International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.3156

(09/2020)

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

Future networks

Framework of network slicing with AI-assisted analysis in IMT-2020 networks

Recommendation ITU-T Y.3156

ITU-T

International Telecommunication Union

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.3599
BIG DATA	Y.3600–Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800–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.3156

Framework of network slicing with AI-assisted analysis in IMT-2020 networks

Summary

Recommendation ITU-T Y.3156 describes the requirements and functional roles of AI-assisted analysis in support of the lifecycle management and orchestration of network slicing. It is intended to be used for the future enhanced operation and maintenance management of network slicing with the purpose of satisfying users' service level agreement (SLA) requirements.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3156	2020-09-29	13	11.1002/1000/14401

Keywords

AI-assisted analysis, IMT-2020, management and orchestration, network slice.

* 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.

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 not received notice of intellectual property, protected by patents, 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 TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.3156

Framework of network slicing with AI-assisted analysis in IMT-2020 networks

1 Scope

This Recommendation describes the framework for the AI-assisted analysis of network slicing in IMT-2020 networks. The Recommendation supports the whole lifecycle management and orchestration of a network slice. This Recommendation includes:

– Requirements of AI-assisted analysis;

– General functional roles of AI-assisted analysis;

– Relations with network slice management and orchestration.

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

[ITU-T Y.3150] Recommendation ITU-T Y.3150 (2019), *High-level technical characteristics of network softwarization for IMT-2020.*

[ITU-T Y.3153] Recommendation ITU-T Y.3153 (2019), *Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network.*

[ITU-T Y.3154] Recommendation ITU-T Y.3154 (2019), *Resource pooling for scalable network slice service management and orchestration in the IMT-2020 network.*

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

[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 network slice [b-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).

3.1.2 network slice instance [b-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.

3.1.3 mobile network [b-ITU-T Q.1762]: A network that provides wireless access to its services and supports mobility.

3.1.4 IMT-2020 [b-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].

3.1.5 network function [b-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.

3.1.6 machine learning model [ITU-T Y.3172]: Model created by applying machine learning techniques to data to learn from.

NOTE 1 – A machine learning model is used to generate predictions (e.g., regression, classification, clustering) on new (untrained) data.

NOTE 2 – A machine learning model may be encapsulated in a deployable fashion in the form of a software (e.g., virtual machine, container) or hardware component (e.g., IoT device).

NOTE 3 – Machine learning techniques include learning algorithms (e.g., learning the function that maps input data attributes to output data).

3.1.7 service level agreement (SLA) [b-ITU-T Y.3500]: Documented agreement between the service provider and customer that identifies services and service targets.

NOTE 1 – A service level agreement can also be established between the service provider and a supplier, an internal group or a customer acting as a supplier.

NOTE 2 – A service level agreement can be included in a contract or another type of documented agreement.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
DDOS	Distributed Denial of Service
FCAPS	Fault, Configuration, Accounting, Performance monitoring and Security
IMT-2020	International Mobile Telecommunication 2020
ML	Machine Learning
M&O	Management and Orchestration
NF	Network Function
NSI	Network Slice Instance
OAM	Operation, Administration and Maintenance
QoE	Quality of Experience
QoS	Quality of Service
RCA	Root Cause Analysis
SLA	Service Level Agreement

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.

6 Introduction of network slicing with AI-assisted analysis in IMT-2020 networks

6.1 Overview

The International Mobile Telecommunication 2020 (IMT-2020) network is expected to bring some new and enhanced capabilities. AI-assisted analysis in the IMT-2020 network will bring new opportunities to network operators, vendors and third parties.

The IMT-2020 network introduces network slicing to provide customized and dedicated network services for vastly different industries running on shared physical infrastructure. It transforms traditional network services (e.g., the services over IMT-2000 networks) to IMT-2020 network services characterized with customization on functions, securities and resource isolation, and optimized topology to match with requirements of a particular service category or individual customers. Compared with traditional networking, network slicing based on network softwarization techniques [ITU-T Y.3150] provides flexibility, agility and diversity of network service offering to the IMT-2020 network; however, it causes complexity in network management and operation in exchange for its merits. From the viewpoint of operational costs, it is not so easy to increase human resource to deal with the problem. On the other hand, the assurance of network slice service level agreement (SLA) is a key role for service providers nowadays. The dynamicity of networking by network slicing have the risk of inducing unexpected network troubles because of its technical and service innovation aspects.

Artificial intelligence (AI) including machine learning (ML) is a leading candidate to tackle these problems. To achieve optimized network management and operation for network slicing with the satisfied quality of experience (QoE) of network slice customers, the IMT-2020 network needs to introduce AI-assisted analysis, which has the capability of data analysis with intelligence to support automated and optimized network slicing.

