ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation

ITU-T Y.3816 (09/2023)

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

Quantum key distribution networks

Quantum key distribution networks – Functional architecture enhancement of machine learning based quality of service assurance

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	Y.100-Y.999
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	Y.1000-Y.1999
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	Y.2000-Y.2999
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
Computing power networks	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.3599
BIG DATA	Y.3600-Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	**Y.3800-Y.3999**
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	Y.4000-Y.4999
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.3816

Quantum key distribution networks – Functional architecture enhancement of machine learning based quality of service assurance

Summary

Recommendation ITU-T Y.3816 specifies functional architecture enhancement of quality of service (QoS) assurance based on machine learning (ML) for quantum key distribution networks (QKDNs).

Recommendation ITU-T Y.3816 first provides an overview of functional architecture enhancement of ML-based QoS assurance for QKDNs. It then describes a functional architecture enhancement of QoS assurance that includes functional components such as QoS data collection, data processing, data storage, data analytics, QoS anomaly detection and prediction, QoS policy decision making, enforcement and reporting. Based on the capabilities described in the functional architecture enhancement, Recommendation ITU-T Y.3816 specifies an operational procedure of QoS assurance for QKDNs.

History [*]

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Y.3816	2023-09-29	13	11.1002/1000/15644

Keywords

Functional architecture, machine learning, QKDN, QoS assurance.

[*] To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.3816

Quantum key distribution networks – Functional architecture enhancement of machine learning based quality of service assurance

1 Scope

This Recommendation specifies a functional architecture enhancement for quality of service (QoS) assurance based on machine learning (ML) for the IMT-2020 network. This Recommendation includes the following:

- an overview of requirements for ML-based QoS assurance for QKDN;
- a functional architecture enhancement for ML-based QoS assurance for QKDN;
- reference points for ML-based QoS assurance for QKDN;
- a procedure for ML-based QoS assurance for QKDN.

This Recommendation uses ML only in the context of QoS assurance. Therefore, any other use of ML lies 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 X.1710] Recommendation ITU-T X.1710 (2020), *Security framework for quantum key distribution networks.*

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

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

[ITU-T Y.3801] Recommendation ITU-T Y.3801 (2020), *Functional requirements for quantum key distribution networks.*

[ITU-T Y.3802] Recommendation ITU-T Y.3802 (2020), *Quantum key distribution networks – Functional architecture.*

[ITU-T Y.3811] Recommendation ITU-T Y.3811 (2022), *Quantum key distribution networks – Functional architecture for quality of service assurance*.

[ITU-T Y.3812] Recommendation ITU-T Y.3812 (2022), *Quantum key distribution networks – Requirements for machine learning based quality of service assurance*.

[ITU-T Y.3814] Recommendation ITU-T Y.3814 (2023), *Quantum key distribution networks – Functional requirements and architecture for machine learning enablement*.

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 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.

3.1.3 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.)

3.1.4 quality of service [b-ITU-T Q.1741.1]: 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 service.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

IMT-2020	International Mobile Telecommunications-2020
KM	Key Manager
KMA	Key Management Agent
KML	Key Management Layer
KPI	Key Performance Indicator
KQM	KML QoS Measurement
KSA	Key Supply Agent
M&O	Management and Orchestration
ML	Machine Learning
PQ	Priority Queuing
QCLMQA	QKDN Control Layer ML-based QoS Assurance
QCRMQA	QKDN Cross-Layer ML-based QoS Assurance
QCRQA	QKDN Cross-Layer QoS Assurance
QKD	Quantum Key Distribution
QKDN	Quantum Key Distribution Network
QL	Quantum Layer
QMDA	QoS ML-based Data Analysis

QMPP QoS ML-based Policy Provisioning

QMQPO QKDN ML-based QoS Planning and Optimization

QoE Quality of Experience

QoS Quality of Service

QQCE QKDN QoS Capabilities Exposure

QQCLS QKDN QoS Cross-Layer Support

QQM QL QoS Measurement

SLA Service Level Agreement

SRC Source

WRED Weighted Random Early Detection

WRR Weighted Round-Robin

5 Conventions

None.

