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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet of things and smart cities and communities – Requirements and use cases

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Internet of things requirements for support of edge computing

Recommendation ITU-T Y.4208

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Recommendation ITU-T Y.4208

Internet of things requirements for support of edge computing

Summary

Some of the capabilities offered by the Internet of thing (IoT), e.g., capabilities for computing, storage and analytics, are evolving in closer proximity to IoT data sources. Recommendation ITU-T Y.4208 provides an overview of related challenges faced by the IoT and describes how IoT-supporting edge computing (EC) may address these challenges. From the edge-computing deployment perspective, service requirements for support of EC capabilities in the IoT are identified, as well as related functional requirements. As an example, scenarios of EC deployment in different application domains, EC scenarios for vehicle-to-everything (V2X) and for smart manufacturing are provided in an appendix.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4208	2020-01-13	20	11.1002/1000/14162

Keywords

Edge computing, functional requirements, IoT requirements, service requirements.

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FOREWORD

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1 Scope

This Recommendation provides service requirements from an edge-computing (EC) deployment perspective. This Recommendation also specifies functional requirements of the Internet of things (IoT) for support of EC.

The scope of this Recommendation includes:

– introduction of EC into the IoT;

– service requirements from an edge-computing deployment perspective;

– functional requirements of the IoT for support of EC.

Some detailed scenarios of EC in the IoT related to different application domains are provided in Appendix I.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Q.1742.11] Recommendation ITU-T Q.1742.11 (2014), *IMT 2000 references (approved as of 31 December 2012) to ANSI-41-evolved core network with cdma2000 access network.*

[ITU-T Y.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things.*

[ITU-T Y.4100] Recommendation ITU-T Y.4100/Y.2066 (2014), *Common requirements of the Internet of things.*

[ITU-T Y.4101] Recommendation ITU-T Y.4101/Y.2067 (2017), *Common requirements and capabilities of a gateway for Internet of things applications*.

[ITU-T Y.4113] Recommendation ITU-T Y.4113 (2016), *Requirements of the network for the Internet of things.*

[ITU-T Y.4114] Recommendation ITU-T Y.4114 (2017), *Specific requirements and capabilities of the Internet of things for big data*.

[ITU-T Y.4401] Recommendation ITU-T Y.4401 (2015), *Functional framework and capabilities of the Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 access network [ITU-T Q.1742.11]: Network that connects access technologies (such as a radio access network) to the core network.

3.1.2 core network [b-ITU-T Y.101]: A portion of the delivery system composed of networks, systems equipment and infrastructures, connecting the service providers to the access network.

3.1.3 device [ITU-T Y.4000]: With regard to the Internet of things, this is a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing.

3.1.4 gateway [ITU-T Y.4101]: A unit in the Internet of things which interconnects the devices with the communication networks. It performs the necessary translation between the protocols used in the communication networks and those used by devices.

3.1.5 Internet of things (IoT) [ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.6 IoT area network [ITU-T Y.4113]: A network of devices for the IoT and gateways interconnected through local connections.

NOTE – This definition is based on "Overview of the Internet of things" [ITU-T Y.4000], where clause 6.2 states "devices can communicate with other devices using direct communication through a local network (i.e., a network providing local connectivity between devices and between devices and a gateway, such as an ad-hoc network)".

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

EC Edge Computing

eNB evolved Node Base

EPC Evolved Packet Core

ETC Electronic Toll Collection

IoT Internet of Things

OPC Object linking and embedding for Process Control

QoS Quality of Service

RSU Roadside Unit

UE User Equipment

V2I Vehicle-to-Infrastructure

V2N Vehicle-to-Network

V2P Vehicle-to-Pedestrian

V2V Vehicle-to-Vehicle

V2X Vehicle-to-Everything

5 Conventions

In this Recommendation:

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keywords "**can optionally**" and "**may**" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Introduction of edge computing in the Internet of things

6.1 Concept of edge computing

Some of the capabilities offered by the IoT, e.g., for computing, storage and analytics, are evolving in close proximity to IoT data sources.

