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

Future networks

Quality of service functional requirements for the IMT-2020 network

Recommendation ITU-T Y.3106

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	**Y.3000–Y.3499**
CLOUD COMPUTING	Y.3500–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.3106

Quality of service functional requirements for the IMT-2020 network

Summary

Recommendation ITU-T Y.3106 specifies the quality of service (QoS) functional requirements for the International Mobile Telecommunications-2020 (IMT- 2020) network.

This Recommendation first provides an overview of QoS requirements for IMT-2020. It then describes the high-level QoS capabilities of the IMT-2020 network, which include: QoS planning, QoS provisioning, QoS monitoring and QoS optimization. Based on these capabilities, Recommendation ITU-T Y.3106 specifies the QoS functional requirements for the IMT-2020 network.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3106	2019-04-29	13	11.1002/1000/13891

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IMT-2020 network, QoS functional requirements.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Table of Contents

Recommendation ITU-T Y.3106

Quality of service functional requirements for the IMT-2020 network

1 Scope

This Recommendation specifies quality of service (QoS) functional requirements for the International Mobile Telecommunications-2020 (IMT-2020) network. This Recommendation provides:

- an overview of QoS requirements for IMT-2020;
- high-level QoS capabilities of the IMT-2020 network;
- QoS functional requirements for the IMT-2020 network.

All functional requirements specified in this Recommendation apply strictly to the IMT-2020 network, which means that those related to the radio access network lie outside the scope of this Recommendation.

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 E.860] Recommendation ITU-T E.860 (2002), *Framework of a service level agreement*.

[ITU-T P.10] Recommendation ITU-T P.10/G.100 (2017), *Vocabulary for performance and quality of service*.

[ITU-T Q.1743] Recommendation ITU-T Q.1743 (2016), *IMT-Advanced references to Release 11 of LTE-Advanced evolved packet core network*.

[ITU-T X.1211] Recommendation ITU-T X.1211 (2014), *Techniques for preventing web-based attacks*.

[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 the IMT-2020 network*.

[ITU-T Y.3110] Recommendation ITU-T Y.3110 (2017), *IMT-2020 network management and orchestration requirements*.

[ITU-T Y.3111] Recommendation ITU-T Y.3111 (2017), *IMT-2020 network management and orchestration framework*.

[ITU-T Y.3170] Recommendation ITU-T Y.3170 (2018), *Requirements for machine learning-based quality of service assurance for the IMT-2020 network*.

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

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 anomaly [ITU-T X.1211]: A pattern in the data that does not conform to the expected behaviour.

3.1.2 IMT-2020 [ITU-T Y.3100]: (Based on [ITU-R M.2083-0]) Systems, system components, and related technologies that support to 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.

3.1.3 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 quality of experience (QoE) [ITU-T P.10]: The degree of delight or annoyance of the user of an application or service.

NOTE – Recognizing on-going research on this topic, this is a working definition which is expected to evolve for some time. (This note is not part of the definition.)

3.1.5 quality of service [b-ITU-T Q.1743]: The collective effect of service performances, which determine the degree of satisfaction of a user of a service. It is characterized by the combined aspects of performance factors applicable to all services, such as:

– service operability performance;

– service accessibility performance;

– service retainability performance;

– service integrity performance; and

– other factors specific to each service.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 service level agreement (SLA): A formal agreement between two or more entities reached after a negotiating activity with the scope to assess service characteristics, responsibilities and priorities of every part. A SLA may include statements about performance, billing, service delivery but also legal and economic issues.

NOTE – Definition based on [ITU-T E.860].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AN Access Network

AR Augmented Reality

CN Core Network

DN	Data Network
E2E	End To End
eMBB	enhanced Mobile Broadband
GBR	Guaranteed Bit Rate
IMT	International Mobile Telecommunications
KPI	Key Performance Indicator
M2M	Machine to Machine
mIoT	massive Internet of Things
MTC	Machine Type Communication
QoE	Quality of Experience
QoS	Quality of Service
RAT	Radio Access Technology
SLA	Service Level Agreement
SLS	Service Level Specification
SP	Slice Provisioning
UE	User Equipment
URLLC	Ultra-Reliable Low Latency Communication
V2X	Vehicle to everything
VR	Virtual Reality

5 Conventions

This Recommendation uses the following conventions:

The term "is required to" indicates 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/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Overview of quality of service requirements for IMT-2020

The IMT-2020 is expected to provide optimized support for a variety of different use cases, services, different traffic loads, and different end user communities [b-3GPP TS 22.261].

