centralised VAE server with multiple V2X application specific servers and multiple MNOs, [3GPP TS 23.286], Figure 7.2.1-4

6.3.3.1.1.2 Distributed deployment

Distributed deployment is where multiple instances of VAE servers are deployed either in the V2X service provider domain or in the mobile network operator domain. The distributed deployment of the V2X servers provide geographical coverage or support multiple PLMN operator domains in a geographical location.

The VAE servers interconnect via VAE-E and the Vs reference point is still used for interaction between V2X application specific server and the VAE server.

Figure 14 illustrates the deployment of mutliple VAE servers in different PLMN operator domains, all providing their VAE capabilities to a single V2X application specific server deployed in the V2X service provider domain. The V2X application specific server connects via Vs to the different VAE servers as usual.

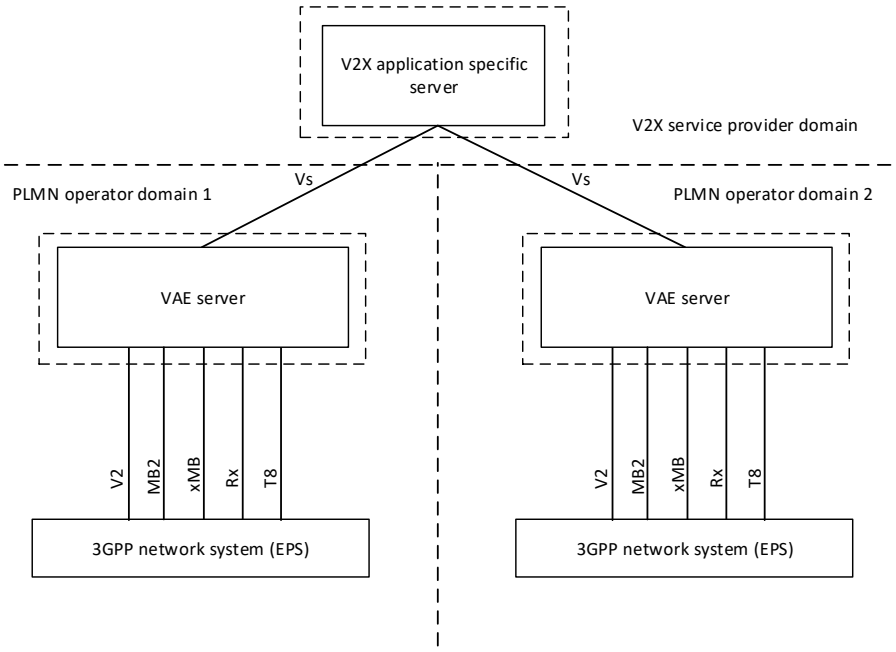

Figure 14: Distributed deployment of VAE servers in multiple PLMN operator domain without interconnection between VAE servers, [3GPP TS 23.286], Figure 7.2.2-1

Figure 15 illustrates the deployment of multiple VAE servers deployed in multiple PLMN operator domains. The V2X application specific server connects via Vs to the VAE server. The interconnection between VAE servers is via VAE-E and supports the V2X applications for the V2X UEs connected to the VAE servers in multiple PLMN operator domains.