6 Overview

A QKDN is expected to be able to provide optimized support for a variety of different quantum key distribution (QKD) services. The key performance indicators (KPIs) include optimal latency, accuracy, throughput, and availability for key distribution.

The one of the challenges of the QKDN is to assure the network performance [b-ITU-T E.417] and different QoS [b-ITU-T Q.1741.1]/QoE [b-ITU-T P.10] requirements of different application scenarios.

The requirements specification of ML-based QoS assurance for the QKDN is specified in [ITU-T Y.3812]. Based on the requirements, this Recommendation specifies ML-based QKDN functional architecture enhancement, associated functional components, reference points among them, and an operational procedure.

7 Functional architecture enhancement of ML-based QoS assurance for QKDN

The QKDN layered functional architecture and the associated functional components are specified in [ITU-T Y.3802]. [ITU-T Y.3811] specifies the functional architecture to assure QoS for QKDNs. Further, [ITU-T Y.3814] specifies a functional architecture enhancement to enable machine-learning (ML) capabilities for QKDN in general. This Recommendation extends functional components required for ML-based QoS assurance as depicted in Figure 1. For this, QoS assurance functions are added to each layer management function and a cross-layer management and orchestration (M&O) function in the QKDN management layer. These QoS assurance enhancement functions interact with each layer ML source/SINK node (SRC/SINK) to collect information and apply QoS assurance ML policies. Note that QoS assurance enhancement functions do not introduce any additional functionality to the QKDN ML layer but utilize them to achieve objective QoS assurance. These elements interact with the QKDN control layer, key management layer (KML) and quantum layer (QL) QoS assurance functions to fulfil the target QoS KPIs, which include planning, monitoring, analysing, optimizing, and provisioning.

