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650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Multi-access Edge Computing (MEC).

Modal verbs terminology

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1 Scope

The present document focuses on identifying the MEC features to support V2X applications. It collects and analyses the relevant V2X use cases (including the findings from external organizations), evaluates the gaps from the defined MEC features and functions, and identifies the new requirements including new features and functions. When necessary, this may include identifying new multi-access edge services or interfaces, as well as changes to existing MEC services or interfaces, data models, application rules and requirements. It will also recommend the necessary normative work to close these gaps if identified.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

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

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

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

[i.1] National Highway Traffic Safety Administration (NHTSA) / Department of Transportation (DOT), "Federal Motor Vehicle Safety Standards; V2V Communications".

NOTE: Available at: https://www.gpo.gov/fdsys/granule/FR-2017-01-12/2016-31059

[i.2] ETSI TR 102 638: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".

[i.3] 3GPP TR 22.885: "Study on LTE support for Vehicle to Everything (V2X) services".

[i.4] ETSI GS MEC 012: "Mobile Edge Computing (MEC); Radio Network Information API".

[i.5] ETSI GS MEC 013: "Mobile Edge Computing (MEC); Location API".

[i.6] ETSI GR MEC 018: "Mobile Edge Computing (MEC); End to End Mobility Aspects".

[i.7] 5G Automotive Association (5GAA) White Paper: "Toward fully connected vehicles: Edge computing for advanced automotive communications".

NOTE: Available at http://5gaa.org/wp-content/uploads/2017/12/5GAA_T-170219-whitepaper-EdgeComputing_5GAA.pdf.

[i.8] ETSI GS MEC 001: "Multi-access Edge Computing (MEC); Terminology".

[i.9] ETSI GS MEC 002: "Multi-access Edge Computing (MEC); Phase 2: Use Cases and Requirements".

[i.10] ETSI TS 123 285: "Universal Mobile Telecommunications System (UMTS); LTE; Architecture enhancements for V2X services (3GPP TS 23.285)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI GS MEC 001 [i.8].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GS MEC 001 [i.8] and the following apply:

5G	Fifth Generation
API	Application Programming Interface
IMA	Intersection Movement Assist
LS	Location Service
MNO	Mobile Network Operator
OEM	Original Equipment Manufacturer
OSS	Operational Support System
PER	Packet Error Rate
PLMN	Public Land Mobile Network
QoE	Quality of Experience
QoS	Quality of Service
QW	Queue Warning
RAB	Radio Access Bearer
RAN	Radio Access Network
RAT	Radio Access Technology
RNI	Radio Network Information
RNIS	Radio Network Information Service
TNL	Transport Network Layer
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VRU	Vulnerable Road User
WLAN	Wireless Local Area Network

4 Overview

The present document identifies the MEC features in order to enable the necessary support for V2X applications.

Clause 5 collects and analyses the relevant V2X use cases (including the findings from external organizations). The recommendations on the services and features are identified for each use case. Evaluation is provided for each recommendation to identify the issues to be solved.

Clause 6 discusses the key issues and the corresponding solutions and further identifies the gaps from the existing MEC functions and features.

Clause 7 concludes the study with the prioritized V2X use cases to be supported in this phase, and the consolidated recommendations. The recommendations for necessary normative work are provided in order to close the identified gaps.

5 Use cases

5.1 Introduction

This clause discusses four use case groups that are commonly known to the V2X communities [i.7], namely "safety", "convenience", "advanced driving assistance" and "vulnerable road user".

5.2 V2X use case group "safety"

5.2.1 Description

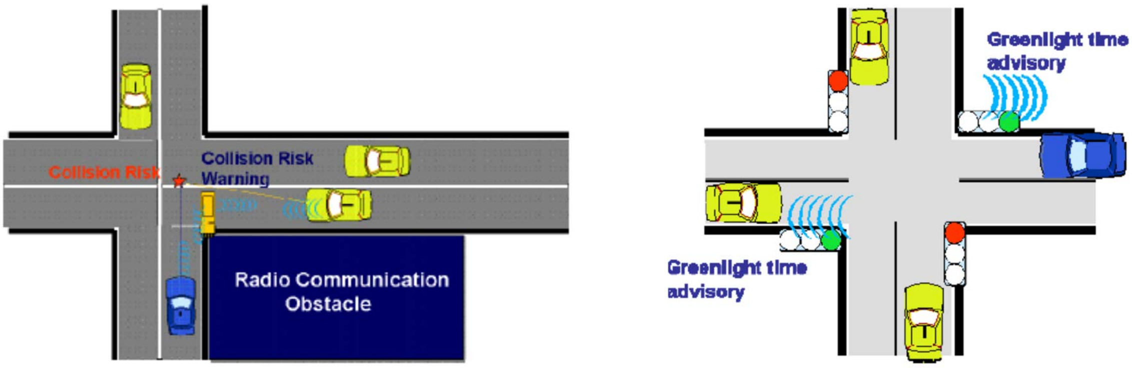
The V2X use case group "Safety" includes several different types of use cases (relevant to MEC) to support road safety using the vehicle-to-infrastructure (V2I) communication in addition to the vehicle-to-vehicle (V2V).

