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

Future networks

Framework for the support of multiple network slicing

Recommendation ITU-T Y.3112

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Recommendation ITU-T Y.3112

Framework for the support of multiple network slicing

Summary

Recommendation ITU-T Y.3112 describes the concept of network slicing and use cases of multiple network slicing. The multiple network slicing enables a single device to simultaneously connect to different network slices. The use case describes the slice service type (SST) for indicating a specific network slice and the slice user group (SUG) for precisely representing the network slice in terms of performance requirements and business models. This Recommendation also specifies the high-level requirements and high-level architecture for multiple network slicing in IMT-2020 network.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3112	2018-05-29	13	11.1002/1000/13611

Keywords

IMT-2020, network function, network slice, network slice instance, network slicing.

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FOREWORD

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Framework for the support of multiple network slicing

1 Scope

This Recommendation describes the concept of network slicing and use cases of multiple network slicing where a single device is simultaneously connecting to different network slices when the device requests different services. The use case describes the slice service type (SST) for indicating a specific network slice and the slice user group (SUG) for precisely representing the network slice in terms of performance requirements and business models. From the multiple network slicing perspective, this Recommendation specifies high-level requirements in service aspect as well as network aspect. It also specifies high-level architecture in terms of network slice and network function.

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 Y.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network.*

[ITU-T Y.3101] Recommendation ITU-T Y.3101 (2018), *Requirements of IMT-2020 network.*

[ITU-T Y.3150] Recommendation ITU-T Y.3150 (2018), *High-level technical characteristics of network softwarization for IMT-2020.*

[ITU-R M.2083] Recommendation ITU-R M.2083-0 (2015), *Framework and overall objectives of the future development of IMT for 2020 and beyond.*

[ITU-R M.2410] Report ITU-R M.2410-0 (2017), *Minimum requirements related to technical performance for IMT-2020 radio interface(s).*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 IMT-2020 [ITU-T Y.3100]: Systems, system components, and related technologies that provide far more enhanced capabilities than those described in [b-ITU-R M.1645].

NOTE – [b-ITU-R M.1645] defines the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 for the radio access network.

3.1.2 network function [ITU-T Y.3100]: In the context of IMT-2020, a processing function in a network.

NOTE 1 – Network functions include but are not limited to network node functionalities, e.g., session management, mobility management and transport functions, whose functional behaviour and interfaces are defined.

NOTE 2 – Network functions can be implemented on a dedicated hardware or as virtualized software functions.

NOTE 3 – Network functions are not regarded as resources, but rather any network functions can be instantiated using the resources.

3.1.3 network slice [ITU-T Y.3100]: A logical network that provides specific network capabilities and network characteristics.

NOTE 1 – Network slices enable the creation of customized networks to provide flexible solutions for different market scenarios which have diverse requirements, with respect to functionalities, performance and resource allocation.

NOTE 2 – A network slice may have the ability to expose its capabilities.

NOTE 3 – The behaviour of a network slice is realized via network slice instance(s).

3.1.4 network slice blueprint [ITU-T Y.3100]: A complete description of the structure, configuration and work flows on how to create and control a network slice instance during its life cycle.

NOTE – A network slice template can be used synonymously with a network slice blueprint.

3.1.5 network slice instance [ITU-T Y.3100]: An instance of network slice, which is created based on network slice blueprint.

NOTE 1 – A network slice instance is composed of a set of managed run-time network functions, and physical/logical/virtual resources to run these network functions, forming a complete instantiated logical network to meet certain network characteristics required by the service instance(s).