The IMT-2020 use cases are consolidated into three typical use case categories: enhance mobile broadband (eMBB) communication, massive machine type communication (MTC) and critical communication of ultra-reliable low latency communications (URLLCs). Typical applications include virtual reality/augmented reality (VR/AR), 4K video streaming, and multi-view 3D live streaming, vehicle to everything (V2X), and machine to machine (M2M) over the IMT-2020 network.

The eMBB use case addresses the human-centric use cases for access to multi-media content, services and data that cover a range of cases, including wide-area coverage and hotspot, which have different requirements.

The MTC 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.

The URLLC has stringent requirements for capabilities such as throughput, latency and availability. Examples include wireless control of industrial manufacturing or production processes, remote medical surgery, distribution automation in a smart grid and transportation safety.

The usage scenarios of IMT-2020 are illustrated in Figure 1 [ITU-R M.2083-0].

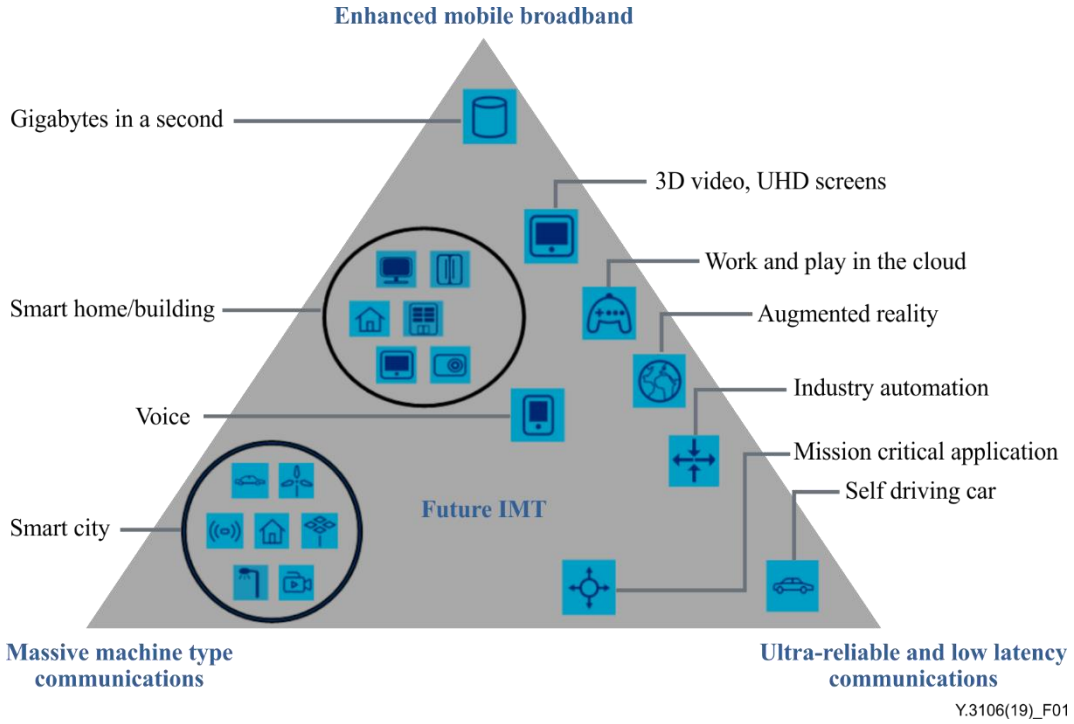

Figure 1 – Usage scenarios of IMT for 2020 and beyond [ITU-R M.2083-0]

The following eight key performance indicators (KPIs) are considered to be key capabilities of IMT-2020 [ITU-R M.2083-0].

1) **Peak data rate**: Maximum achievable data rate under ideal conditions per user or device (in gigabits per second). The peak data rate of IMT-2020 for enhanced mobile broadband (eMBB) is expected to reach 10 Gbit/s. However, under certain conditions and scenarios, IMT-2020 would support up to 20 Gbit/s peak data rate.

2) **User-experienced data rate**: Achievable data rate that is available ubiquitously across the coverage area to a mobile user/device (in megabits per second or gigabits per second). For wide area coverage cases, e.g., in urban and suburban areas, a user-experienced data rate of 100 Mbit/s is expected to be enabled. In hotspot cases, the user-experienced data rate is expected to reach higher values (e.g., 1 Gbit/s indoor).

3) **Latency**: The contribution by the radio network to the time from when the source sends a packet to when the destination receives it (in milliseconds). IMT-2020 would be able to provide 1 ms over-the-air latency, capable of supporting services with very low latency requirements.

4) **Mobility**: Maximum speed at which a specified QoS [ITU-T Q.1743] and seamless transfer between radio nodes that may belong to different layers or radio access technologies (RATs) can be achieved (in kilometres per hour). IMT-2020 is also expected to enable high mobility up to 500 km/h with acceptable QoS. This is envisioned in particular for high speed trains.