Intersection Movement Assist (IMA)

This type of use cases was specifically listed in the US DOT NHTSA publication 2016-0126 [i.1], and ETSI TR 102 638 [i.2]. The main purpose of IMA is to warn drivers of vehicles approaching from a lateral direction at an intersection. IMA is designed to avoid intersection crossing crashes, the most severe crashes based on the fatality counts. Intersection crashes include intersection, intersection-related, driveway/alley, and driveway access related crashes. Figure 5.2.1-1 illustrates two typical scenarios:

a) intersection collision warning, and

b) intersection management.



a) intersection collision warning b) intersection management

Figure 5.2.1-1: V2X "safety" use cases

Queue Warning (QW) [i.3**]**

In a lot of situations, a queue of vehicles on the road may pose a potential danger and cause delay of traffic, e.g. when a turning queue extends to other lanes. Using the V2I service, the queue information can be made available to other drivers beforehand. This minimizes the likelihood of crashes and allows for mitigation actions.

5.2.2 Recommendations

This group of V2X use cases requires the support of roadside infrastructure for the V2V and V2I communications. In the case that the Multi-access Edge Computing system is used to provide the V2X support, the related recommendations on the services and features enabled in the system include:

[R-5.2.2-1] It is recommended that the MEC system provides feedback information from the network to the vehicle in support of V2X functions, predicting whether a communication channel is currently reliable or not (e.g. in terms of fulfilling latency requirements and 100 % packet arrival).

[R-5.2.2-2] It is recommended that the MEC system provides interoperability by supporting V2X information exchange among road users connected through different access technologies or networks or mobile operators.

[R-5.2.2-3] It is recommended that the MEC system enables multi-operator operation for V2X mobiles/users to provide service continuity across access network coverage nationwide and across borders of different operators' networks.

[R-5.2.2-4] It is recommended that the MEC systems provide interoperability in a multi-operator scenario, enabling MEC apps in different systems to communicate securely with each other, in order to enable synchronization in multi-operator systems also in absence of cellular coverage (outside of 3GPP™ domain).

[R-5.2.2-5] It is recommended that the MEC system provides interoperability in a multi-operator scenario, enabling MEC apps to communicate securely with the V2X-related 3GPP™ core network logical functions (e.g. V2X control function) and gathering PC5 [i.10] V2X relevant information (e.g. PC5 configuration parameters) from 3GPP™ network.

5.2.3 Evaluation

[R-5.2.2-1] In current MEC system, the RNI API can provide up-to-date radio network information to the service consumer, i.e. the V2X functions. However, current QoS-related information in RNI API is not sufficient in order to allow necessary prediction regarding the QoS performance (e.g. latency, throughput, reliability). Therefore, potential enhancements on RNI API for the prediction should be considered including both relevant measurements in RAN or processed results for the prediction. This enhanced service could also be provided by a new API.

[R-5.2.2-2] In current MEC definition, MEC system includes not only 3GPP™ access, but also other non-3GPP™ access. Therefore the MEC system is RAT agnostic and will be enhanced for multi-access if needed. There is no need to consider the different access networks within an operator's system in this study. Moreover, the information exchange among MEC system from different operators may require potential enhancement on the horizontal communication for the MEC system.

[R-5.2.2-3] The operator network is normally region specific or country specific. The V2X service requires a seamless coverage of the communication, and unified service regardless the subscription of the users. In previous experience, network sharing and roaming agreement could help to achieve this. However, each of them have its own limitations, which may not meet the requirements. Normally the MEC system could be shared by operators, but the interaction with the underlying networks from different operators may need more efforts in business coordination rather than technical obstacles. It is also possible that the MEC system could also be operator-specific, thus the horizontal communication enhancements among different operators may be considered to provide a sort of "MEC platform as a service" paradigm.

[R-5.2.2-4] The MEC system can be a preferred environment for hosting V2X application server functions in charge of the authorization for the usage of V2X services. Thus, in order to ensure alignment across different operators' domains (also in absence of cellular coverage), the MEC system hosts V2X application functions (with at least one MEC Host for each operator domain hosting such functions). In order to ensure interoperability, the MEC apps should communicate securely with 3GPP™ core network in order to gather relevant information from 3GPP™ network (i.e. the list of authorized UEs, the relevant information about the authorization based on the UE subscription and the relevant PC5 configuration parameters).

5.3 V2X use case group "convenience"

5.3.1 Description

Software updates and other telematics use cases are typically included in this group, which can technically be implemented with existing access technology and are partly already supported by car manufacturers.

5.3.2 Recommendations

This group of V2X use cases requires cost effective communication to be enabled between the vehicles and the backend server (e.g. car OEM's server). In the case that the Multi-access Edge Computing system is used, the related recommendations on the services and features enabled in the system include:

[R-5.3.2-1] It is recommended that the MEC system enables multi-operator operation for V2X mobiles/users to provide service continuity across access network coverage nationwide and across borders of different operators' networks.

5.3.3 Evaluation

[R-5.3.2-1] The operator network is normally region specific or country specific. The V2X service requires a seamless coverage of the communication, and unified service regardless the subscription of the users. In previous experience, network sharing and roaming agreement could help to achieve this. However, each of them have its own limitations, which may not meet the requirements. Normally the MEC system could be shared by operators, but the interaction with the underlying networks from different operators may need more efforts in business coordination rather than technical obstacles. It is also possible that the MEC system could also be operator-specific, thus the horizontal communication enhancements among different operators may be considered to provide a sort of "MEC platform as a service" paradigm.