For the purposes of this Recommendation, IoT data usually comes via devices and gateways. IoT devices or gateways may need to have computing, storage and intelligence support from IoT platform(s) or IoT application server(s). Compared to capabilities for computing, storage and intelligence accessed via the core network, EC enables deployment in proximity to IoT data sources and may provide IoT services with increased performance. Examples of increased performance include lower service response delay, higher service reliability and higher service access capacity.

IoT requirements for support of EC may differ depending on context (e.g., applications and network technologies). EC is intended to offer flexibility (e.g., related to performance, deployment models and applications) with respect to identified needs. It is important to assess which service and functional requirements are needed in a given context. For example, not all IoT technical components may require capabilities related to support of EC.

A number of efforts (and technical standards) are currently devoted to EC technical aspects from different perspectives, e.g., [b-ECC] [b-EdgeX] [b-IIC] [b-MEC] and [b-OECI].

6.2 Internet of things challenges

To identify the requirements of the IoT to support EC, the IoT challenges described in clauses 6.2.1 and 6.2.2 need to be investigated.

6.2.1 Challenges faced by the Internet of things network

[ITU-T Y.4113] specifies a basic model of the network for the IoT, as shown in Figure 1. Multiple network technologies can be used as the IoT area network, access network and core network [ITU-T Y.4113].

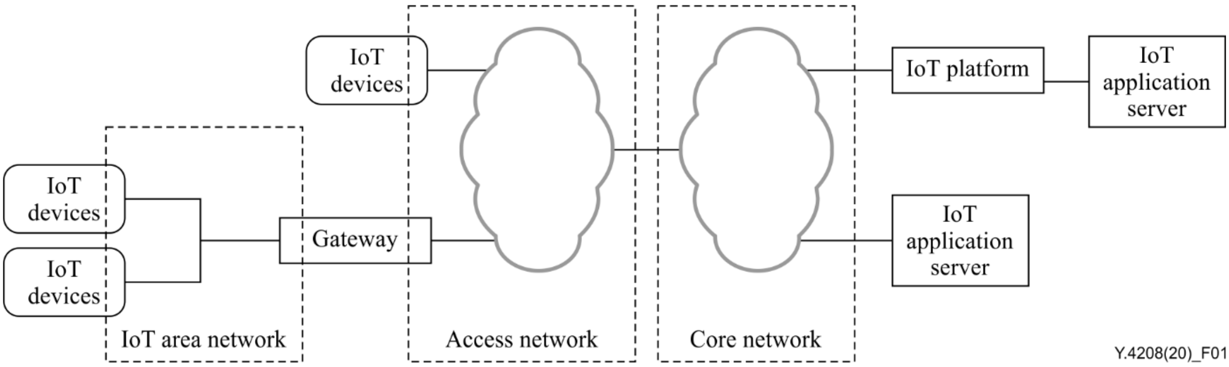


Figure 1 – Basic model of the network for the Internet of things [ITU-T Y.4113]

[ITU-T Y.4113] identifies general IoT network issues, including:

– packet loss and higher latency due to simultaneous data transmission;

– unreliability of short-range radio communications in the IoT area network;

– network overload due to the large amount of traffic to be processed.

In the basic model of the network for the IoT, heavy computing, storage and intelligence capabilities are typically deployed on IoT platforms or IoT application servers accessed via the core network, and light computing, storage and intelligence capabilities are typically deployed locally in the IoT device and the gateway, as shown in Figure 2.

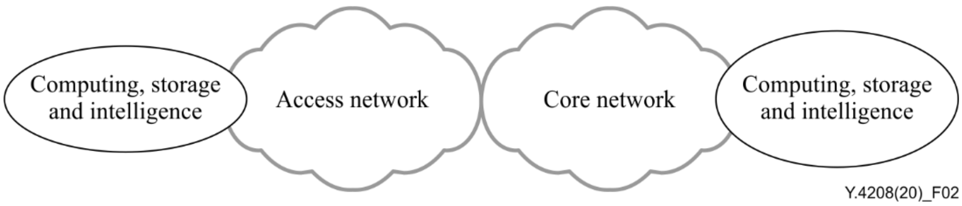


Figure 2 – Typical computing, storage and intelligence capabilities deployment under the basic model of the network for the Internet of things

To support EC, the IoT may need to be enhanced to support computing, storage and intelligence capabilities evolving in closer proximity to IoT data sources. With this support from the IoT, the computing, storage and intelligence capabilities distribution enables a new deployment model, as shown in Figure 3.