NOTE 2 – A network slice instance may also be shared across multiple service instances provided by the network operator. A network slice instance may be composed of none, one or more sub-network slice instances which may be shared with another network slice instance.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3G Third Generation

4G Forth Generation

AMF Access and Mobility Management Function

AR Augmented Reality

E2E End-to-End

eMBB enhanced Mobile Broadband

HD High Definition

IMT International Mobile Telecommunications

KPI Key Performance Indicator

mIoT massive Internet of Things

MVNO Mobile Virtual Network Operator

NF Network Function

NS Network Slice

NSI Network Slice Instance

NSTI	Network Slice Type Indication
SMF	Session Management Function
SST	Slice Service Type
SUG	Slice User Group
UE	User Equipment
UHD	Ultra-High Definition
URLLC	Ultra-Reliable Low Latency Communications
V2X	Vehicle to Everything
VR	Virtual Reality

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

6 Overview

The IMT-2020 network is expected to be able to support a variety of different services and applications beyond the current IMT [ITU-R M.2083]. In the IMT-2020 network, the services and the applications can have a variety of different requirements on functionality (e.g., priority, charging, policy control, security and mobility), differences in performance requirements (e.g., latency, mobility, availability, reliability and data rates), or differences in serving users (e.g., public safety users, corporate customers, roamers, or hosting an MVNO) [b-3GPP TS 22.261]. Network slicing is recognized as a key enabler supporting different types of services in that it can provide each service over corresponding network slice that is logically isolated by slicing a single physical network into multiple, end-to-end (E2E) networks [b-NGMN].

Furthermore, a broad variety of capabilities can be tightly coupled with these intended different use cases for IMT-2020 [ITU-R M.2083], [b-3GPP TS 22.261]. The use cases for IMT-2020 include:

– Enhanced mobile broadband (eMBB): This use case pertains to high data rates, high user density, high user mobility, highly variable data rates, deployment and coverage. The enhanced mobile broadband will come with new application areas and requirements in addition to existing mobile broadband applications for improved performance and an increasingly seamless user experience.

– Massive Internet of things (mIoT): This use case is characterized by a very large number of connected devices typically transmitting a relatively low volume of non-delay-sensitive data. Devices are required to be low cost and have a very long battery life.

– Ultra-reliable and low latency communications (URLLC): This use case has stringent requirements for capabilities such as throughput, latency and reliability. Some examples include wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid, transportation safety, etc.

Network slicing enables the operator to provide customised networks by slicing one physical network into multiple, virtual, end-to-end networks, referred to as network slices. Each network slice can be defined according to different requirements on functionality, performance and specific users. Moreover, the slices can be operated by different service providers (e.g., tenants, 3rd parties).

For each network slice, dedicated resources (e.g., virtualized network functions, network bandwidth, QoS) are guaranteed and an error or fault that occurs in one slice does not cause any effects on communication in other slices.

Up to now, mobile networks (e.g., 3G, 4G), mainly serving mobile phones, have been optimized for voice and Internet services in a centralized deployment. However, in the IMT-2020 network, they will have to serve a variety of devices with different requirements and needs. Some of the most commonly mentioned use cases for IMT-2020 are enhanced mobile broadband, massive IoT and URLLC. These all have different requirements on performance [b-Netmanias]. For instance, the mIOT use case that connects stationary sensors measuring temperature, humidity, precipitation, etc. to mobile networks, does not require features such as handover or location update, which have been critical in serving mobile phones.

In the eMBB use case, high data rates are driven by the increasing use of data for services such as streaming 4K/8K ultra-high definition (UHD) and interactive services such as augmented reality (AR). These services come with stringent requirements for user experienced data rates as well as associated requirements for latency to meet service requirements [ITU-R M.2410].

On the other hand, the URLLC use case (e.g., autonomous driving, remote controlled robots) requires, unlike a mobile broadband service, a substantially lower latency as well as higher reliability, as indicated in Table 6-1.

Table 6-1 – Use cases for IMT-2020

Use cases	Minimum performance requirements	Examples
eMBB	Higher bit rate (e.g., 20 Gbit/s downlink peak data rate)	4K/8K UHD, hologram, AR/VR
mIoT	Massive connection	Sensor network (metering, agriculture, building, logistics, city, home, etc.)
URLLC	Lower latency (e.g., 1ms), higher reliability, higher positioning accuracy	Motion control, autonomous driving, automated factory, smart-grid, AR/VR

NOTE – These requirements are not intended to restrict the full range of capabilities or performance.