5.4 V2X use case group "advanced driving assistance"

5.4.1 Description

Advanced driving assistance represented by the two use cases (related to MEC) collects the most challenging requirements for V2X. It can require distribution of a relative large amount of data with high reliability and low latency in parallel. Additionally, the advanced driving use cases would benefit from predictive reliability. This means that vehicles moving along should have the possibility to receive a prediction of the network availability to plan ahead.

Real Time Situational Awareness & High Definition (Local) Maps

Real time situational awareness is essential for autonomous vehicles especially at critical road segments in cases of changing road conditions (e.g. new traffic cone detected by another vehicle some time ago). In addition, the relevant high definition local maps need to be made available via downloading from a backend server.

The use case for real time situational awareness and High Definition (Local) Maps should not only be seen as a case to distribute information on relatively slow changing road conditions. The case should be extended to distribute and aggregate locally available information in real time to the traffic participants via road side units.

See-Through (or High Definition Sensor Sharing)

In this type of use cases vehicles such as trucks, minivans, cars in platoons are required to share camera images of road conditions ahead of them to vehicles behind them.

5.4.2 Recommendations

In the case that the Multi-access Edge Computing system is used, the related recommendations on the services and features enabled in the system include:

[R-5.4.2-1] It is recommended that the MEC system enables the support for locally aggregating the real-time information from the connected nodes with very low latency.

[R-5.4.2-2] It is recommended that the MEC system enables the support for locally distributing the real-time information to the connected nodes with very low latency.

NOTE: Examples of connected nodes are base stations in a mobile network or access points in a WLAN, which are connected to the MEC system.

[R-5.4.2-3] It is recommended that the MEC system provides predictive quality related information to the vehicle when the various connectivity parameters (like Latency, PER, signal-strength …) are going to change.

[R-5.4.2-4] It is recommended that the MEC system provides interoperability by supporting V2X information exchange among road users connected through different access technologies or networks or mobile operators.

[R-5.4.2-5] It is recommended that the MEC system enables multi-operator operation for V2X mobiles/users to provide service continuity across access network coverage nationwide and across borders of different operators' networks.

5.4.3 Evaluation

[R-5.4.2-1] The MEC system is supposed to serve only local area, which is several connected nodes in the underlying network. To serve several connected nodes, the MEC system should be deployed in an aggregating position. There is no extra standard work needed to specify the information aggregation.

[R-5.4.2-2] The MEC system is supposed to serve only local area, which is several connected nodes in the underlying network. To serve several connected nodes, the MEC system should be deployed in an aggregating position. There is no extra standard work needed to specify the information distribution.

[R-5.4.2-3] In current MEC system, the RNI API can provide up to date radio network information. The various connectivity parameter including PER, signal-strength are not in the list of the RNI API. The parameters are rather timely changed, may not be useful considering other network information including the network topology, policy and even the scheduler algorithm, etc. Therefore, this service could also be provided by a new API designed to expose appropriately pre-processed information for applications' consumption, but may not be useful for the end user if there is no much detailed radio network running information. The extra processing or analysis of the data should be done inside the network or dedicated applications.

[R-5.4.2-4] In current MEC definition, MEC system includes not only 3GPP™ access, but also other non-3GPP™ access. Therefore the MEC system is RAT agnostic and will be enhanced for multi-access if needed. There is no need to consider the different access networks within an operator's system in this study. Moreover, the information exchange among MEC system from different operators may require potential enhancement on the horizontal communication for the MEC system.

[R-5.4.2-5] The operator network is normally region specific or country specific. The V2X service requires a seamless coverage of the communication, and unified service regardless of the subscription of the users. In previous experience, network sharing and roaming agreement could be some precedence to achieve this. However, each of them have its own limitations, which may not meet the requirements. Normally the MEC system could be shared by operators, but the interaction with the underlying networks from different operators may need more efforts in business coordination rather than technical obstacles. It is also possible that the MEC system could also be operator-specific, thus the horizontal communication enhancements among different operators may be considered to provide a sort of "MEC platform as a service" paradigm.

5.5 V2X use case group "vulnerable road user"

5.5.1 Description

The vulnerable road user (VRU) use case covers pedestrians and cyclists. A critical requirement to allow efficient use of information provided by VRUs is the accuracy of the positioning information provided by these traffic participants. Additional means to use available information for better and reliable accuracy is crucial to allow a real-world usage of information shared from VRUs. Cooperation between vehicles and vulnerable road users (such as pedestrians, cyclists, etc.) through their mobile devices (e.g. smartphone, tablets) will be an important key element to improve traffic safety and to avoid accidents.

5.5.2 Recommendations

In the case that the Multi-access Edge Computing system is used, the related recommendations on the services and features enabled in the system include:

[R-5.5.2-1] It is recommended that the MEC system enables the support for timely accurate positioning assisted by available positioning technologies including radio network functions.

[R-5.5.2-2] It is recommended that the MEC system provides interoperability by supporting V2X information exchange among road users connected through different access technologies or networks or mobile operators.