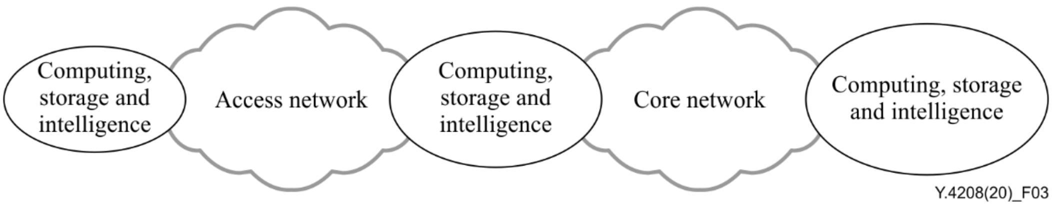


Figure 3 – New computing, storage and intelligence capabilities deployment model supported by enhanced Internet of things infrastructure

IoT infrastructure enhancement to support edge deployment may alleviate some IoT network issues identified in [ITU-T Y.4113], e.g., overload of network traffic at the core network may be decreased. However, new issues may appear, including, but not limited to:

• how to improve the capabilities of IoT technical components in order to support different service requirements at the edge;

- how to coordinate IoT technical components and assign related resources (e.g., computation, storage, network) to support EC.

The existing IoT technical components may need additional capabilities to those identified in [ITU-T Y.4113], in order to handle these new challenges, separately or in cooperation, to support EC.

6.2.2 Challenges faced by data processing in the Internet of things

[ITU-T Y.4114] addresses IoT challenges from the IoT data ecosystem aspect, including:

– fulfilment of different service requirements;

– being interoperable;

– being scalable and flexible;

– efficient usage of IoT data.

Due to IoT infrastructure enhancement, some IoT network issues identified in [ITU-T Y.4114], e.g., meeting different transmission latency requirements, may be relieved. However, new issues may appear for big data processing in the IoT, including, but not limited to:

- collection, pre-processing, storage, querying, analysis, transfer and visualization [ITU-T Y.4114] of data across IoT data sources, IoT platform(s) and application server(s) deployed in proximity to IoT data sources, as well as across IoT platform(s) and application server(s) deployed remotely from data sources;
- splitting and assignment of relevant big data processing tasks to different IoT technical components in order to meet service requirements;
- protection of data from unauthorized usage by newly introduced IoT platform(s) and application server(s) deployed in proximity to data sources.

6.3 Addressing the Internet of things challenges

Clauses 6.3.1 and 6.3.2 describe how IoT-supporting EC may address the identified IoT challenges.

6.3.1 Help reducing data overload

IoT-supporting EC may reduce data overload by buffering, storage and processing of data in IoT devices or gateways at the edge of the network. So, it can help to reduce data overload in data centres, mitigating big data challenges faced by data intensive IoT applications.

6.3.2 Enabling more flexible service provisioning

IoT-supporting EC may provide more flexible services by analysing data in IoT devices or gateways at the edge of network. Distributing data analysis and service-provisioning capabilities to IoT devices or gateways may be based on service-provisioning rules customized by IoT users or applications.

7 Service requirements from an edge-computing deployment perspective

This clause focuses on service requirements of the IoT [ITU-T Y.4000] to support EC. Service requirements are described from a deployment perspective [ITU-T Y.4401].

Based on the service requirements identified in this clause, clause 8 describes functional requirements from the angle of which logical functionalities IoT technical components need in order to fulfil service requirements.

Appendix I provides some detailed scenarios of EC in the IoT related to different application domains in support to the requirements identified in this clause and clause 8.

7.1 Edge-computing deployment perspective

From a deployment perspective, the IoT technical components [ITU-T Y.4113] – as shown in Figure 4 – may need to support requirements corresponding to EC enablement.