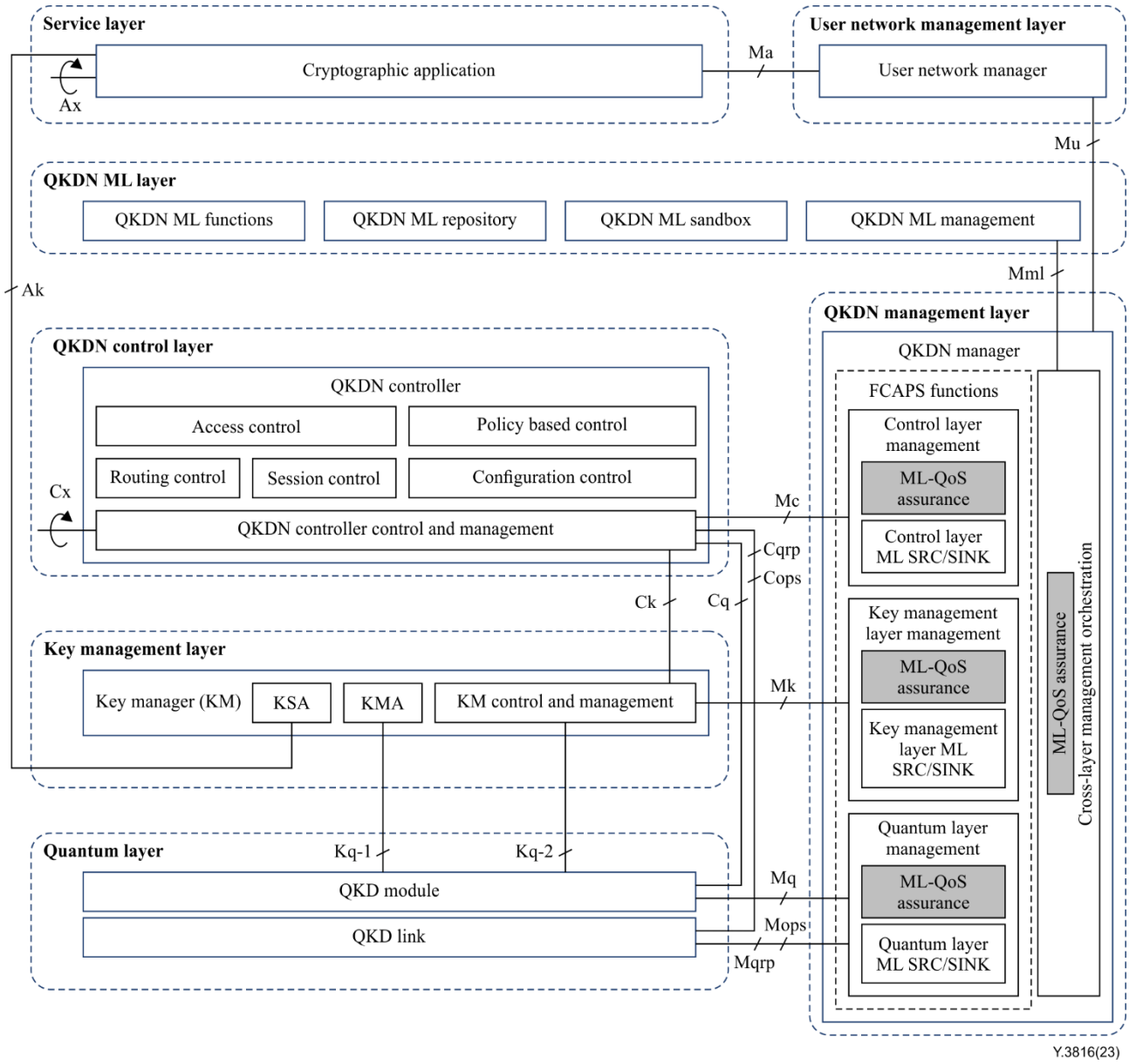

Figure 1 – Functional architecture of ML-based QoS assurance for QKDN

7.1 Functional entities for ML-based QoS assurance management enhancement

The ML-based QoS assurance management functional entities and associated enhancement are illustrated in Figure 2. The dark shaded functional entities are ML-enabled QoS assurance enhancement. The QKDN control layer ML-based QoS assurance (QCLMQA) functional entities include: QoS ML-based data analysis (QMDA); QoS ML-based policy generation; and QMPP functions. The KML ML-based QoS assurance functional entities include: KML QoS measurement; KML QoS ML-based policy enforcement; and KML QoS ML-based mapping and abstraction functions. The QL ML-based QoS assurance functional entities include: QL QoS measurement; QL QoS ML-based policy enforcement; and QL ML-based QoS mapping and abstraction. The cross-layer M&O ML-based QoS assurance functional entities include: QKDN QoS capability exposure to external management systems; QKDN service level agreement (SLA) support; QMQPO; and QQCLS functions.