[R-5.5.2-3] It is recommended that the MEC system enables multi-operator operation for V2X mobiles/users to provide service continuity across access network coverage nationwide and across borders of different operators' networks.

5.5.3 Evaluation

[R-5.5.2-1] The position service is already provided by the published location API, which is gathering information from the underlying network. The new requirement from V2X cases is to provide more accurate position in a short time or real-time. This may not require the updates of the current location API, but requires the underlying network to enhance its positioning functions to meet the requirements, e.g. 5G system will provide a new and accurate positioning service.

[R-5.5.2-2] In current MEC definition, MEC system includes not only 3GPP™ access, but also other non-3GPP™ access. Therefore the MEC system is RAT agnostic and will be enhanced for multi-access if needed. There is no need to consider the different access networks within an operator's system in this study. Moreover, the information exchange among MEC system from different operators may require potential enhancement on the horizontal communication for the MEC system.

[R-5.5.2-3] The operator network is normally region specific or country specific. The V2X service requires a seamless coverage of the communication, and unified service regardless the subscription of the users. In previous experience, network sharing and roaming agreement could help to achieve this. However, each of them have its own limitations, which may not meet the requirements. Normally the MEC system could be shared by operators, but the interaction with the underlying networks from different operators may need more efforts in business coordination rather than technical obstacles. It is also possible that the MEC system could also be operator-specific, thus the horizontal communication enhancements among different operators may be considered to provide a sort of "MEC platform as a service" paradigm.

6 Key issues and solutions

6.1 Key issue 1: mobility and QoE support

6.1.1 Introduction

The nature of the most V2X applications requires mobility support in order to guarantee the quality of experience. The figure below shows several example MEC support for V2X use cases, where the vehicles communicate using telecommunication networks. Various V2X applications have different requirements, for example, some infotainment applications have high throughput and low latency requirements while some autonomous driving applications demand very low latency and very high reliability and availability.

In the cases where a vehicle (that engages in V2X communications) travels across multiple cells it is critical for some V2X applications to maintain the service continuity while guarantee the quality of the service and user experience.

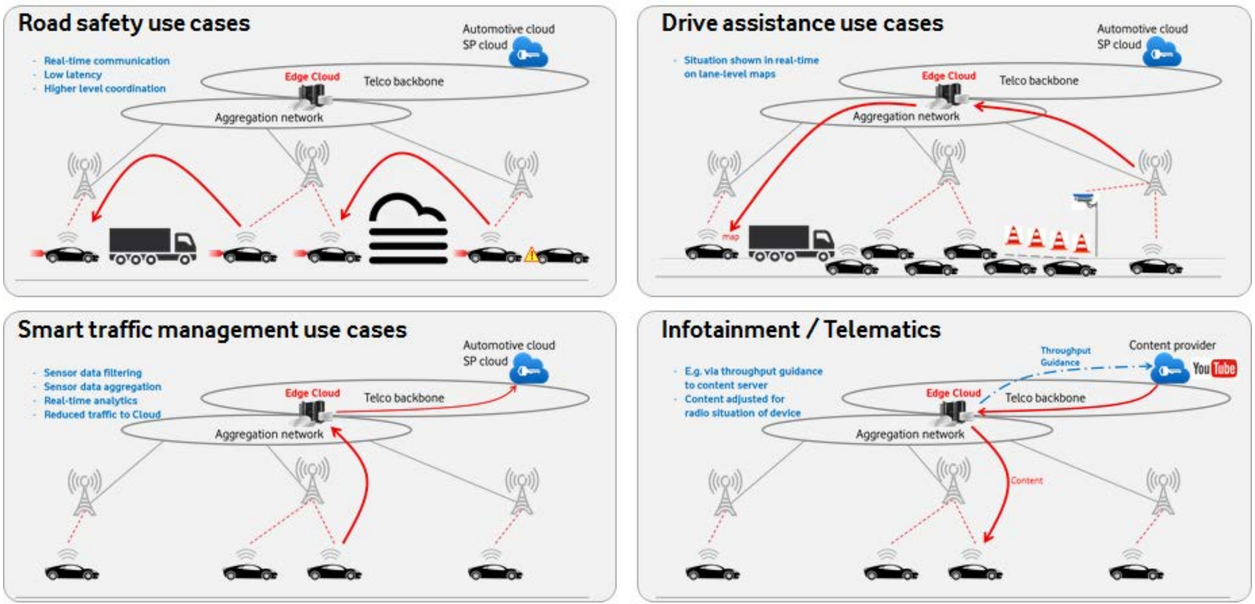


Figure 6.1.1-1: Example MEC support for V2X use cases

6.1.2 Solution 1-1: predictive QoS support

6.1.2.1 Description

In various mobility scenarios, as captured in ETSI GR MEC 018 [i.6], prediction of the handover with the estimated QoS performance (e.g. latency, throughput, reliability) can help the vehicle UEs with the base station selection as well as the MEC host selection therefore enhances the support for V2X applications.

