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Recommendation

ITU-T Y.3124 (09/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Future networks

Quality of service monitoring requirements and framework for IMT-2020 and beyond

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Recommendation ITU-T Y.3124

Quality of service monitoring requirements and framework for IMT-2020 and beyond

Summary

Recommendation ITU-T Y.3124 specifies quality of service (QoS) monitoring requirements and framework for IMT-2020 and beyond. It first provides an introduction to QoS monitoring for that context. QoS monitoring requirements and framework are specified accordingly.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
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Framework, IMT-2020, QoS monitoring, requirements.

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Quality of service monitoring requirements and framework for IMT-2020 and beyond

1 Scope

This Recommendation specifies quality of service (QoS) monitoring requirements and framework for IMT-2020 and beyond, and includes:

- an introduction;
- requirements;
- a framework.

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

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

[ITU-T Y.3106] Recommendation ITU-T Y.3106 (2019), *Quality of service functional requirements for the IMT-2020 network*.

[ITU-T Y.3107] Recommendation ITU-T Y.3107 (2019), *Functional architecture for QoS assurance management in the IMT-2020 network*.

[ITU-T Y.3109] Recommendation ITU-T Y.3109 (2021), *Quality of service assurance-related requirements and framework for virtual reality delivery using mobile edge computing supported by IMT-2020.*

[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-T Y.3175] Recommendation ITU-T Y.3175 (2020), *Functional architecture of machine learning-based quality of service assurance for the IMT-2020 network.*

[ITU-T Y.3324] Recommendation ITU-T Y.3324 (2018), *Requirements and architectural framework for autonomic management and control of IMT-2020 networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 assurance [b-ITU-T X.1500]: The degree of confidence that the process or deliverable meets defined characteristics or objectives.

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

NOTE 1 – [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.

NOTE 2 – This definition is based on [b-ITU-R M.2083-0].

3.1.3 network performance [b-ITU-T E.417]: The performance of a portion of a telecommunications network that is measured between a pair of network-user or network-network interfaces using objectively defined and observed performance parameters.

3.1.4 quality of experience (QoE) [b-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 (QoS) [b-ITU-T P.10]: The totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service (see [b-ITU-T E.800]).

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
AN	Access Network
CN	Core Network
E2E	End to End
IMT-2020	International Mobile Telecommunications-2020
ML	Machine Learning
QoE	Quality of Experience
QoS	Quality of Service
SDN	Software-defined Networking
SLA	Service Level Agreement
UE	User Equipment

5 Conventions

This Recommendation uses the following conventions:

The phrase "is required" indicates a requirement that must be strictly followed, and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The phrase "is recommended" indicates a requirement that is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

6 Introduction

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. All IMT-2020 and beyond services and usage scenarios (enhanced mobile broadband, ultra-reliable low latency communication, massive machine type communication) are supported by different network slice instances during the lifecycle of service. 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 [ITU-T Y.3106], [ITU-T Y.3107].

IMT-2020 network QoS planning provides an estimate of the network coverage, capacity and resource requirements. IMT-2020 network QoS provisioning includes: translation of service-centric service level agreement (SLA) to resource-facing network slice descriptions; unified and E2E QoS control; QoS interworking and mapping; and efficient E2E QoS provisioning. IMT-2020 network QoS optimization can be seen as a process to improve the overall network quality, user QoE 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], [ITU-T Y.3175] and updates of network configuration parameters.

QoS monitoring is important for customer QoS assurance [ITU-T Y.3109] and network service offered by IMT-2020 network service providers. QoS monitoring plays an important role in IMT-2020 QoS lifecycle management, especially for IMT-2020 network service providers or regulators to ensure:

– that customer QoS requirements are met;
– that QoS planned by service provider meets customer requirements;
– that QoS supplied by service provider is in accordance with that planned;
– that customer-perceived, service provider-delivered and planned QoS are equal;
– where the QoS bottleneck is for QoS gaps between all these four viewpoints;
– optimization methods for IMT-2020 to improve the overall network quality, user QoE and to ensure that network resources are efficiently utilized.

IMT-2020 networks are very complicated and are composed of many different network domains, such as fronthaul, backhaul, and core networks (CNs), so that it is simply not easy to deploy a single traditional QoS monitoring and analytics solution to cover the entire network environment. This complexity is typically solved by distributed QoS monitoring and analytics across multiple domains. That is, a separate monitoring and analytics manager collects and analyses the QoS characteristics of each domain. The best way to solve specific problems may be to decompose the problem into smaller parts covering specific network domains.

Besides the use case of QoS monitoring and analytics in an IMT-2020 network administered by a single operator, QoS monitoring and analytics across multiple IMT-2020 networks administered by multiple operators become much more complex. For such an environment, which is multi-layer, multi-domain and multi-technology, the ultimate form of network-wide QoS monitoring and analytics will be in the form of orchestration of systems handling these activities in underlying domains. That is, federation will occur across domains through a group of QoS monitoring and analytics systems, essentially to coordinate from one domain to the next. More likely, a multi-domain QoS monitoring and analytics orchestrator will be used to coordinate the domain QoS system.