Figure 6-1 provides a high level concept of network slicing. A network slice is composed of a collection of necessary network functions (e.g., being virtualized and/or physical) that supports the service requirements of particular use case(s). It shall be possible to direct devices to their proper slices in order to meet respective requirements, based on device or service type. For example, a mobile phone requesting a high definition (HD) streaming service is directed to an eMBB slice. The mIoT slice and the URLLC slice are respectively allocated to a sensor measuring temperature and an automobile using vehicle to everything (V2X) communication service.

Network slicing allows the IMT-2020 network operator to provide dedicated logical networks (i.e., network slices) with customer specific functionalities. A network slice, spanning all the network segments including the radio access network, transport network and core network, can be dedicated to specific types of service [ITU-T Y.3101]. When a user equipment (UE) is only associated with a single dedicated network slice, the IMT-2020 network can identify the association of UEs with a network slice based on user subscription, context, service provider's policy, etc.

Otherwise while a UE can access multiple slices simultaneously; it should provide information to the network to assist the network slice selection process.

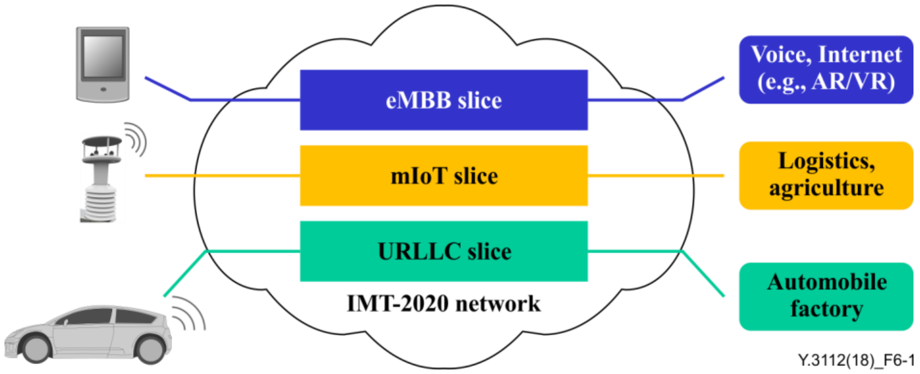

Figure 6-1 – The concept of network slicing

Based on the concept of network slicing, the use cases for multiple network slicing are described in clause 7. Clause 8 specifies how to indicate a network slice and select a network slice. In clauses 9 and 10 respectively, high-level requirements and architecture also specify necessary functions in order to select a proper network slice.

7 Use cases of multiple network slicing

In general, a UE can be connected to one or more network slices simultaneously according to the different requesting service types and performance requirements. The autonomous driving car, described in this clause, is one of the use cases where the UE is connected to different network slices simultaneously. The network slices enable the creation of customized networks to provide flexible solutions for different market scenarios which have diverse requirements, with respect to functionalities, performance and resource allocation.

In Figure 7-1 an autonomous driving car is connected to the network via V2X communication. A user, sitting in the car, initiates a HD video streaming service through the infotainment system available in the car. In this use case, the V2X communication service requires a lower latency but not necessarily a higher bit rate, whereas, the HD video streaming service requires a higher bit rate but is tolerant of latency.

Therefore, the V2X communication service and the HD video streaming service are allocated to different network slices providing their respective performance requirements which in this example are the URLLC slice and the eMBB slice respectively.