Figure 6.1.2.1-1 shows an example of the prediction of handover timing for the connected car use case. The transit time in each cell can be estimated by the assistance of the UE application (e.g. the in-car navigation system) or by a MEC-based solution. The location service (e.g. based on the Location Service defined in ETSI GS MEC 013 [i.5] and the enhancements to LS) may also support prediction of the handover timing by retrieving the location information of vehicle UEs and base stations. Moreover the estimated QoS performance of the available cells (e.g. based on the RNI service defined in ETSI GS MEC 012 [i.4] and the enhancements to RNIS) can help with optimal base station and ME host selection so that the UE vehicle can always receive the maximum QoE along the trajectory.

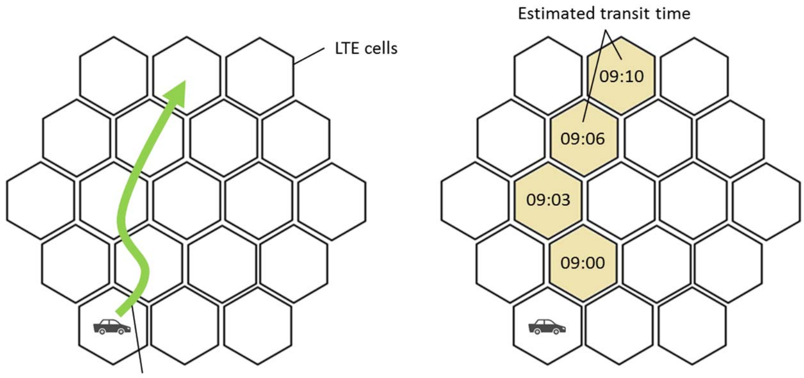


Figure 6.1.2.1-1: The prediction of handover timing for a connected car use case

In another example, the relocation of application state information to the target MEC host is completed before connecting to the MEC host, as shown in figure 6.1.2.1-2. The MEC system enables the prediction of the handover timing and informs the MEC application, which then initiates state relocation to the optimal MEC host in advance.

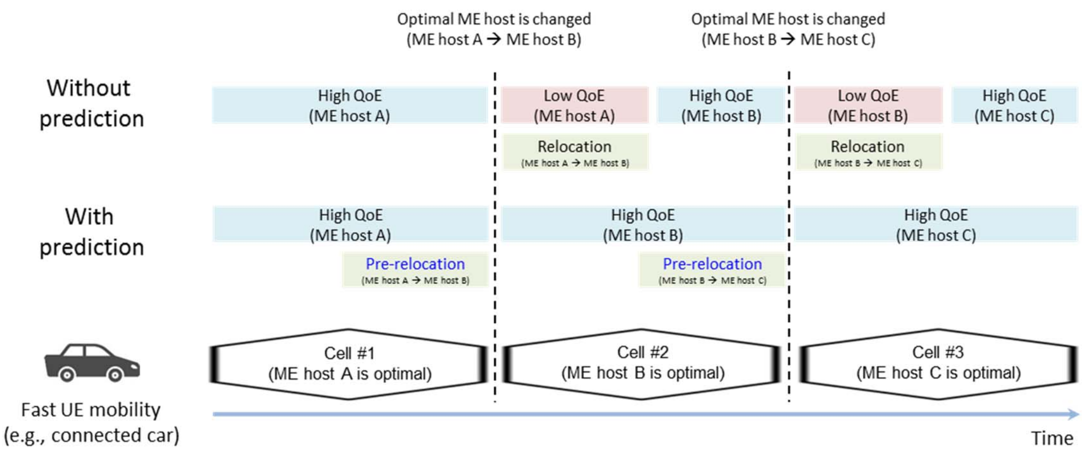


Figure 6.1.2.1-2: Pre-relocation of application state information

Additionally, the advanced driving use cases would benefit from predictive reliability. This means that vehicles moving along should have the possibility to receive a prediction of the network availability to plan ahead. This type of information is needed especially for automatic driving functions. For High Definition Sensor Sharing or see-Through it is imperatively required that a vehicle will know when the data-stream from the other vehicle, or from the infrastructure, will not be available anymore. In this way the vehicle can only start an overtaking manoeuvre when it is certain that the information will be available throughout this manoeuvre to be performed. Another example is when vehicles enter a tunnel, or approach a jammed part of the city where connectivity is not available, or with a degraded set of parameters. Knowing how the network will look like would enable individual vehicles to configure their internal systems (buffers, sensors, etc.) in order to provide and receive information in the required quality.

6.1.2.2 Gap analysis

There are several features specified in ETSI GS MEC 012 [i.4] that are related handover prediction:

- CellChangeNotification - provides the update on the status of the UE handover procedure; the information is available from the preparation stage of a handover procedure till the completion of the whole procedure.
- MeasRepUeNotification - provides further detail through UE measurement reports that are associated with different triggering events.

In addition, there are several features defined about RAB and S1 bearer information, which might help with QoS prediction.

However the features specified in the current ETSI GS MEC 012 [i.4] are not sufficient in order to allow necessary prediction regarding the QoS performance (e.g. latency, throughput, reliability). Further enhancements are expected.

6.2 Key issue 2: low latency communication support with multi-operator operation

6.2.1 Introduction

Wireless communication is a key enabling technology of co-operative intelligent transportation systems. Road users (including vehicles, cyclists, pedestrians) involved in the communication (e.g. LTE™-V2X) may use services provided by different operators. Cross-operator interoperability is therefore critical for V2X applications enabled in the edge cloud. Moreover, it will be extremely important for application providers that they will be able to develop, test, deploy and maintain their applications based on standard processes and procedures applying to all MEC-enabled networks per country or region. In addition, there are already existing V2X related applications available for the Internet-based cloud solutions. It is therefore critical to make sure that it will not result in an excessive effort for application providers when moving from one or few cloud instances on the Internet to numerous MEC-based instances per country per network operator.