5) **Connection density**: Total number of connected or accessible devices per unit area (per square kilometre). IMT-2020 is expected to support a connection density of up to $10^6/km^2$, for example in massive MTC scenarios.

6) **Energy efficiency**: On the network side, energy efficiency refers to the quantity of information bits transmitted to or received from users per unit of energy consumption of the radio access network (RAN) (in bits per joule); On the device side, energy efficiency refers to quantity of information bits per unit of energy consumption of the communication module (in bits per joule). The energy consumption for the RAN of IMT-2020 should not be greater than IMT networks deployed today, while delivering the enhanced capabilities.

7) **Spectrum efficiency**: Average data throughput per unit of spectrum resource and per cell (bits per second per hertz). The spectrum efficiency is expected to be three times higher compared to IMT-Advanced for eMBB.

8) **Area traffic capacity**: Total traffic throughput served per geographic area (in megabits per second per square metre). IMT-2020 is expected to support 10 $Mbit/s/m^2$ area traffic capacity, for example in hot spots.

The IMT-2020 should be able to provide these capabilities without undue burden on energy consumption, network equipment cost and deployment cost to make future IMT sustainable and affordable.

7 High-level QoS capabilities of the IMT-2020 network

According to [ITU-T Y.3101], the IMT-2020 network is required to support unified QoS control and end-to-end (E2E) QoS mechanisms independently of network access technologies. The IMT-2020 network is recommended to support finer granularity of QoS control mechanisms than those supported by legacy networks. The IMT-2020 network is recommended to support user-initiated QoS control mechanisms in order to support diverse service performance to comply with a service level specification (SLS) resulting from a negotiation between a customer and a service provider in an SLA [ITU-T E.860].

All services and usage scenarios (eMBB, URLLC, massive Internet of things (mIoT)) are supported by different network slice (see clause 3.1.3) instances during the lifecycle of service. The IMT-2020 network slice lifecycle orchestration, management requirements and functionalities are specified in [ITU-T Y.3110] and [ITU-T Y.3111]. Orchestration functionalities are specified in the functional elements: slice capacity planning and optimization; slice provisioning (SP); and inter-slice orchestration. Management functionalities are specified in the functional elements: slice fault/security/charging management; slice resource monitoring; analytics; and resource repository. They work together to achieve slice lifecycle management objectives. During the lifecycle of services and associated network slice instances, QoS lifecycle management is also involved, which can be classified into four interdependent categories: IMT-2020 network QoS planning; QoS provisioning; QoS monitoring; and QoS optimization, which can be seen in Figure 2.

IMT-2020 network QoS planning provides an estimate of the network coverage, capacity and resources requirements. This requires the knowledge of real traffic estimates and network topology for each analysed area, utilization of accurate models for signal and user data transmissions and implementation of the actual network element characteristics, functionalities and parameters.

IMT-2020 network QoS provisioning includes: translation of service-centric SLA to resource-facing network slice descriptions; unified and E2E QoS controlling; QoS interworking and mapping; and efficient E2E QoS provisioning.

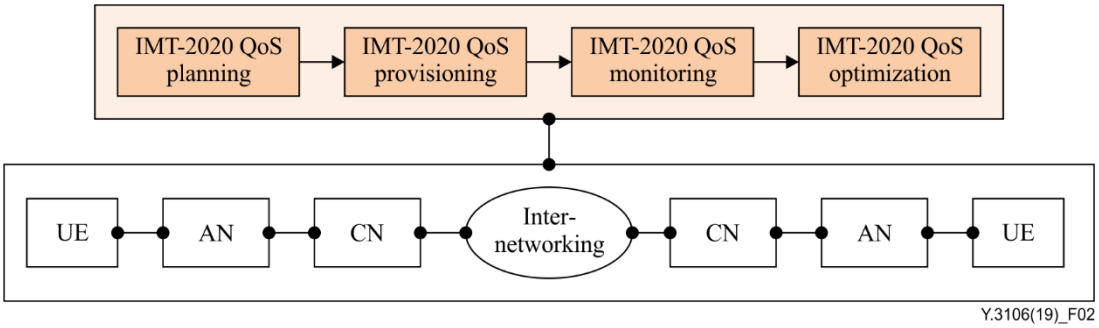

Figure 2 – High-level QoS capabilities of the IMT-2020 network

IMT-2020 network QoS optimization can be seen as a process to improve the overall network quality, user's QoE (see clause 3.1.4) and to ensure that network resources are efficiently utilized. This includes IMT-2020 QoS monitoring [b-3GPP TS 22.261], measurements, analysis of measurement results, anomaly [ITU-T X.1211] detection, anomaly prediction [ITU-T Y.3170] and updates of the network configuration parameters [b-Soldani].