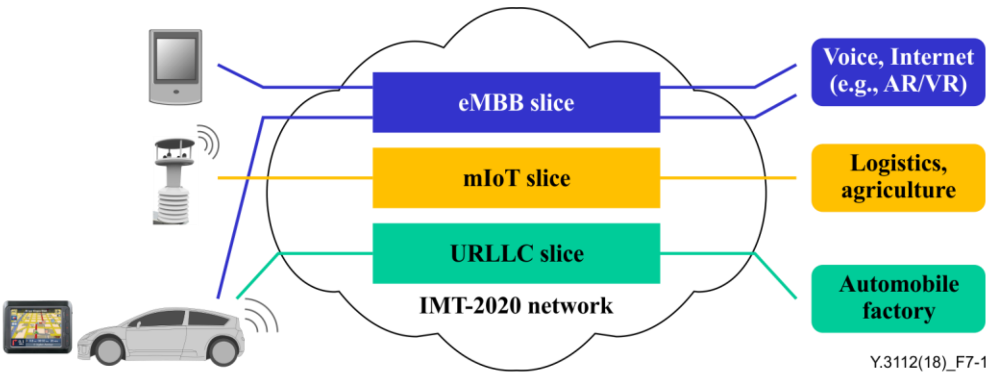

Figure 7-1 – Use case for network slicing; Autonomous driving car

From the business deployment model perspective, a network slice may indicate the vehicles constructed with a specific motor and can be used to efficiently manage and update their configuration changes. Figure 7-2 shows a use case where network slices are used to identify autonomous driving cars with different types of motor.

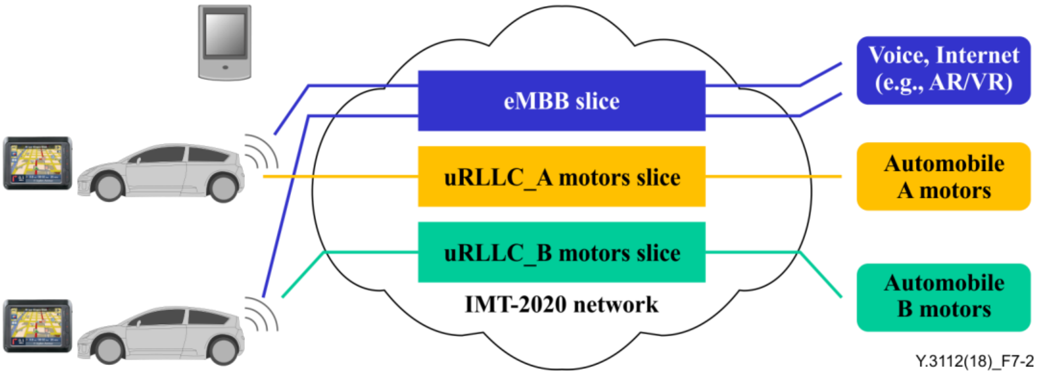

Figure 7-2 – Use case where network slices are used to identify autonomous driving cars with different types of motor

According to [b-3GPP TS 22.261], the IMT-2020 network is assumed to support motion-to-photon latency in the range of 7-15ms while maintaining the required user data rate of 250Mbps for virtual reality (VR). A specific service such as virtual reality (VR), as illustrated in Figure 7-3, can require both a higher data rate and lower latency as well as both eMBB and URLLC [ITU-R M.2083]. This means that a UE is required to provide network slice indication information when it has the capability to request multiple network slices. The information is required to be one of the network slice types to which the UE wishes to connect when registering to the IMT-2020 network. It depends on the network operator's policy to identify what can be considered a proper network slice when the capabilities pertaining to the different use cases are requested or whether the combination of an eMBB slice and a URLLC slice is necessary.