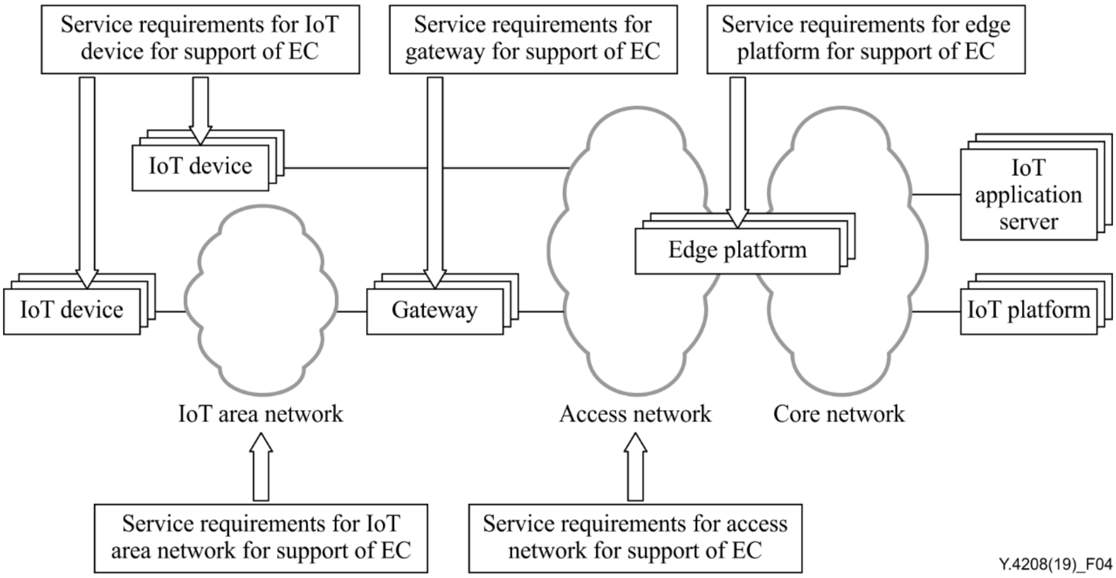


Figure 4 – Service requirements from an EC deployment perspective

(1) IoT device [ITU-T Y.4000]: In order to support EC enablement, IoT devices may need to enhance their capabilities related to computation, storage and connectivity, for example.

(2) IoT area network [ITU-T Y.4113]: The IoT area network may need to enhance its capabilities, e.g., in terms of reliability, bandwidth and latency, in order to fulfil EC-related service requirements. Vehicle-to-vehicle (V2V) scenarios described in Appendix I are examples of these IoT area network requirements.

(3) Gateway [ITU-T Y.4101]: In order to support EC, apart from common capabilities [ITU-T Y.4101], the gateway may need to enhance its capabilities, e.g., in terms of computation, storage and connectivity.

(4) Access network [ITU-T Q.1742.11]: In order to support EC, the access network may need to enhance its network capabilities.

(5) Edge platform: in order to support EC, some IoT capabilities move from IoT platform(s) and IoT application server(s) to a new IoT technical component, the edge platform. Cooperation between edge platforms, gateways, devices, IoT platforms or IoT application servers may be needed.

NOTE – The edge platform is usually a kind of cloud platform.

7.2 Service requirements for support of edge-computing capabilities in the Internet of things

7.2.1 Service requirements for Internet of things devices

(1) The IoT device is recommended to have computing and storage capabilities to support the processing of collected data directly, with or without help from gateway(s) or edge platform(s). Vehicle-to-infrastructure (V2I) and vehicle-to-network (V2N) scenarios described in clause I.1 are examples of these IoT device requirements.

7.2.2 Service requirements for the gateway

(1) The gateway is recommended to provide capabilities to support the performance balance among IoT devices, e.g., for computation, storage and network consumption. For example,

if one or more IoT devices managed by the gateway are overloaded, the gateway can assign related tasks to other managed IoT devices for relief. Smart manufacturing scenarios described in clause I.2 are examples of these IoT gateway requirements.