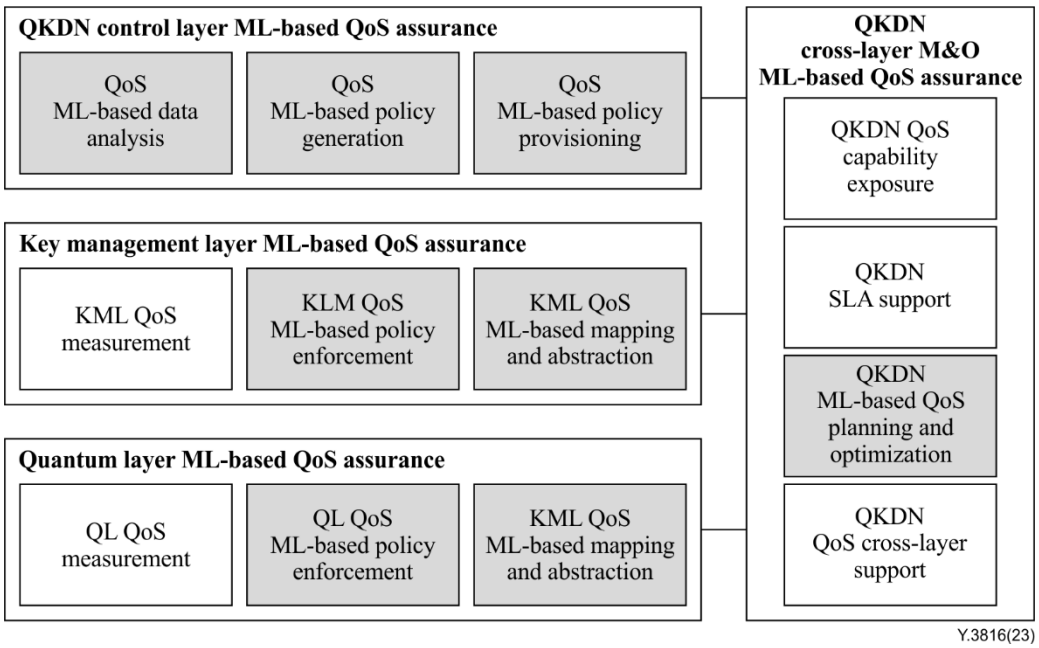

Figure 2 – QKDN ML-based QoS assurance functional entities

7.1.1 QKDN control layer ML-based QoS assurance functional entity

The QCLMQA functional entity includes the following functions.

- **QoS ML-based data analysis**

The QMDA functional entity receives QoS related information from the QL and KML QoS measurement (KQM) functional entity and performs ML-based analysis for QoS assurance. For example, it can construct a correlation between QoS information and QoS anomalies based on the ML models generated by training of the measured data sets.

Based on such analysis, it can detect or predict QoS related anomalies that can be utilized to achieve QoS assurance for QKDNs.

- **QoS ML-based policy generation**

The QoS ML-based policy generation functional entity generates QoS policies to guarantee the quality of QKDN services based on the analysed results supplied by the QMDA functional entity. The policies include KML QoS policies and QL QoS policies. They are delivered to the QoS enforcement functional entity of the corresponding layer for further layer specific enforcement.

- **QoS ML-based policy provisioning**

The QMPP functional entity translates its QoS policies to resource-facing KML and QL specific optimal provisioning rules to enforce QoS assurance control, QoS interworking and mapping and efficient end-to-end) QoS provisioning. It then triggers each layer QoS policy enforcement functional entity to complete provisioning processes. It also performs verification of the intended provisioning.

7.1.2 Key management layer ML-based QoS assurance functional entity

The QKDN key management layer ML-based QoS assurance functional entity includes the following functions.

- **KML QoS ML-based policy enforcement**

The KML QoS ML-based policy enforcement functional entity enforces KML QoS policy sent from the control layer. It mainly focuses on queue management associated with KML links such as those for the key management agent (KMA) and key supply agent (KSA). An important goal of queue management is to minimize the steady-state queue size while not under-utilizing the link as well as avoiding the lock-out phenomenon where a single connection or flow monopolizes the queue space.

The detailed QoS enforcement functions include packet marking, congestion avoidance, queue shaping and queue scheduling with a finer level of QoS granularities (e.g., per flow). Schemes for queue management differ mainly in the criteria for dropping packets. The use of multiple queues introduces further variation in the schemes, e.g., in the way packets are distributed among the queues. It can utilize weighted random early detection (WRED) queue management algorithm, priority queuing (PQ) and weighted round-robin (WRR) queue scheduling algorithms.

- **KML QoS ML-based mapping and abstraction**

The KML QoS ML-based mapping and abstraction functional entity is used to support appropriate QoS interworking of networks whose packets traverse different network domains (e.g., mapping key manager (KM) access network QoS classes to KM backbone network QoS classes). A QoS class can be associated with three attributes: priority; packet delay budget; and packet error loss rate.

7.1.3 Quantum layer ML-based QoS assurance functional entity

The QKDN QL ML-based QoS assurance functional entity includes the following functions.

- **QL QoS ML-based policy enforcement**

The QL QoS ML-based enforcement functional entity enforces QL QoS policy sent from the QMPP functional entity in the QKDN control layer. It mainly focuses on queue management associated with quantum and classical channels. An important goal of queue management is to minimize the steady-state queue size while not under-utilizing the link as well as avoiding the lock-out phenomenon in which a single connection or flow monopolizes the queue space. The detailed QoS enforcement functions include packet marking, congestion avoidance, queue shaping and queue scheduling with a finer level of QoS granularities (e.g., per flow). Schemes for queue management differ mainly in the criteria for dropping packets. The use of multiple queues introduces further variation in the schemes, e.g., in the way packets are distributed among the queues. It can utilize a WRED queue management algorithm, PQ and WRR queue scheduling algorithms.