A mobile operator network is typically region specific or country specific, which provides services directly to its own customers (subscribers) while providing communications with other operators' customers via the core network level interworking between two operators' networks. In a multi-operator scenario, the end-to-end latency between the vehicles is limited by the location of peering points for data traffic between the mobile operators' networks. These peering points are usually located centrally in the mobile operators' networks. To achieve the low latency communications for most delay sensitive V2X applications in multi-operator case, the horizontal communication path to enable local peering points between operators' networks is essential. The following clauses consider different business models in this case.

6.2.2 Solution 2-1: shared underlying network

6.2.2.1 Description

The underlying network is shared between operators e.g. RAN sharing, similarly e.g. to a nation-wide shared energy grid infrastructure, etc. The MEC system should also be shared as a part of the unified infrastructure. The multiple operator support becomes more a business problem rather than a technical problem. The horizontal communication path to enable local peering points communication is essential to guarantee the low latency transmission when deploying the Transport network. The case is the same as the case of a single operator supporting MEC system. In the following figure, the direct communication link between the points of the two MEC hosts is needed to shorten the transmission latency. More efforts are needed in business coordination between operators e.g. multiple OSSs coordination to the shared orchestrator, etc.

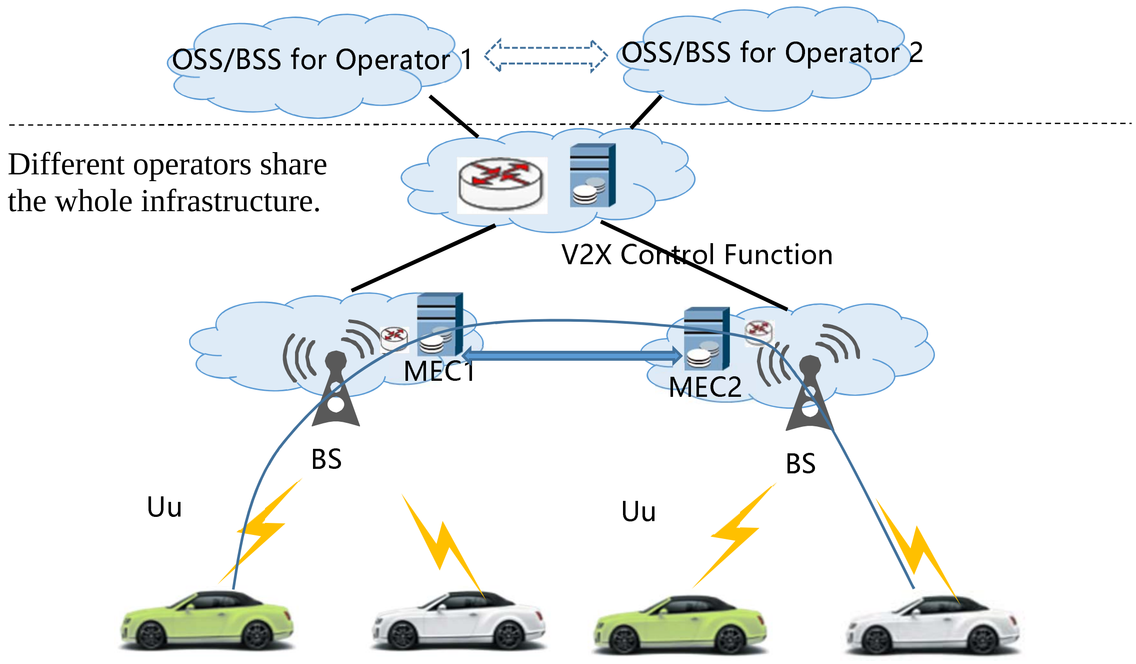


Figure 6.2.2.1-1: Example shared underlying network use case

6.2.2.2 Gap analysis

The business coordination between operators, their OSSs, are in service level, as the infrastructure is shared. The coordination includes multiple OSSs coordination to the shared orchestrator, etc.

In addition, standardizing a V2X service API is beneficial to improve the coordination among V2X applications hosted in different MEC hosts and in the external cloud.

6.2.3 Solution 2-2: independent underlying network

6.2.3.1 Description

The underlying network is independently operated by different operators, as they use their own licensed band for V2X service. However, on the service level, the MEC system can be shared by the involved operators, or offered by a 3rd party, or the MEC systems are run independently by each operator. The key requirement is to have a coordinated V2X service, while it could still be run in different operators' MEC systems. There should be a horizontal communication path to enable direct communication between the peering points, which is different with the traditional TNL arrangements between different PLMNs. This is to guarantee the low latency transmission for V2X services. There are two subcases:

1) the MEC system is shared by the operators, requiring low latency communication with both underlying networks;

2) the adjacent MEC hosts belong to different operators, requiring the low latency communication path between the peer points.

The cases are anyway requiring the coordination between the involved operators in both network planning and especially transport network planning.