(2) The gateway is recommended to support collaboration among IoT devices to support requirements corresponding to EC enablement.

(3) The gateway may support collaboration with other gateways to support requirements corresponding to EC enablement.

(4) If IoT device(s) connect(s) to the access network via the gateway, the gateway is recommended to support context awareness, e.g., context information at connectivity and application levels.

7.2.3 Service requirements for the edge platform

(1) Depending on service requirements, the edge platform may support time-sensitive applications.

(2) Depending on service requirements, the edge platform is recommended to support applications with different service requirements, e.g., bandwidth, storage or computation.

(3) Depending on service requirements, the edge platform is recommended to support multiple network interfaces and application interfaces in order to support connection between elements, e.g., an IoT device, gateway, edge platform, IoT platform and IoT application server.

(4) Depending on service requirements, the edge platform may provide IoT applications with the location of IoT devices. The V2N scenarios described in Appendix I are examples of this requirement.

(5) Depending on service requirements, the edge platform may support high integrity and availability applications. The V2I, V2V and V2N scenarios in Appendix I are examples of this requirement.

7.2.4 Service requirements for the Internet of things area network

The IoT area network is recommended to be enhanced, including enabling transmission latency and connection fault probability reduction. The V2V, V2P and V2I scenarios described in Appendix I are examples of these IoT area network requirements.

7.2.5 Service requirements for the access network

The access network may support flexible network capabilities as necessary and appropriate in IoT for support of EC.

The V2N scenario described in Appendix I is an example of access network capabilities.

8 Functional requirements of the Internet of things to support edge computing

The categories of functional requirements of the IoT to support EC in clauses 8.1 to 8.4 are based on the categories of IoT common requirement specified in [ITU-T Y.4100].

8.1 Data management requirements

As described in [ITU-T Y.4100], data management requirements refer to the functional requirements for storage, aggregation, transfer and processing of IoT data. The enhanced data management requirements of the IoT to support EC are as described in clauses 8.1.1 and 8.1.2.

8.1.1 Data processing at the edge of the network

According to clauses 7.2.1 entry (1), 7.2.2 entry (1), 7.2.3 entry (1) and 7.2.3 entry (2), in order to support data processing in EC, capabilities to process data at the edge of the network are required.

8.1.2 Data buffering and storage at the edge of the network

According to clauses 7.2.1 entry (1), 7.2.2 entry (1), 7.2.3 entry (1) and 7.2.3 entry (2), in order to support data buffering and storage in EC, the capabilities to buffer and store data at the edge of the network are required.

8.2 Functional requirements to support service provisioning

Service provisioning refers to the supply of services from providers to users.

8.2.1 Location awareness and location-based service provisioning

According to clause 7.2.3 entry (4), the capability to analyse location awareness data for IoT devices or gateways is recommended.

According to clause 7.2.3 entry (4), IoT devices, gateways or edge platform(s) are recommended to support location-based service provisioning.

8.2.2 Context awareness and context-based service provisioning

According to clause 7.2.3 entry (3), interface context awareness, e.g., network interface context and application interface context, is required.

According to clause 7.2.2 entry (4), the capabilities to analyse context aware data and context-based service provisioning in IoT devices or gateways are recommended.

8.3 Application support requirements

As described in [ITU-T Y.4100], application support requirements refer to the functional requirements for the development of IoT applications in different application domains. The enhanced application support requirements of the IoT to support EC are described in clauses 8.3.1 and 8.3.2.

8.3.1 Collaboration at the edge of the network

According to clauses 7.2.2 entry (2) and 7.2.2 entry (3), in order to support collaboration at the edge of the network, the capabilities to collaborate among IoT devices, gateways and the edge platform in respect of service provisioning are required.

NOTE – "Collaboration is required among services or among devices accessing, with the same goal, IoT applications, so that the IoT can enable autonomous goal-driven collaboration among such services or devices." is specified in clause 8.3.4 of" [ITU-T Y.4100].

8.3.2 Network capability exposure

According to clause 7.2.4, the IoT area network is required to be able to expose appropriate network capabilities to IoT applications according to their requirements, e.g., in order to support time-sensitive services or high-bandwidth services.