Operators want to leverage artificial intelligence (AI), software-defined networking (SDN) and network function virtualization technology to achieve a holistic, global view and its QoS monitoring of their network with visibility of the multiple network layers and across the various domains of the network regardless of whether the underlying equipment is from multiple vendors. Thus, the necessity

of intelligent orchestration of multiple QoS monitoring and analytics systems, especially a standardized federation mechanism to encompass such heterogeneity is strongly required. In summary, what is needed is to derive is a generic QoS monitoring and analytics architecture that can cover both the intra- and inter-operator domain environment.

This Recommendation specifies the IMT-2020 QoS monitoring requirements for user equipment (UE), access network (AN), CN and E2E service in clause 7. A framework of QoS monitoring for IMT-2020 and beyond is specified in clause 8.

7 Requirements

7.1 User equipment

– It is recommended that a mechanism for UE QoS data collection be provided.

– It is recommended that a mechanism for UE QoS data normalization after collection be provided.

– It is recommended that a mechanism for UE QoS data analytics be provided.

– It is recommended that monitoring of UE QoS parameters using active mode or passive mode be supported.

– It is recommended that monitoring of UE QoS parameters using walk testing or drive testing be supported.

7.2 Access network including x-haul

– It is required that capability for QoS data collection of AN functions including physical and virtual radio units, distributed units and centralized units and links among them be supported.

– It is required that capability for QoS data collection of AN slices be supported.

– It is required that capability for QoS data normalization and data pre-processing after data collection of AN functions and links among them be supported.

– It is required that capability of statistical or AI-enabled AN QoS data analytics be supported.

– It is recommended that capability to monitor IMT-2020 radio coverage be supported.

– It is required that capability to access and expose to or from the AN analytics function be supported.

– It is required that capability to access and expose to or from the management data analytics function be supported.

7.3 Core network

– It is required that capability for QoS data collection of CN user and control planes functions be supported.

– It is required that capability for QoS data collection of CN slices be supported.

– It is required that capability for QoS data normalization and data pre-processing after data collection of CN user and control planes functions be supported.

– It is required that capability of statistical or AI-enabled CN QoS data analytics be supported.

– It is required that capability to monitor the number of registered subscribers for AMF be supported.

– It is required that capability to monitor the number of protocol data unit sessions for session management function be supported.

– It is required that capability to monitor user data performance information for user plane function be supported.

– It is required that capability to access and expose to or from the CN analytics functions be supported.
– It is required that capability to access and expose to or from the management data analytics functions be supported.

7.4 End-to-end network and service

– It is recommended that capability to collect QoS data be supported for E2E networks from UE to CN.
– It is recommended that capability to collect QoS data be supported for network slices that represent E2E networks from UE to CN.
– It is recommended that capability of E2E QoS analytics by combining results of unit measurements throughout E2E path be supported.
– It is recommended that capability to collect QoS data be supported for E2E services.
– It is recommended that capability to monitor QoS per service (e.g., voice, file transfer, streaming, augmented reality/virtual reality or web browsing) be supported.

7.5 Machine learning-based QoS analytics

– It is recommended that a generic QoS analytics architecture based on machine learning (ML) be specified to ensure QoS of IMT-2020 networks.
– It is recommended that capability of ML-based QoS analytics be supported for multi-IMT-2020 domains including AN and CN.
– It is recommended that capability of ML-based multi-domain QoS analytics orchestration be supported.
– It is recommended that support capability to expose ML-based QoS analytics information be supported for other applications.

7.6 Autonomic monitoring

– It is recommended that capability of autonomic measurement of managed resources be supported in IMT-2020 networks and services.
– It is recommended that capability of autonomic analytics of measured data be supported to meet the SLA.
– It is recommended that capability of autonomic monitoring decision-making based on ML-enabled learning capabilities be supported.
– It is recommended that capability to expose autonomic monitoring decisions be supported for other applications.

8 Framework

To meet the QoS monitoring requirements identified in the clause 7, a QoS monitoring framework architecture is specified in this clause. Figure 1 depicts functional elements and their interrelationships. It consists of a multi-layer and multi-domain IMT-2020 network to be monitored, an autonomic QoS monitoring and management functional element that ensures the target resources and performs optimal analytics whose process is preferably autonomic, and hierarchical SDN control and monitoring functional elements to monitor and control target resources under optimal conditions based on the SLA. It needs to be hierarchical because of the complexity of the target IMT-2020 networks, which are multi-layer, multi-technology and multi-domain.

To support QoS of the target networks, the full lifecycle processes, which consist of measurement of resource information such as performance, fault, and security anomaly data, normalization of the

collected data, analysis of the normalized data, learning from input data sets, policy decisions, control actions generation and enforcement actions, need to be supported. These processes can be managed by a management system with interventions by human operators or autonomically depending on the complexity and criticality of the target actions. This framework supports both alternatives.