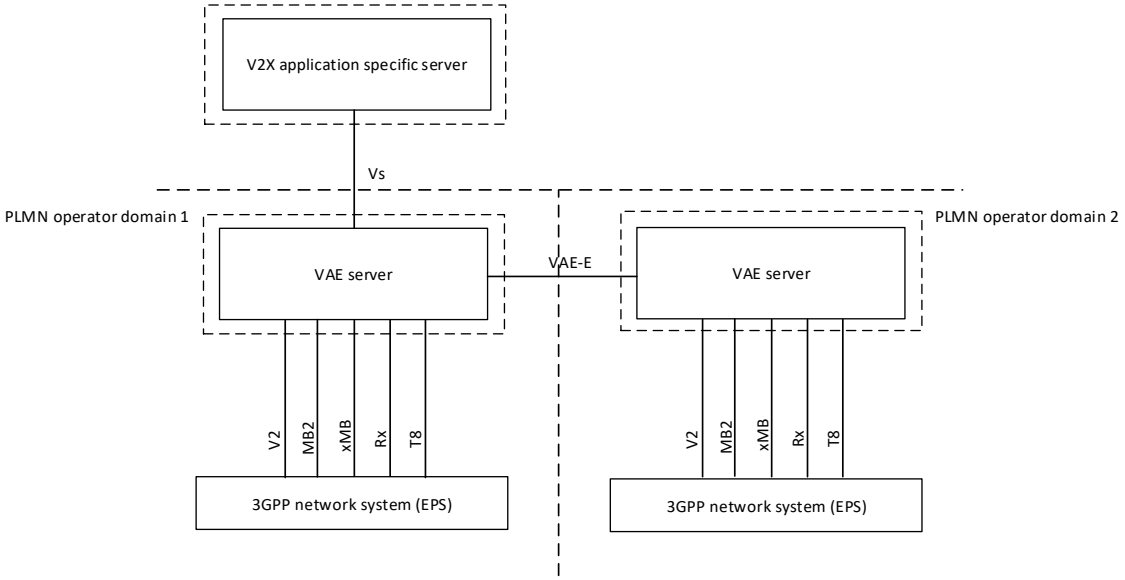

Figure 15: Distributed deployment of VAE servers in multiple PLMN operator domains with interconnection between VAE servers, [3GPP TS 23.286], Figure 7.2.2-2

Figure 16 illustrates the deployment of multiple VAE servers in PLMN operator domains based on geographical coverage. The V2X application specific server connects via Vs to the VAE server 1. The VAE servers interconnect via VAE-E and support the V2X communications to the V2X UEs connected to the VAE servers.

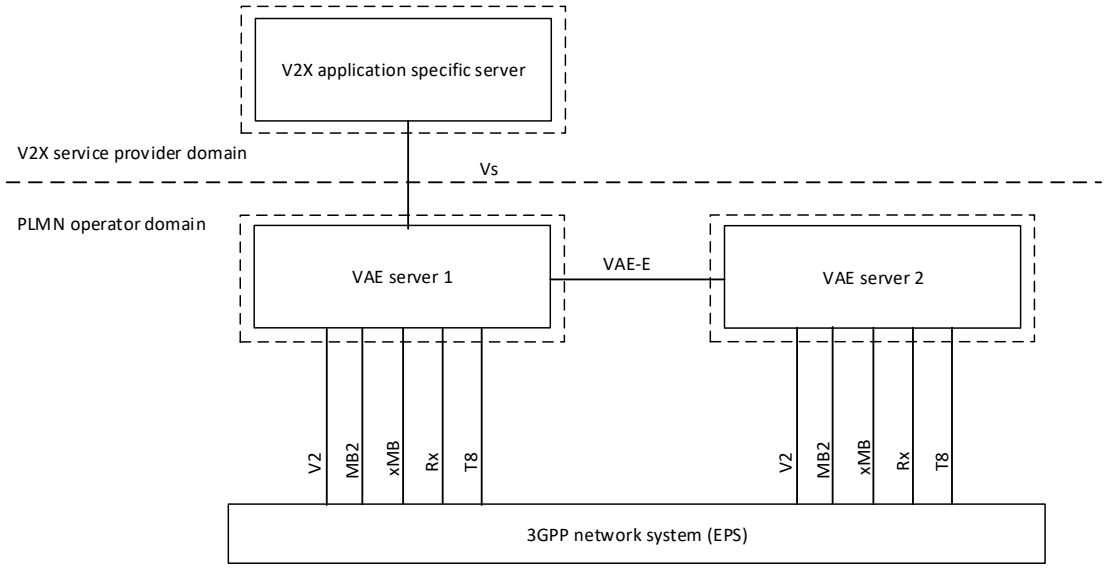

Figure 16: Distributed deployment of VAE servers in the PLMN operator domain, [3GPP TS 23.286], Figure 7.2.2-3

Figure 17 illustrates another deployment option of multiple VAE servers based on geographical coverage but in the V2X service provider domain.