NOTE – According to clause 7.2.5, the IoT access network may expose appropriate network capabilities in IoT for support of EC.

8.4 Management requirements

As described in [ITU-T Y.4100], the IoT non-functional requirements refer to the requirements related to the implementation and operation of the IoT. Management capabilities belong to the category of IoT non-functional requirements.

8.4.1 Distributed service management

According to clauses 7.2.2 entry (2) and 7.2.2 entry (3), in order to support service management at the edge of the network, distributed service management is recommended.

NOTE – The service management functions may be distributed to multiple edge platforms from the deployment perspective.

8.4.2 Distributed account management

According to clauses 7.2.2 entry (2) and 7.2.2 entry (3), in order to support account management at the edge of the network, distributed account management is recommended.

NOTE – The account information and related operations need to be synchronized with the associated edge platform and IoT platform from the deployment perspective.

Appendix I

Detailed scenarios of edge computing in the Internet of things related to different application domains

(This appendix does not form an integral part of this Recommendation.)

I.1 Edge-computing scenarios for vehicle-to-everything

Vehicle-to-everything (V2X) [b-3GPP TS 22.185] [b-ETSI TR 102 638] is one important domain in which EC technology can be applied.

V2X applications can be classified into the following four types [b-3GPP TS 22.185]:

– vehicle-to-vehicle (V2V) applications;

– vehicle-to-infrastructure (V2I) applications;

– vehicle-to-network (V2N) applications;

– vehicle-to-pedestrian (V2P) applications.

Based on the capabilities provided by EC and their deployment, the four types of V2X applications can be enriched with more intelligent services for end-users.

I.1.1 Vehicle-to-vehicle

V2V involves vehicles in proximity to each other exchanging application information [b-3GPP TS 22.185]. In this case, EC capabilities may need to be deployed in the vehicles so that the vehicles can transmit data and handle V2V-related messages.

In V2V scenarios, vehicles connect to each other as in an IoT area network. The IoT area network may need enhanced capabilities to support V2V.

In V2V scenarios, data exchanged between vehicles should have high integrity and availability, e.g., speed and accelerated speed of the vehicles.

Figure I.1 shows a V2V scenario example.

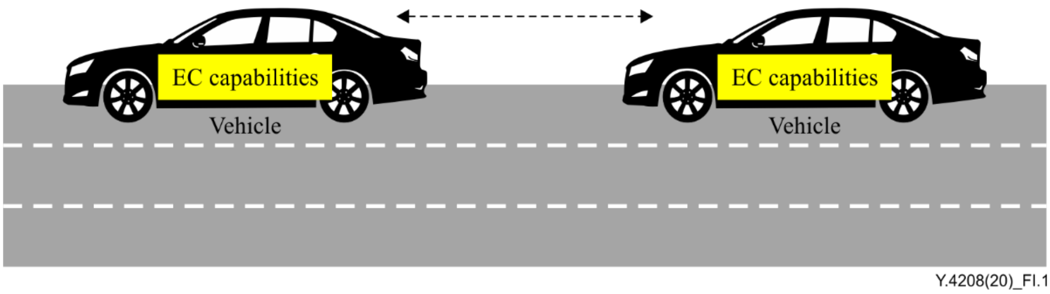


Figure I.1 – V2V scenario example

I.1.2 Vehicle-to-infrastructure

V2I involves a vehicle with applications support exchanging messages containing application information with a roadside unit (RSU) in proximity to the vehicle or locally relevant application server [b-3GPP TS 22.185]. In this case, the RSU and the vehicle may need to deploy EC capabilities to support applications involving both the vehicle and the RSU.

In V2I scenarios, the data exchanged between the vehicle and RSU or local application server should have high integrity and availability, e.g., financial data for electronic toll collection (ETC) applications. Figure I.2 shows a V2I scenario example.