Clause 8 identifies QoS functional requirements for service-driven IMT-2020 network QoS planning, QoS provisioning, QoS monitoring and QoS optimization for the fulfilment of required service KPIs.

8 Quality of service functional requirements for the IMT-2020 network

8.1 Quality of service planning requirements for the IMT-2020 network

IMT-2020 network QoS planning requirements are as follows:

– it is required to support service-driven QoS planning for the IMT-2020 network;

– it is required to support dynamical modelling of diversified IMT-2020 usage scenarios (eMBB, MTC and URLLC);

– it is required to convert service models to traffic models accurately;

– it is required to support an accurate estimate of network coverage, capacity, resources and network slices requirements;

– it is required to estimate and allocate network resources in a way that maximizes its utilization efficiently;

– it is recommended to support QoS-aware routing to satisfy different service requirements for delay, bandwidth, throughput, load balance, cost, etc.

8.2 Quality of service provisioning requirements for the IMT-2020 network

IMT-2020 network QoS provisioning requirements are as follows:

– it is required to support E2E QoS for diversified IMT-2020 usage scenarios (eMBB, MTC and URLLC);

– it is required to support translating service-centric SLA to resource-facing network slice descriptions;

– it is required to support efficient E2E QoS provisioning with the capabilities of global network view, on demand softwarized network functions, autonomous network slicing management and orchestration.

– it is required to support unified and access-agnostic (fixed or mobile access) QoS control from a core network (CN) perspective;
– it is required to support proper QoS interworking and mapping among user equipment (UE), access network (AN), CN and other data network (DN);
– it is required to support a finer level of QoS granularities based on flows to meet different service requirements;
– it can optionally support both QoS flows that require guaranteed bit rate (GBR QoS flows) or QoS flows that do not require GBR (non-GBR QoS flows);
– it is required to support QoS enforcement, which includes flow classification, marking, congestion avoidance, queue shaping and queue scheduling based on QoS rule(s);
– it is recommended to support QoE awareness that can dynamically adapt user QoE demands to QoS parameters;
– it is recommended to support QoS capabilities exposure that can be accessed by authorized parties.

8.3 Quality of service monitoring requirements for the IMT-2020 network

IMT-2020 network QoS monitoring requirements are as follows:

– it is required to provide a mechanism for supporting real time E2E QoS monitoring;
– it can optionally support measuring QoS parameters using active mode or passive mode;
– it is required to provide an interface to application for QoS monitoring (e.g., to initiate QoS monitoring, request QoS parameters, events or logging information);
– it is required to respond to an authorized user request to provide real-time QoS monitoring information within a specified time after receiving the request;
– it is required to provide real time QoS parameters and events information to an authorized application or network entity;
– it is required to support an update or refresh rate for real time QoS monitoring within a specified time;
– it is required to log the history of QoS events – including, for example, parts of the SLA that are not met, time-stamp of the events and event position (e.g., UE and radio access points associated with the events);
– it is required to support different levels of granularity for QoS monitoring (e.g., per flow or set of flows);
– it is recommended to provide event notification upon detecting error that the negotiated QoS level cannot be met or guaranteed;
– it is recommended to provide notification of QoS events to authorized users per pre-defined patterns (e.g., every time the bandwidth drops below a pre-defined threshold for QoS parameters, the authorized user is notified and event is logged);
– it is recommended to provide statistical information of service parameters and error types while a communication service is in operation.

8.4 Quality of service optimization requirements for the IMT-2020 network

IMT-2020 QoS optimization requirements are as follows:

– it is required to support intelligent QoS anomaly detection based on the analysis of QoS data;
– it is required to support traffic prediction based on the analysis of QoS data;
– it is required to support QoS anomaly prediction based on the analysis of QoS data;

– it is recommended to support QoE prediction based on the analysis of QoS data;
– it is required to support QoS optimization to provide and ensure a desired service performance level during the lifecycle of the service.

9 Security consideration

The QoS management of IMT-2020 network includes UE, ANs, and CN that are subject to security and privacy measures. Sensitive information should be protected as a high priority in order to avoid leaking and unauthorized access. Security and privacy concerns should be aligned with the requirements specified in [b-ITU-T Q.1762], [ITU-T Y.3101] and [b-ITU-T Y.2701].

Bibliography

[b-ITU-T Q.1762] Recommendation ITU-T Q.1762/Y.2802 (2007), *Fixed-mobile convergence general requirements*.

[b-ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

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