- **QL QoS ML-based mapping and abstraction**

The QL QoS ML-based mapping and abstraction functional entity is used to support appropriate QoS interworking of networks whose packets traverse different network domains (e.g., mapping quantum access network QoS classes to quantum backbone network QoS classes). A QoS class can be associated with three attributes: priority; packet delay budget; and packet error loss rate.

7.1.4 QKDN Cross-layer M&O ML-based QoS assurance functional entity

The QKDN cross-layer M&O ML-based QoS assurance functional entity includes the following functions.

- **QKDN QoS ML-based planning and optimization**

QKDN QoS ML-based planning receives information about real QKDN QL and KML traffic estimates and topology, utilization of accurate models for control and user data (e.g., key information) transmissions and implementation of the actual QKDN functional entities characteristics, functionalities and parameters. QoS planning then provides an estimate of the QKDN coverage, capacity and resources requirements.

QKDN QoS ML-based optimization can update QoS planning results to improve the overall QKDN quality and user QoE, and to ensure that the QKDN resources are efficiently utilized.

The estimation and optimization results are realized by QoS provisioning in the underlying QKDN.

8 Reference points of ML-based QoS assurance for QKDN

The following reference points are relevant to communications between a QKDN manager and the QL, KML, and QKDN control layer for the purpose of ML-based QoS assurance.

– **Mq**: a reference point connecting the QKDN manager with a QKD module control and management function in a QKD module. Mq enables the QKDN manager to communicate management information to the QKD module. For ML-based QoS assurance, this reference point is extended to support an ML-based QoS assurance QL QKD module functionality, such as QKD module QoS ML-based policy enforcement or QoS ML-based mapping and abstraction.

– **Mops**: a reference point connecting the QKDN manager and an optical switching/splitting function in a QKD link. Mops enables the QKDN manager to communicate management information to the QKD link. For ML-based QoS assurance, this reference point is extended to support a QL QKD link functionality, such as QKD link QoS ML-based policy enforcement or QoS ML-based mapping and abstraction.

– **Mqrp**: a reference point connecting the QKDN manager and a quantum relay function in a QKD link. Mqrp enables the QKDN manager to communicate management information about the quantum relay to the QKD link. For ML-based QoS assurance, this reference point is extended to support a QL quantum relay functionality, such as quantum relay QoS ML-based policy enforcement or QoS policy-based mapping and abstraction.

– **Mk**: a reference point connecting the QKDN manager and KM control and management function in a KM. Mk enables the QKDN manager to communicate management information to a KMA and a KSA. For ML-based QoS assurance, this reference point is extended to support key management layer QoS assurance functionality, such as QoS ML-based policy enforcement or QoS ML-based mapping and abstraction.

– **Mc**: a reference point connecting the QKDN manager and a QKDN controller control and management function in a QKDN controller. Mc enables the QKDN manager to communicate management information to the QKDN controller. For ML-based QoS assurance, this reference point is extended to support control layer QoS assurance functionality, such as QMDA, QoS ML-based policy generation or QMPP.

– **Mu**: a reference point connecting a user network manager in a user network and the QKDN manager in the QKDN. Mu enables the QKDN manager to communicate management information to the user network manager. For ML-based QoS assurance, this reference point is extended to support cross-layer QoS assurance functionality specifically, ML-based QoS planning and optimization.

9 Procedure of ML-based QoS assurance for QKDN

During the lifecycle of QKDN services, the QKDN QoS assurance lifecycle is also involved. This clause describes an ML-based operational QoS assurance lifecycle procedure in the QKD network shown in Figure 3.