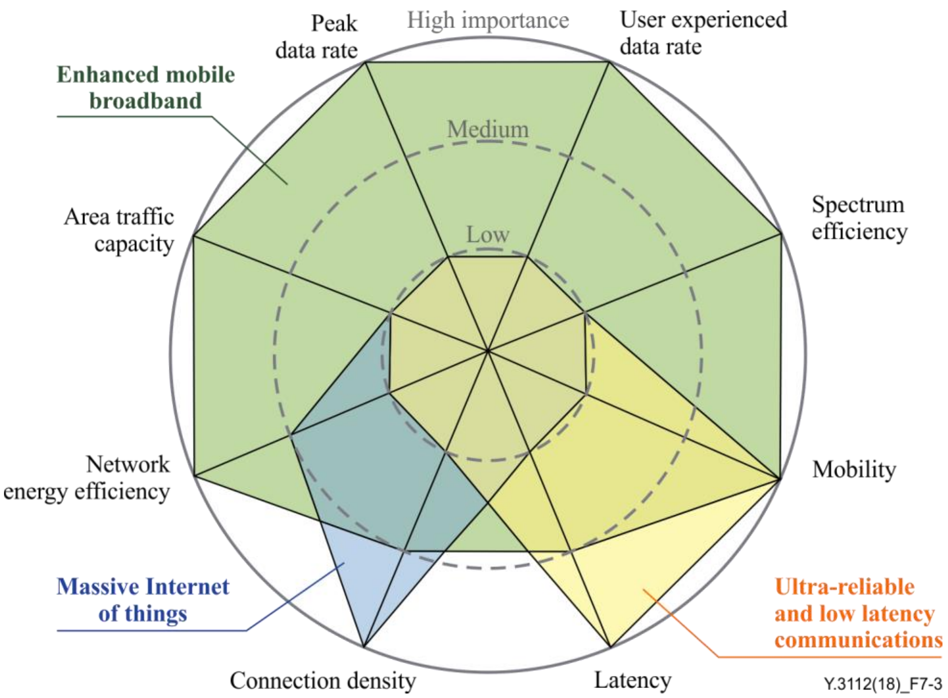

Figure 7-3 – The importance of key capabilities in different usage scenarios

8 Network slice indication and selection

This clause specifies how a network slice is indicated and then selected.

8.1 Indication of a network slice

The network slice is regarded as having evolved from traditional virtual private networks which purposely enable different users to send and receive their own data on transport networks through isolated and secured network paths.

In addition, the network slice is extended to include different service features as well as different groups of users. Network slices, therefore, can explicitly represent what kinds of services and user groups they can provide. For example, network slice types may be identified in terms of different functionality requirements (e.g., charging, policy control, security and mobility), differences in performance requirements (e.g., latency, mobility and data rates), or according to specific users (e.g., corporate customers, roamers, or hosting an MVNO) [ITU-T Y.3101], [b-3GPP TS 22.261] and need to be explicitly identified with a particular indication.

From the above use cases, the network slice indication can include three factors in the network function aspects; 1) different functionality, 2) performance requirements and 3) user groups. The combination of different functionality and performance requirements can probably be simplified into service type, for example eMBB, URLLC, mIoT, etc. Consequentially, the network slice type indication (NSTI) can be comprised of two kinds of information:

– Slice service type (SST): Refers to the different services that require different functionality and performance of network functions. It may be classified in detail as a way to deeply segment the performance requirements of the network functions. Examples of SST are eMBB, URLLC, mIoT and eMBB+URLLC;
– Slice user group (SUG): Is optional information that complements the slice service type (SST) to allow further differentiation in different user groups.

The NSTI information is required to include all possible service types that a UE is capable of requesting from the IMT-2020 network in advance when a UE is initially registered or re-registered. Receiving the NSTI information from a UE, the network finally approves the NSTI information to allow the UE to possibly request all network services, after considering the operator's policy and network status. The UE is able to include only one NSTI when requesting a particular network service from the IMT-2020 network.