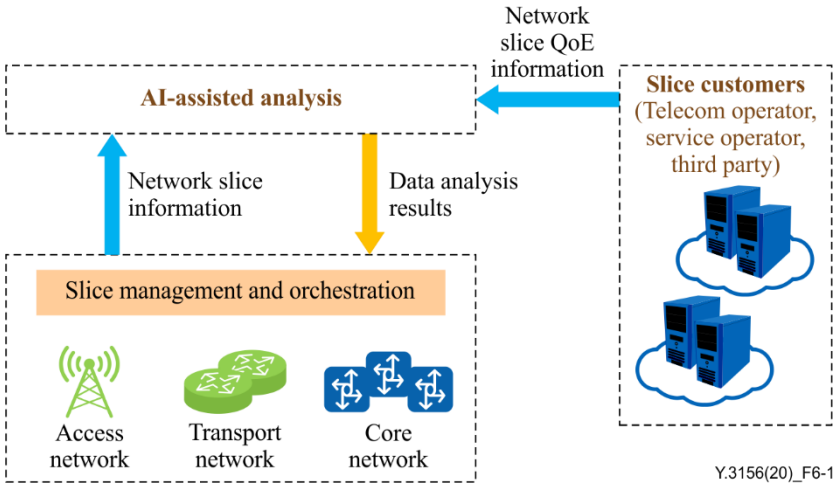

Figure 6-1 – An overview of network slicing with AI-assisted analysis

The overview of AI-assisted analysis for network slicing is shown in Figure 6-1, which includes: network slice customers as defined in clause 8.2 (e.g., telecom operators, service operators, and third parties), slice management and orchestration (M&O) in the IMT-2020 network as defined in [ITU-T Y.3111] and [ITU-T Y.3324], and AI-assisted analysis.

The AI-assisted analysis acts as a medium for bridging the operator's network and the network slice customers. It collects network slice customer's QoE information and network slice information from the slice M&O as data sources, and gives analysis results by using intelligent algorithms.

For example, for network slice resource optimization by using an intelligent algorithm, the AI-assisted analysis calculates a network resource allocation plan (e.g., targeted logical/physical resources, assigned bandwidth, and an execution schedule) that can match the customer's requirements. If the allocation plan is examined its feasibility and safeness, then the slice M&O triggers the dynamic adjustment of network resources.

6.2 AI-assisted analysis for network slice lifecycle management

The AI-assisted analysis supports the whole lifecycle management of each network slice instance (NSI). The network slice instance is a managed entity in an operator's network.

NOTE – The lifecycle of the NSI is independent of the lifecycle of service instance(s). In particular, service instances are not necessarily active through the whole duration of the run-time phase of the supporting NSI.

[ITU-T Y.3154] introduces the lifecycle management of the NSI as shown in Figure 6-2. The lifecycle management of the NSI conducts its two process phases: i) NSI preparation phase and ii) NSI runtime management phase.

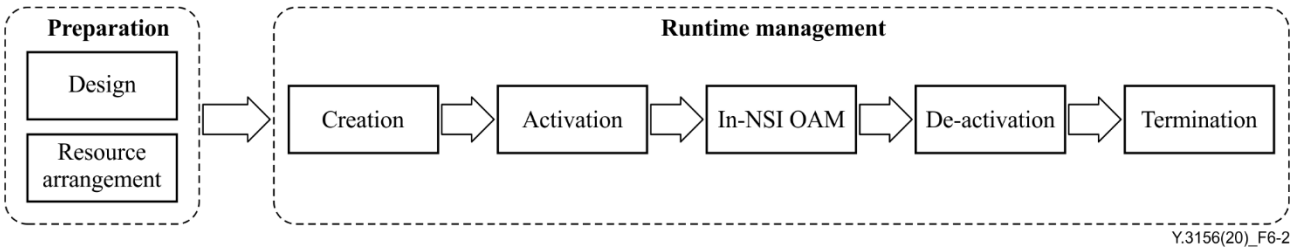

Figure 6-2 – Lifecycle phases of an NSI [ITU-T Y.3154]

Key phases and their procedures of network slicing that are expected to need AI-assisted analysis include, but are not limited to:

– Network slice preparation phase: consists of network slice design including network slice template creation, and resource planning, pre-allocation and pre-provisioning;

– NSI runtime management: consists of NSI creation, activation, inter/intra-NSI operation, administration and maintenance (OAM), de-activation, termination. Inter/Intra-NSI OAM includes fault, configuration, accounting, performance monitoring and security (FCAPS) functionalities for a single NSI and a coordination functionality between multiple NSIs.

7 Requirements of AI-assisted analysis for network slicing in IMT-2020 networks

The assurance of network slice SLA is a key role of a network slice service provider. To achieve the satisfied QoE of the network slice customers, AI-assisted analysis gives an effective way to support automated network slicing.