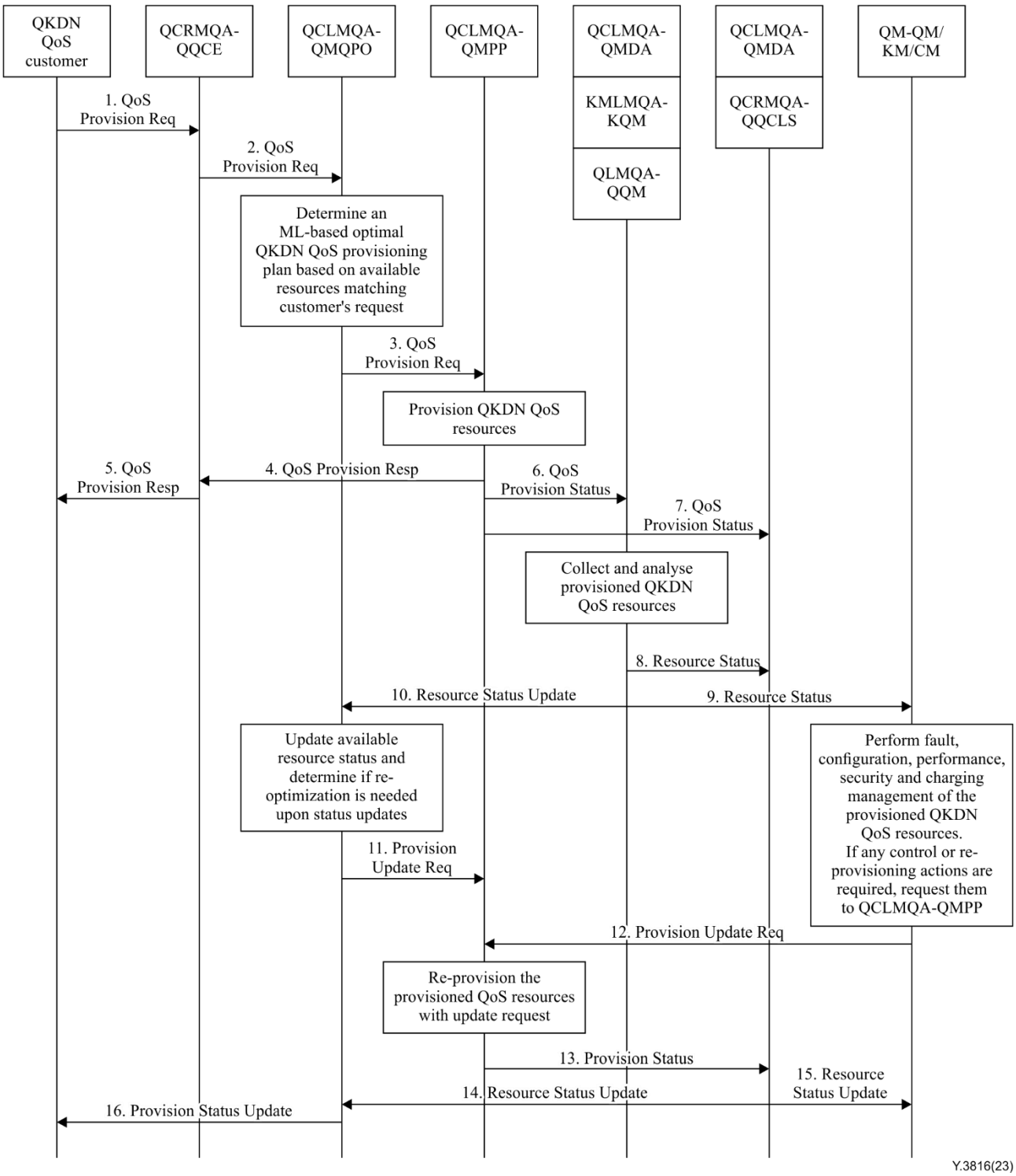

Figure 3 – An operational procedure for QKDN ML-based QoS assurance

1) The QKDN customer requests QKDN resources to be provisioned with its specified service requirements based on the SLA between a QKDN customer and a QKDN provider. The QKDN resources to be provisioned include a QoS-enabled key relay route, KML resources to be provisioned with QoS requirements and QL resources to be provisioned with QoS requirements. The QKDN QoS capabilities exposure (QQCE) functional element in the QKDN cross-layer ML-based QoS assurance (QCRMQA) functional entity can open the QoS capabilities for third parties. The QKDN SLA support functional element also provides QoS information from the SLA template for QKDN QoS provisioning that includes: statements about performance; billing; and service delivery.

2) The QCRMQA-QQCE functional element receives the customer's request and carries it to the QMQPO functional element in the QCRMQA functional entity.