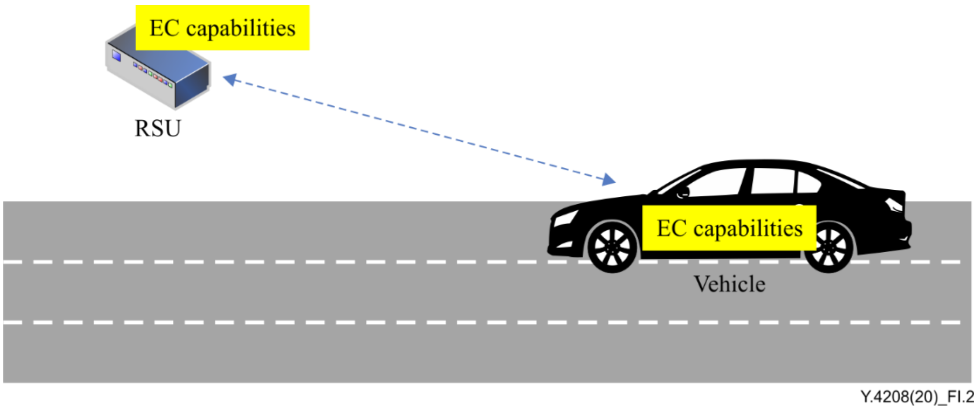


Figure I.2 – V2I scenario example

I.1.3 Vehicle-to-network

V2N involves a vehicle with applications supporting the transmission of messages containing application information to an edge platform to provide optimized network quality of service (QoS) and necessary computing and storage capabilities [b-3GPP TS 22.185], e.g., an emergency call as a V2N application needs edge platform support for car-locating capabilities. In this case, EC capabilities may need to be deployed in the vehicle and the edge application server.

In V2N scenarios, the data exchanged between the vehicle and edge platform should have high integrity and availability, e.g., driver's information and car information for emergency calls. Figure I.3 shows a V2N scenario example.

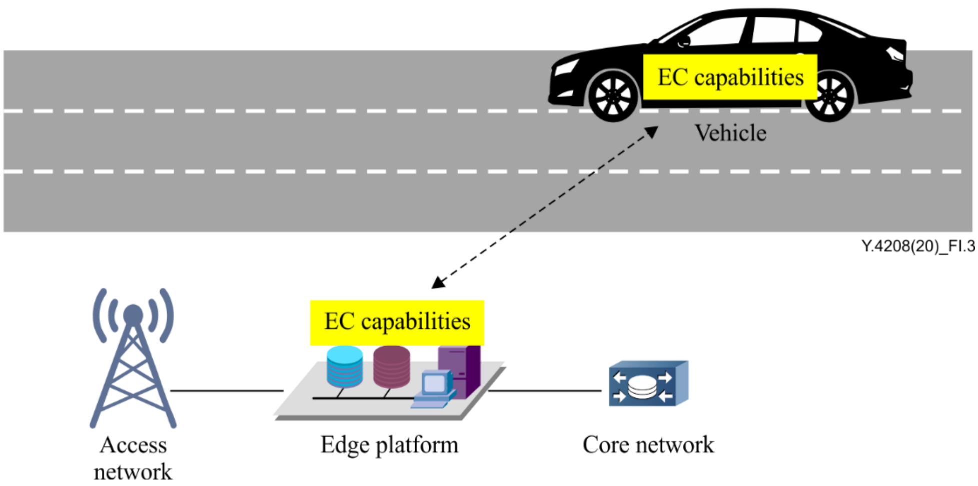


Figure I.3 – V2N scenario example

I.1.4 Vehicle-to-pedestrian

V2P involves vehicles and user equipment (UE) used by pedestrians that are in proximity to each other exchanging application information [b-3GPP TS 22.185]. The V2P applications exchange messages containing V2P information, and this exchange may be directly among vehicles and UE or may need to be supported by an RSU. In this case, EC capabilities may be deployed in the vehicle, UE and the RSU. Figure I.4 shows a V2P scenario example.