An AI-assisted analysis functional entity may collect QoS/QoE related data from user equipment, access networks, transport networks, core networks, a network slice M&O etc. in order to analyze the performance of heterogeneous services together with network dynamics [ITU-T Y.3170].

7.1 General requirements

This clause introduces the general requirements of the AI-assisted analysis functional entity.

[REQ G-1]: The AI-assisted analysis functional entity is required to support guaranteeing the SLA of network slice services for network slice customers including service providers and third parties.

[REQ G-2]: The AI-assisted analysis functional entity is required to collect QoE information from network slice customers for supporting the lifecycle management of NSIs.

[REQ G-3]: The AI-assisted analysis functional entity is required to interact with a slice M&O functional entity for supporting the lifecycle management of NSIs.

[REQ G-4]: The AI-assisted analysis functional entity is recommended to have the capability of verifying whether impacts, which are caused according to analysis results, on network slice services fall within the tolerable range.

[REQ G-5]: The AI-assisted analysis functional entity is recommended to support providing real-time differentiated quality of service (QoS) services for network slice customers.

NOTE – Real-time differentiated QoS services are based on the AI-assisted analysis of the situation at service time and location, the characteristics of accessed business, customer communication rules including an access method, a network real-time load and other aspects, and form the best matching QoS control parameters. [ITU-T Y.3170] introduces relevant requirements on ML-based QoS assurance.

7.2 Requirements for customer support

Customer support with AI-assisted analysis for network slicing provides intelligent customer services to help network slice customers to select or arrange optimal customized network slice services.

NOTE – [b-ITU-T Y.3103] describes a variety of business role models regarding network slice services.

[REQ C-1]: The AI-assisted analysis functional entity for customer support is required to support optimal matching between network slice templates and the requirements of network slice customers.

[REQ C-2]: The AI-assisted analysis functional entity for customer support is recommended to support providing network slice services with industry intelligent user association (i.e., the finding process on who has similar requirements).

[REQ C-3]: The AI-assisted analysis functional entity for customer support is recommended to classify service scenarios to efficiently determine corresponding network slice design templates for providing personalized network slice services.

[REQ C-4]: The AI-assisted analysis functional entity for customer support is required to support intelligent customer services using a self-service portal, which provides consultation, self-customization including the arrangement of a network slice template and other service support.

7.3 Requirements for network slice preparation

Network slice preparation with AI-assisted analysis is a set of processes before network slice creation. For example, network slice instance templates for resource allocation can be revised by AI-assisted analysis.

[REQ P-1]: The AI-assisted analysis functional entity for network slice preparation is required to support designing network slices based on network slice customers' intentions.

[REQ P-2]: The AI-assisted analysis functional entity is recommended to have the capability to interpret customer requirements and change them into detailed specifications of an NSI.

[REQ P-3]: The AI-assisted analysis functional entity for network slice preparation is required to support automated pre-configuration of a network slice instance [ITU-T Y.3153].

[REQ P-4]: The AI-assisted analysis functional entity for network slice preparation is required to support resource allocation based on an operator's deployment policy to meet SLA requirements.

[REQ P-5]: The AI-assisted analysis functional entity for network slice preparation is required to support the preparation processes of multiple NSIs with optimal shared resources if resource sharing is possible.

[REQ P-6]: The AI-assisted analysis functional entity for network slice preparation is required to support the examination of feasibility for providing a new network slice instance.

7.4 Requirements for automation of runtime management

Network slice life cycle management with AI-assisted analysis covers run-time processes: creation, activation, inter/intra-slice OAM, de-activation and termination to realize an optimized network slice.

[REQ R-1]: The AI-assisted analysis functional entity for runtime management is recommended to have the capability to take into account the change of operational policies.

NOTE 1 – The IMT-2020 network may change a network policy adapted to a network slice depending on network situations (e.g., a network uses a pre-set general policy in case of normal situation, and the network replaces with an optional policy in case of network failures).

[REQ R-2]: The AI-assisted analysis functional entity for runtime management is required to support automated processes to create, activate, inter/intra slice OAM, deactivate and terminate a network slice.

[REQ R-3]: The AI-assisted analysis functional entity for runtime management is recommended to support an operator to create and update the policy of network slice automation.

[REQ R-4]: The AI-assisted analysis functional entity for runtime management is required to support automated healing for a network slice instance.

[REQ R-5]: The AI-assisted analysis functional entity for runtime management is required to support automated optimization including automated scaling within and between NSIs.

NOTE 2 – The NSIs can be modified automatically to avoid degradation of services in case of network function overload, dynamic topology change, etc.

7.5 Requirements for inter/intra-slice OAM

Inter/Intra-slice OAM with AI-assisted analysis provides fault location detection capability and supports automated optimization and healing actions for a network slice.

[REQ O-1]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to have the capability of monitoring and analysing the status of the target NSIs, including the status of network functions and services.