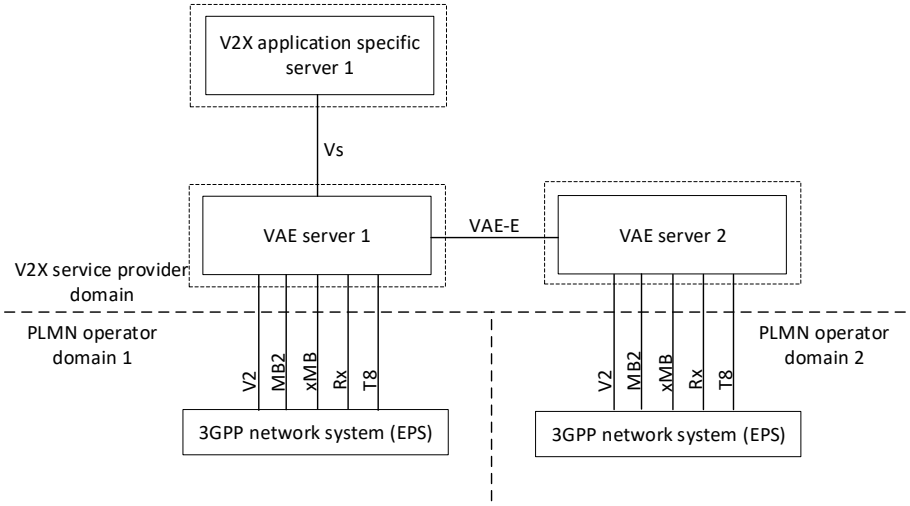

Figure 17: Distributed deployment of VAE servers in the V2X service provider domain, [3GPP TS 23.286], Figure 7.2.2-4

6.4 Description of components of the architecture

6.4.1 Functional components

The following functional components are included in the V2X Application Layer Reference Architecture:

Vehicle-to-anything Application Server (V2X AS)

The V2X AS routes C-ITS messages between V2X Apps (using cellular communication) and disseminates C-ITS messages within a geographical area.

Vehicle-to-anything Application (V2X App)

The V2X App sends and receives C-ITS messages to and from the V2X AS (using cellular communication). Furthermore, the V2X App sends and receives C-ITS messages to and from other V2X Apps (using short-range communication).

Original Equipment Manufacturer Application Server (OEM AS)

The OEM AS offers services to vehicles manufactured by the OEM and to its drivers and passengers. The services could be telematics, infotainment, navigation, security certificate and safety services, to name a few.

Original Equipment Manufacturer Application (OEM App)

The OEM App integrates the services offered by OEM AS into vehicles. Moreover, the OEM App delivers services to drivers and passengers via the vehicles' human-machine-interface (HMI).

Road Traffic Authority[3] Application Server (RTA AS)

The RTA AS offers traffic efficiency and traffic safety services to the vehicles. These types of services are partly driven by legislation. Furthermore, RTA AS manages Road Side Infrastructure, such as variable road signs, traffic lights and video surveillance cameras.

Road Traffic Authority Application (RTA App)

The RTA App integrates the services offered by RTA AS into vehicles or into Road Side Infrastructure. Furthermore, RTA App may exchange traffic efficiency and traffic safety information with other RTA Apps.

Service Provider Application Server (SP AS)

Various professional services are offered to vehicles, VRUs and other recipients. These include fleet management or personal services such as infotainment. Although these services are delivered by Service Provider application servers to the vehicles, the services may still be authorised and controlled by the OEM AS.

Service Provider Application (SP App)

The SP App integrates the services offered by SP AS into vehicles and VRUs. Moreover, the SP App exposes services to driver and passenger via the vehicles' human-machine-interface (HMI) and to VRUs.