8.2 Selection of network slice

IMT-2020 networks need a lot of network functions to provide a variety of use cases, i.e., eMBB, URLLC and mIoT. From the network slicing perspective, the functions can be classified into two types based on the possible areas where the corresponding functions can deploy in IMT-2020 networks. Firstly some functions such as network slice selection would be deployed in providing their capabilities to other functions in all IMT-2020 networks. These functions would be deployed in a centralized manner [b-3GPP TS 23.501]. In addition their implementation would be in single or multiple network slices, depending on the operator's policy.

Alternatively, the functions that are related to key performance indicators (KPIs) would be deployed in a distributed manner. Therefore the functions such as mobility management, session management and data path control can be deployed in every specific area such as a set of tracking areas and registration areas. The functions would be further divided into two types; UE level function and service session level function. The UE level function can be a contact point to a UE for providing a service in IMT-2020 networks. Therefore a single UE level function, for example registration management and mobility management, should be selected in every specific area. For the purposes of this Recommendation the access and mobility management function (AMF) is used as it serves as an example of a function supporting registration management and mobility management functions. A single AMF can have all of the proper capabilities for supporting every service session that the UE wants to make. Consequently AMF relocation may be avoided. AMF can logically reside in multiple network slices serving the UE. This AMF in a network slice can interact with other functions in each network slice.

The session management and data path control functions, for example, can possibly belong to the service level function. They can exist within different network slices according to related the KPIs. The service level function is used as an example in this Recommendation as a function supporting the session management function. Therefore a specific session management function (SMF) should be selected supporting the required capabilities when the UE requests a specific service session from IMT-2020 networks.

The UE can request multiple service sessions simultaneously. In this regard, the AMF interacts with the multiple SMFs with different network slices.

The network slice instance (NSI) can be instantiated into static and dynamic methods according to the selection sequence of the instances. In static network slicing, necessary NSIs are provisioned in configuration time and the NSI includes the proper network function (NF) instances that meet needs from the NSI. The selection sequence of NF instances is to first choose a single NSI among available NSIs and then select the relevant NF instances within the selected network slice instance. Therefore the NF instances within the other NSIs cannot even be a candidate to be picked up. Alternatively, dynamic network slicing can first select the proper NF instances according to network slice indication and then make the NSI comprising the selected NF instances. With this method, the best NF can be selected among available NFs with the same capabilities in the IMT-2020 network with consideration of the resource availability and the load status. Regarding the new request therefore once the NSI is determined, the selection of NF instances is not repeatedly required. While considering the operator's policy or the service features, the proper network slicing method can be determined.

(1) Network slice instance selection

The network slice type indication (NSTI) is required to include at most a single slice service type (SST) when a UE requests a specific service from the IMT-2020 network, which may indicate either a use case (e.g., eMBB, mIoT and URLLC) or their combination (e.g., eMBB+URLLC, etc.). Furthermore the NSTI can include the SST as well as the slice user group (SUG) in order to precisely indicate a specific NSI when the SUG can include a detail of performance requirements as well as the user group in a particular area. Examples can be "URLLC with latency 100ms", "URLLC with latency 5ms", "eMBB with 100Mbit BW for user in urban area", "eMBB with 10Mbit BW for user in rural area". The granularity of NSTI can be mutually negotiated between the UE and the network, based on the operator's policy.

The network determines the NSI by comparing the NSTI from the UE with the availability of NSI in the IMT-2020 network. If the granularity of network-provided NSI is finer than the NSTI from the UE or the same level, then the network with the additional help of other information, e.g., operator's policy and subscription information, can select the NSI that the UE wants.

(2) Network function selection

The NSI is comprised of the relevant network functions (NFs) for providing a specific service. Furthermore the NSI can include multiple NFs with the same features. Among the multiple NFs, a single NF can be selected as a load balancing consideration.

9 High-level requirements of multiple network slicing

– UE level network functions, e.g., registration management and mobility management, etc., are required to be shared among multiple network slices.

NOTE – Some of the shared functions can be global and used for all network slices whereas some of them can be tenant (e.g., service provider) specific and shared between slices of the same tenant only.