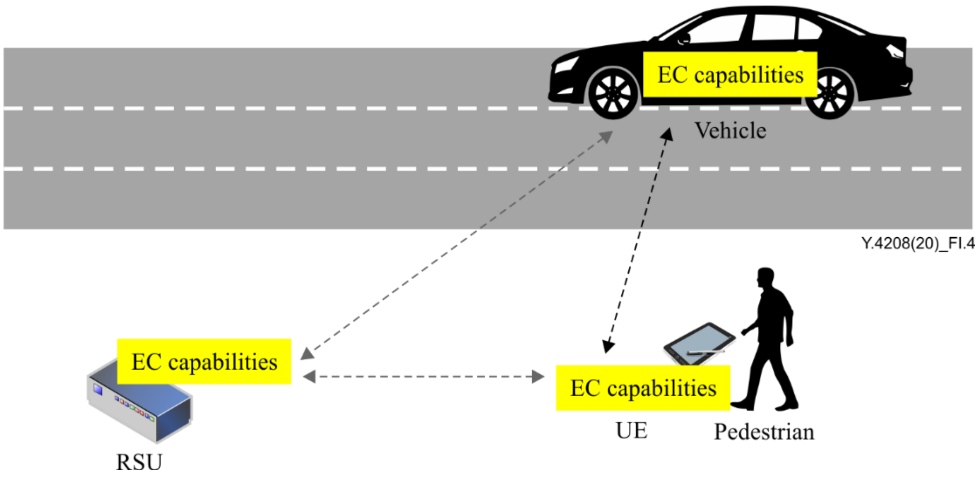


Figure I.4 – V2P scenario example

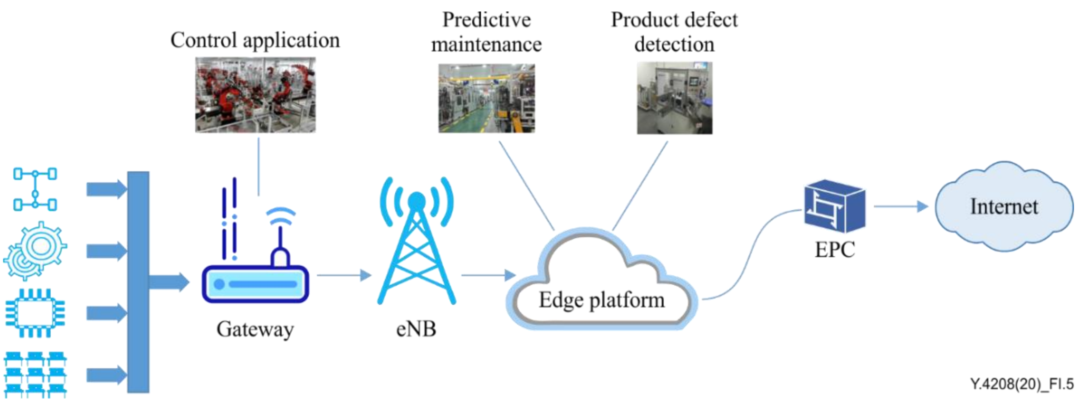
I.2 Edge-computing scenarios for smart manufacturing

For some control applications in smart manufacturing, the network transmission latency may need to be lower than 10 ms. On the other hand, the effective latency, based on practical measurements, may be higher than 100 ms in scenarios where the data needs to be transferred via a fourth generation cellular network to the cloud-hosted data centre accessed via the core network.

EC is a method of optimizing data transmission latency for central cloud-computing deployments by processing data at the edge of the network, in proximity to the data source. In smart manufacturing, EC may be used in the following two ways:

– Deploying EC at the gateway: heterogeneous industrial protocols, e.g., [b-Modbus], [b-PROFIBUS], object linking and embedding for process control unified architecture [b-OPC UA], cannot connect to the Internet directly. The gateway may deploy EC capabilities to provide functions such as industrial protocol conversion, data fusion and data cache to industrial terminal devices, and to provide industrial applications that may be deployed in the local cloud, as shown in Figure I.5.

– Deploying EC at the edge platform: the edge platform integrates local network, computing and storage capabilities inside the factory, and can provide industrial applications in proximity to the users, as shown in Figure I.5. Because the edge platform is deployed close to the factory, real-time connectivity and increased integrity for data processing are achieved.



eNB: evolved node base; EPC: evolved packet core

Figure I.5 – Edge computing scenarios for smart manufacturing

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