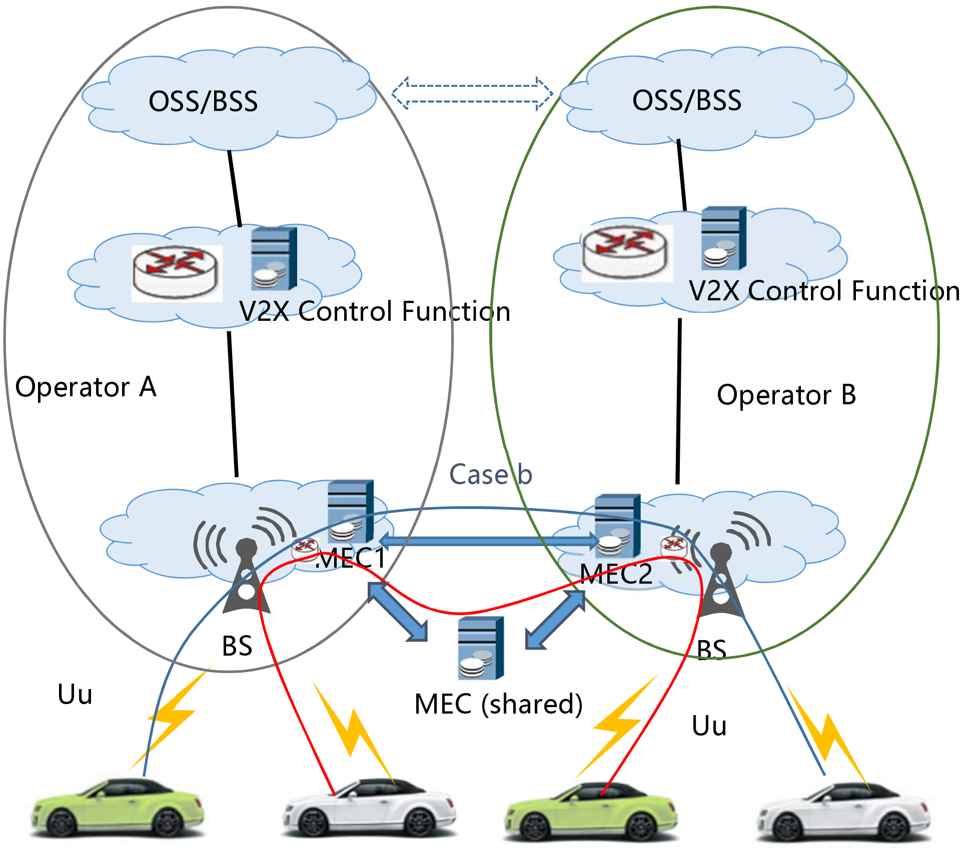


Figure 6.2.3.1-1: Example shared MEC system use case

6.2.3.2 Gap analysis

The coordination between all involved MNOs is required on both service level and network planning level. Similar service level coordination should also be consider as described in clause 6.2.2.2. The planning of transport network to enable a direct low latency communication path between the involved networks is essential. In principle such direct transmission path may be arranged via the aggregator ring, access ring, or even via the TNL backbone. On TNL aspects no specific technical work in the scope of the present document is foreseen.

A standardized V2X service API is beneficial to improve the coordination among V2X applications hosted in different MEC hosts (within a MEC system or in different MEC systems) and in the external cloud.

6.3 Key issue 3: communication traffic coordination with vehicles

6.3.1 Introduction

Connected vehicles generate various data such as vehicle information from CAN (controller area network), manifold radar, camera, drive recorder, etc. which will be uploaded through the radio network in order to provide V2X services in clause 5. The information has different requirements for communications, however, at least urgent information that requires real-time communication should be transferred to cloud with low latency and high reliability. For example, the information related to safety should be prioritized to transmit, however, that related to convenience use cases may be processed with low emergency.

The vehicle transportation traffic congestion may give rise to radio network congestion, which degrades the quality of V2X services. In general, LTE™ uplink radio resource is limited compared with that of downlink and hence is prone to radio network congestion. To overcome this issue, it is essential to harmonise vehicles with MEC system for controlling radio network congestion especially in uplink.

6.3.2 Solution 3-1: inform communication traffic congestion to vehicles

6.3.2.1 Description

Various information for V2X services may be transferred through radio network. If MEC system can predictively recognize the radio network congestion based on vehicle transitions and then notify it to the vehicle, the transmission of non-real-time information can pause in order to prioritize urgent V2X communications.

Radio network congestion is in proportion to the number of vehicles, which is correlated by RNI services specified in ETSI GS MEC 012 [i.4]. The estimation of the number of vehicles connecting to a base station helps to predict radio network congestion. Figure 6.3.2.1-1 shows an example of the estimation of transportation mapping to radio cell. The ingress/egress rate indicates the rate of vehicle transitions from/to the adjacent radio cell, which may be calculated by the location specified in ETSI GS MEC 012 [i.4] and ETSI GS MEC 013 [i.5]. It also depends on the road structure, and then the accuracy of the estimation may be improved if MEC system can associate road structure with radio cell area. These rates are used for predicting the number of vehicles in the next time slot, for example, by Markov chain model. As shown in the figure 6.3.2.1-1, vehicle accident may cause transportation traffic congestion. This increases the number of vehicles in radio cell where the accident occurs, and in turn propagates to the linked cells as well.