– Service level network functions, e.g., session management and data path control, etc., are required to be slice-specific.

– IMT-2020 network is required to instantiate at least one network slice instance (e.g., eMBB) inherited from the characteristics of the network slice (e.g., eMBB).

– A UE is recommended to provide all supporting network slice type indications to a network when the UE registers with the network.

– A UE is required to provide a single network slice type indication including a specific network slice when the UE requests the network to establish a service session.

– IMT-2020 network is recommended to create a network slice instance based on the network slice type indication provided by the UE or a default value if the indication is not available.

NOTE – Availability of network slices and instances depends on network operator's policy.

– IMT-2020 network is required to select a network slice instance based on the network slice type indication provided by the UE or a default value if the indication is not available.

– IMT-2020 network is recommended to allocate a default value for the setwork slice type indication when a UE subscribes to the network.

– IMT-2020 network is recommended to add and/or remove the network functions in order to change the configuration of a network slice instance.

– IMT-2020 network is required to minimize the impact, in changing the configuration of a network slice, on services being provided by itself and other network slices.

10 High-level architecture of multiple network slicing

Network slices enable the creation of customized networks to provide flexible solutions for different market scenarios which have diverse requirements, with respect to functionalities, performance and resource allocation [ITU-T Y.3100]. The network slices with diverse requirements, therefore, need to provide different services according to their performance requirements. This also means that each network slice should provide only corresponding services.

From the UE perspective, a number of different services can be initiated at the same time and the services should be served by connecting to corresponding different network slices. Each network slice includes the specific network functions that satisfy their service requirements. Therefore the UE level network function (e.g., AMF) should be selected in order to meet the highest demand of performance requirement among the UE level network functions within different network slices. On the other hand, the service level network function should be selected within each corresponding network slice.

From the network perspective, the network slices should be isolated enough between them in order to minimize interference. The interaction between the different service level network functions can occur in the same network slice. In addition, the network slice instance is the realization of a network slice, which is created based on network slice blueprint [ITU-T Y.3100]. Even multiple network slice instances can be instantiated according to a corresponding network slice (e.g., eMBB). On the other hand the interaction between a UE level network function instance (e.g., AMF) and a service level network function instance (e.g., SMF) should be supported while keeping an appropriate isolation level of the network slice instances. Therefore a specific service session can be established through a UE, a UE level network function, various service level network functions and a server (e.g., streaming server, automobile server, etc.) over Internet as shown in Figure 10-1.

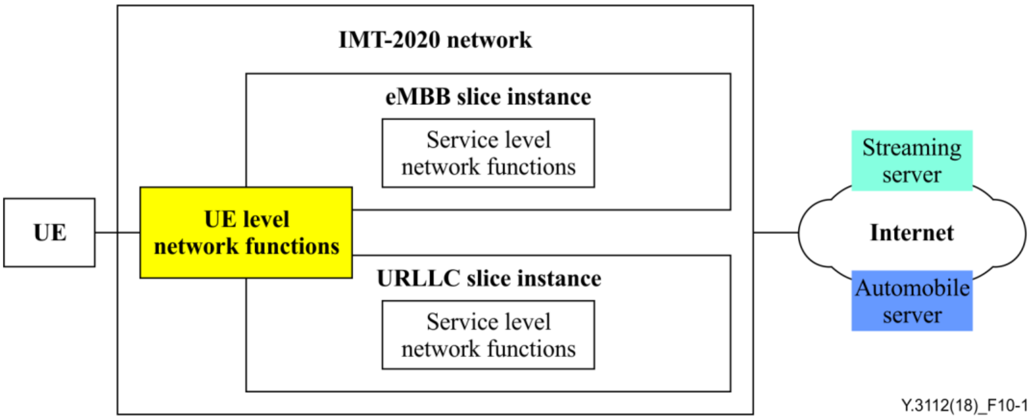

Figure 10-1 – Network functions from the UE perspective

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