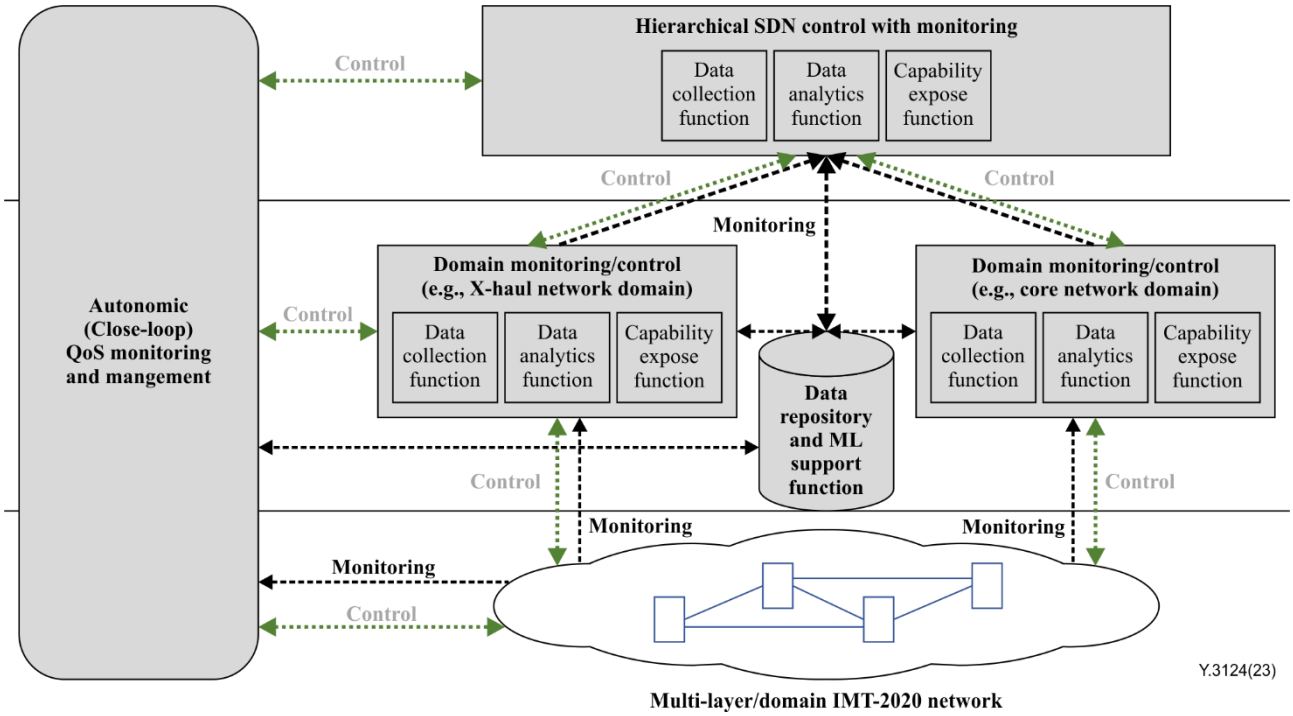

Figure 1 – Framework architecture of QoS monitoring for IMT-2020 networks

More specifically, a data collection function in a domain-monitoring or control functional element first collects and receives various domain resource raw data and events such as resource configuration data, performance statistics, alarms and logging data. The data measurement can be either polling or streaming from underlying resources. The measured data can be provided to a data analytics function to analyse for various purposes such as assessment of faults, performance and security management. The results of analytics can be further supplied or consumed via a capability exposure function by the hierarchical SDN control with monitoring functional element when E2E management is needed. If a domain specific control decision is required, the analytics results can be used to generate appropriate control policies by their associated domain control functional element. These processes do not assume involvement of autonomics. Note that the measurement and analytics can be applied to various purposes as mentioned, the main focus of this Recommendation is QoS assurance.

For E2E QoS assurance, the autonomic QoS monitoring and management functional element utilizes measured and processed data in the common data repository to analyse performance across multiple domains over an E2E path or slice. The common data repository can be distributed to support complexity of the data to be handles. If there are any anomalies (e.g., those related to faults, performance or security) over the E2E path or slice, it performs appropriate remedial actions via the hierarchical SDN control with monitoring functional element and underlying domain monitoring or control elements. These remedial actions can be provided in either a traditional or autonomic manner.

When autonomic QoS monitoring is enabled, an autonomic QoS monitoring and management functional element either imports the measured data from the domain monitoring or control functional element, or monitors the raw data required from the target IMT-2020 network domain(s). Both functional elements can also utilize a common data repository to share the measurement data of common interests. In addition, autonomic QoS monitoring for slices in the IMT-2020 networks can utilize capabilities specified in [ITU-T Y.3324].

9 Security considerations

The QoS monitoring of an IMT-2020 network involves measurement and analysis of UE, ANs and CNs that are subject to security and privacy measures. Sensitive information should be protected as a high priority in order to avoid data leakage and unauthorized access. Security and privacy concerns should be aligned with the requirements specified in [b-ITU-T Y.2701] and [ITU-T Y.3101].

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