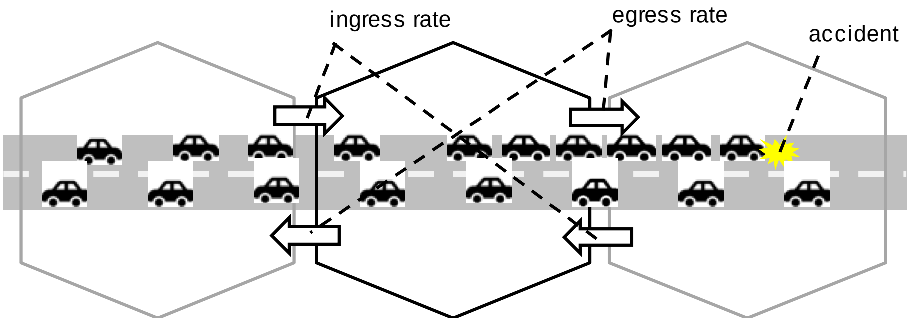


Figure 6.3.2.1-1: The estimation of transportation mapping to radio cells

When the radio network congestion is predicted, the warning can be notified to the vehicles in the congested area. The vehicles that received the warning refrain from or postpone transmitting information that does not require real time communications. It helps to deliver urgent information with low latency and high reliability.

Moreover, if MEC system can recognize the contents of transferred data along with the impact on radio network congestion, the MEC system can instruct a vehicle which data transmission should be suspended or how long it should be suspended. The suspended data will be transmitted after the vehicle passed through the congested area.

6.3.2.2 Gap analysis

There are several features that help to predict radio network congestion. The followings are specified in ETSI GS MEC 012 [i.4]:

- CellChangeNotification - provides the update on the status of the UE handover procedure; the information is available for ingress/egress rate.
- RabInfo - provides the number of active UEs in a cell that helps to predict the radio network congestion.

The following feature is specified in ETSI GS MEC 013 [i.5]:

- UserInfo - provides the geographical coordinates where the UE is. This may also improve the accuracy of the prediction by identifying the detailed UE location that can map to the road structure.

There is no existing interface to provide notifications to the UE as discussed above.

7 Conclusion and Recommendations

7.1 Prioritized V2X use cases

There are four use case groups that have been analysed with recommendations associated; and each recommendation has then been evaluated with open issues identified:

- "Safety": include several different types of road safety use cases using V2I and V2V communications.
- "Convenience": include software updates and other telematics use cases, which can technically be implemented with existing access technology and are partly already supported by car manufacturers.
- "Advanced driving assistance": this group of use cases collects the most challenging recommendations for V2X, which can require distribution of a relative large amount of data with high reliability and low latency in parallel. Additionally, the advanced driving use cases would benefit from predictive reliability.
- "Vulnerable road user": this group of use cases covers both pedestrians and cyclists.

These four use case groups represent the typical V2X use cases that need to be supported in this phase.

7.2 Consolidated recommendations

There are several recommendations that are common to these four use case groups, which represent the common recommendations on MEC services and features. Taking into account the evaluations made for each recommendation, the overall consolidated recommendations can be summarized below:

[CR-1] It is recommended that the MEC system supports the capability to provide feedback information from the network to the vehicle in support of V2X functions, which helps with predicting whether a communication channel is currently reliable or not (e.g. in terms of fulfilling latency requirements and 100 % packet arrival).

[CR-2] It is recommended that the MEC system supports the capability to provide quality related information from the network to the vehicle about when the various connectivity parameters (like Latency, PER, signal-strength …) are going to change.

[CR-3] It is recommended that the MEC system provides interoperability by supporting V2X information exchange among road users connected through different access technologies or networks or mobile operators.

[CR-4] It is recommended that the MEC system enables multi-operator operation for V2X mobiles/users to provide service continuity across access network coverage nationwide and across borders of different operators' networks.

[CR-5] It is recommended that the MEC systems provide interoperability in a multi-operator scenario, enabling MEC apps in different systems to communicate securely with each other, in order to enable synchronization in multi-operator systems also in absence of cellular coverage (outside of 3GPP™ domain).

[CR-6] It is recommended that the MEC system provides interoperability in a multi-operator scenario, enabling MEC apps to communicate securely with the V2X-related 3GPP™ core network logical functions (e.g. V2X control function) and gathering PC5 V2X relevant information (e.g. PC5 configuration parameters) from 3GPP™ network.

7.3 Recommendations for future work

Three key issues are identified and discussed with potential solutions, which are related to the key recommendations on the predictive QoS support and multi-operator support. Taking into account of the gap analysis provided in clause 6, it is therefore recommended:

- To capture the consolidated recommendations as normative requirements in ETSI GS MEC 002 [i.9].
- To enhance the RNI API (in ETSI GS MEC 012 [i.4]) in order to allow necessary prediction regarding the QoS performance (e.g. latency, throughput, reliability).
- Standardizing a V2X service API is beneficial to improve the coordination and interoperability among V2X applications hosted in different MEC hosts and in the external cloud in a multi-vendor, multi-network operator and multi-access environment.

History

Document history		
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