3) After ML-based QoS planning and optimization is decided, the QMQPO then determines an ML-based optimal QoS resource-provisioning plan based on the available resources that match the customer's request. Once the provisioning policy is determined, the QMQPO requests provisioning from the QMPP functional element in the QKDN control layer QoS assurance functional entity.

4-5) QMPP then performs the QoS-provisioning task requested. It involves various sub-tasks including QoS related aspects: ML-based QoS provisioning; policy enforcement and mapping; etc. Upon completion of the provisioning process, QMPP sends a provision response message to the customer via QQCE.

6) At the same time, a provision status is sent to the QL QoS measurement (QQM), KQM and CL QMDA functional elements to initiate the monitoring and ML-based analysis of the provisioned resources.

7) The status update is also sent to QMDA and the QQCLS in the QCRQA functional entity to store the provisioned resource information. Both QMDA and QQCLS have a resource repository to store resource status information for their analysis functions.

8) QQM, KQM and QMDA perform collection, monitoring and ML-based analysis tasks on the provisioned resources. QoS-related data is also collected. Data and information collected and analysed are then stored in both QMDA and QQCLS repositories for further processing.

9-10) QoS policy information is also stored in QMDA and QQCLS repositories. When QMDA and QQCLS receive resource status updates, they are stored in the repository and, at the same time, a notification is emitted to all functional elements that are listening to the status updates. In this case, an update notification is sent to QKDN QL management, KML management and control layer management functional entities for fault, configuration, performance, security, and charging purposes, and finally to QMQPO for cross-layer QoS management.

11) When QMQPO receives the notification, it updates the available resource status and determines whether re-optimization is needed upon status updates by utilizing ML capabilities.

12) Also, when the quantum layer management/KM layer management/control layer management in the QKDN management function receive the notification, they manage faults, configuration, performance, security and charging of the provisioned resources and determine whether any control or re-provisioning actions are required by utilizing ML capabilities. If so, they send a request to QMPP for provisioning update processes.

13-15) QMPP, upon receiving the provisioning update requests, performs ML-based re-provisioning tasks for provisioned QKDN QoS resources. When the re-provisioning tasks are done, QMPP generates the provision status for QMDA and QQCLS repositories and they further convey the notification to the QM/KM/CM, QMQPO and QKDN QoS customer for resource status updates.

16) QMQPO finally sends the provision status update to the customer.

10 Security considerations

This Recommendation describes high-level and functional requirements for ML-based QoS assurance for QKDNs; therefore, security requirements described in [ITU-T X.1710], [ITU-T Y.3801] and [ITU-T Y.3802] and general network security requirements and mechanisms in IP based networks described in [ITU-T Y.2701] and [ITU-T Y.3101] should be applied. Details lie outside the scope of this Recommendation.

Bibliography

[b-ITU-T E.417] Recommendation ITU-T E.417 (2005), *Framework for the network management of IP-based networks.*

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

[b-ITU-T Q.1741.1] Recommendation ITU-T Q.1741.1 (2002), *IMT-2000 references to release 1999 of GSM evolved UMTS core network with UTRAN access network.*

[b-ITU-T X.1500] Recommendation ITU-T X.1500 (2011), *Overview of cybersecurity information exchange.*

[b-ITU-T Y.3172] Recommendation ITU-T Y.3172 (2019), *Architectural framework for machine learning in future networks including IMT-2020*.

[b-ITU-T Y.3174] Recommendation ITU-T Y.3174 (2020), *Framework for data handling to enable machine learning in future networks including IMT-2020.*

[b-ITU-T Y.3800] Recommendation ITU-T Y.3800 (2019), *Overview on networks supporting quantum key distribution.*

[b-ITU-T Y.3803] Recommendation ITU-T Y.3803 (2020), *Quantum key distribution networks – Key management*.

[b-ITU-T Y.3804] Recommendation ITU-T Y.3804 (2020), *Quantum key distribution networks – Control and management*.

[b-ITU-T Y.3806] Recommendation ITU-T Y.3806 (2021), *Quantum key distribution networks – Requirements of quality of service assurance.*

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Published in Switzerland
Geneva, 2023