Interchange Function (IF)

Given the large number of different Road Traffic Authorities in the world, Interchange Functions are needed to scale up and secure the message exchanges between RTA ASs, OEM ASs and SP ASs.

6.4.2 Stakeholders for functional components

Various stakeholders may take responsibility for different functional components in this Application Layer Reference Architecture. Possible stakeholders for functional components are listed in Table 1 below.

[3] Other terms are used in some regions, e.g. Road Traffic Operator (RTO) or Infrastructure Owner Operator (IOO)

Functional component	Possible stakeholders
V2X AS	• Mobile Network Operator • Road Traffic Authority
V2X App	• Vehicle owner • Vulnerable Road User
OEM AS	• Original Equipment Manufacturer
OEM App	• Vehicle owner
RTA AS	• Road Traffic Authority
RTA App	• Road Traffic Authority • Vehicle owner • Vulnerable Road User
SP AS	• Service Provider
SP App	• Vehicle owner
IF	• Mobile Network Operator • Road Traffic Authority • Service Provider

Table 1: Possible stakeholders for functional components

6.5 Description of reference points of the architecture

In this chapter, all reference points in the functional view of the Application Layer Reference Architecture are described. The following aspects are described for the reference points:

- The two functions that are connected via the reference point
- The type of services provided over the reference point
- The corresponding message formats and message exchange protocols

A number of different message formats are standardised in various Standards Development Organisations (SDOs), see examples in Table 2 below.

Abbreviation	Name	Reference
CAM	Cooperative Awareness Message	[CAM]
DENM	Decentralised Environmental Notification Message	[DENM]
IVIM	In-Vehicle Information Message	[IVIM]
SREM	Signal Request Extended Message	[SREM]
SSEM	Signal request Status Extended Message	[SSEM]
SPATEM	Signal Phase and Timing Extended Message	[SPATEM]
MAPEM	Map (topology) Extended Message	[MAPEM]
BSM	Basic Safety Messages	[BSM]
PSM	Personal Safety Message	[PSM]
DATEX II	Data Exchange II	[DATEX II]
SENSORIS	SENSOR Interface Specification	[SENSORIS]

Table 2: Message Formats

Messages in formats specified by ETSI and SAE may be transmitted directly between different functional components via short-range communication (using 3GPP PC5 interface).

Messages in all these formats may also be exchanged between different functional components by message exchange protocols over IP based networks. The IP based networks may be both wired and wireless (using 3GPP Uu interface). Examples of message exchange protocols are provided in Table 3 below.

Abbreviation	Name	Reference
HTTP	Hypertext Transfer Protocol	[HTTP]
MQTT	Message Queue Telemetry Transport	[MQTT]
AMQP	Advanced Message Queuing Protocol	[AMQP]

Table 3: Message Exchange Protocols

NOTE: The services, message formats and message exchange protocols described below are just examples (it is not meant to be an exhaustive list).

6.5.1 Vehicle-to-anything (V2X) Reference Points

The V2X Reference Points are described in Table 4 below. The reference points V1 and V5 have already been introduced by 3GPP in [3GPP TS 23.285].

Reference Point	Function 1	Function 2	Services	Message Exchange Protocols	Message Formats
V1 (Gas-app)	V2X AS	V2X App	C-ITS	HTTP, MQTT	DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
V5 (Gapp-app)	V2X App	V2X App	C-ITS		CAM, DENM, BSM, PSM
V0 (Gas-as)	V2X AS	V2X AS	C-ITS	HTTP, MQTT	DENM, IVIM, SREM, SSEM, SPATEM, MAPEM

Table 4: V2X Reference Points

6.5.2 Road Traffic Authority (RTA) Reference Points

Reference Point	Function 1	Function 2	Services	Message Exchange Protocols	Message Formats
R1 (Gas-app)	RTA AS	RTA App	C-ITS	HTTP, MQTT	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
R2 (Gapp-app)	RTA App	RTA App	C-ITS		DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
R3 (Gas-as)	RTA AS	V2X AS	C-ITS	HTTP, MQTT	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
R4 (Gas-as)	RTA AS	RTA AS	C-ITS	HTTP, MQTT	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
R5 (Gas-as)	RTA AS	SP AS	C-ITS	HTTP, MQTT	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM

Table 5: RTA Reference Points

6.5.3 Original Equipment Manufacturer (OEM) Reference Points

Reference Point	Function 1	Function 2	Services	Message Exchange Protocols	Message Formats
O1 (Gas-app)	OEM AS	OEM App	Telematics, infotainment, navigation, sensor sharing	HTTP, MQTT	SENSORIS, Proprietary
			ADAS	HTTP, MQTT	DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
O2 (Gas-as)	OEM AS	SP AS	Infotainment, navigation, fleet management…	HTTP	Proprietary
O3 (Gas-as)	OEM AS	RTA AS	ADAS	HTTP, AMQP, MQTT	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
O4 (Gas-as)	OEM AS	OEM AS	Sensor sharing	HTTP, AMQP, MQTT	SENSORIS, Proprietary
O5 (Gas-as)	OEM AS	V2X AS	C-ITS	HTTP, MQTT	DENM, IVIM, SREM, SSEM, SPATEM, MAPEM

Table 6: OEM Reference Points

Reference Point O3 may be used instead of the combination of reference points I2 and I3 in markets where no Interchange Function is deployed.

6.5.4 Service Provider (SP) Reference Points

Reference Point	Function 1	Function 2	Services	Message Exchange Protocols	Message Formats
P1 (Gas-app)	SP AS	SP App	Infotainment, navigation, fleet management…	HTTP	Proprietary
P2 (Gas-as)	SP AS	SP AS	Infotainment, navigation, fleet management…	HTTP	Proprietary
P3 (Gas-as)	SP AS	V2X AS	C-ITS	HTTP, MQTT	DENM, IVIM, SREM, SSEM, SPATEM, MAPEM

Table 7: SP Reference Points

6.5.5 Interchange Function (IF) Reference Points

Reference Point	Function 1	Function 2	Services	Message Exchange Protocols	Message Formats
I1 (Gas-if)	Interchange Function	V2X AS	Message exchange	AMQP[4]	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
I2 (Gas-if)	Interchange Function	RTA AS	Message exchange	AMQP	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
I3 (Gas-if)	Interchange Function	OEM AS	Message exchange	AMQP	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
I4 (Gas-if)	Interchange Function	SP AS	Message exchange	AMQP	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM
I5 (Gif-if)	Interchange Function	Interchange Function	Federation of Interchange Functions	AMQP	DATEX II, DENM, IVIM, SREM, SSEM, SPATEM, MAPEM

Table 8: IF Reference Points

Federation of Interchange Functions means that several Interchange Functions can exchange messages between each other.

[4] AMQP is selected by the European C-Roads Platform [C-Roads Platform].

7 Conclusion

This technical report introduces an Application Layer Reference Architecture for the automotive ecosystem, taking the following stakeholders into account:

- Vehicle Original Equipment Manufacturers (OEMs)
- Mobile Network Operators (MNOs)
- Road Traffic Authorities (RTAs)
- Service Providers (SPs), e.g. navigation service providers and infotainment service providers

The Application Layer Reference Architecture is described from three different viewpoints:

- Functional view, with functional components and Reference Points between them
- Deployment views, with the functions deployed in different cloud systems and devices
- Implementation views, with different implementation options

It is recommended that this Application Layer Reference Architecture be used as a baseline in other 5GAA WG work items as well as 5GAA Cross-WG items, to describe use cases involving multiple stakeholders in the automotive ecosystem.

Annex A:
Change history

Date	Meeting	TDoc	Subject/Comment
2020-02	F2F Brussels	A-200045	First version
2020-04	Call # 30	A-200064	Second version
2020-05	VF2F	A-200094	Version for approval