NOTE – Examples of parameters of the NSIs to be monitored are throughput, latency, the number of connections, etc. Based on monitored and analysed results, a slice M&O functional entity may automatically re-configure some slice-specific parameters for the NSIs to improve the performance of services provided via the NSIs.

[REQ O-2]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to have the capability of gathering automated process results.

[REQ O-3]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to support resolving the conflicts of automated optimization actions for a network slice instance [ITU-T Y.3153].

[REQ O-4]: The AI-assisted analysis functional entity for inter/intra-slice OAM is recommended to support preventing the conflicts of automated optimization actions for a network slice instance [ITU-T Y.3153].

[REQ O-5]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to provide traffic prediction and the results of corresponding resources requirements analysis to support proactively triggering the scale up/down of NSIs to adapt a tidal effect.

[REQ O-6]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to support the efficient utilization of common virtual resources for multiple NSIs when it is possible to coordinate requirements between NSIs.

[REQ O-7]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to have the capability of performing data mining of historical alarms (e.g., to build a diagnostic rule base and to find out the root cause of the alarms of NSIs).

[REQ O-8]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to have the capability of predicting abnormal status and to support performing prevention actions.

[REQ O-9]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to support the automatic selection of optimal recovery actions when it detects faults.

[REQ O-10]: The AI-assisted analysis functional entity for inter/intra-slice OAM is recommended to support the constant improvement of automated workflows of the network slice M&O.

[REQ O-11]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to have the capability of achieving QoS detection and prediction based on massive data collection, modelling and analysis.

[REQ O-12]: The AI-assisted analysis functional entity for inter/intra-slice OAM is required to support QoS relevant warning.

[REQ O-13]: The AI-assisted analysis functional entity for inter/intra-slice OAM is recommended to support giving notification and/or advice (e.g., early termination of business, change of business operations) to operators in advance of taking operation and maintenance actions when a serious situation change occurs including failures are detected.

8 High-level framework of AI-assisted analysis for network slicing

8.1 Functional description of AI-assisted analysis

An AI-assisted analysis functional entity is responsible to give data analysis results used for the optimization of network slice operation with AI technologies including machine learning (ML) [ITU-T Y.3172].

The AI-assisted analysis includes three processes: data collection, model training and analysis with AI/ML models.

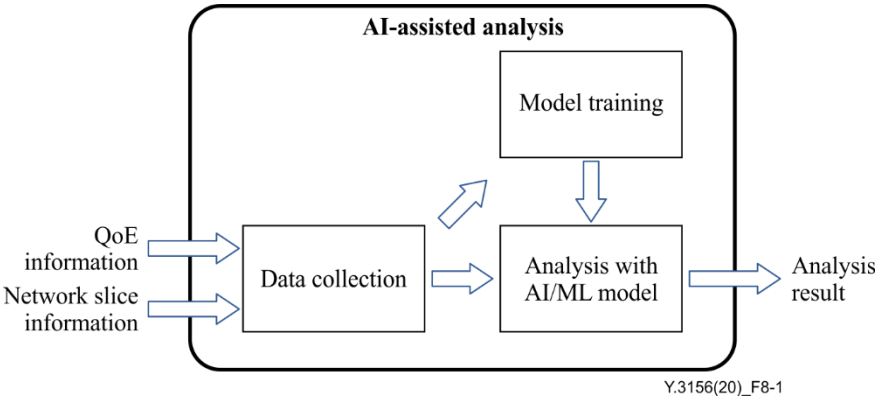

Figure 8-1 – Key processes of AI-assisted analysis

The AI-assisted analysis functional entity uses the following two types of data:

a) Network slice QoE information: collected from network slice customers including third parties who consume network slice services. This information, which may include network slice QoE requirements, can be composed of:
   i) Network coverage area;
   ii) Number of subscribers;
   iii) Customer satisfaction.

b) Network slice information: collected via network slice management and orchestration (M&O), which can manage different network domains. This information includes:
   i) Network function (NF) performance measurement data;
   ii) Fault supervision data;
   iii) Network QoS data.
   iv) Resource usage data (e.g., the usage rate of allocated resources for a specific NSI).

Model training, which includes ML model training, with advanced AI/ML algorithms elaborates specific models for network slicing.

Trained models may include a traffic prediction model, a faulty root cause analysis (RCA) model, a QoE evaluation model, etc. The traffic prediction model provides a useful traffic prediction based on the analysis of historical and real-time traffic data of network slice instances. The faulty RCA model is to identify a root failure and derivative failures by reasoning with correlation rules. The QoE evaluation model maps QoE information perceived by network slice customers with QoS information provided by network slice M&O.

NOTE – In order to obtain optimal user service experience, it is necessary to measure service experience of individual users by taking corresponding network attributes with proper weights into account (e.g., upload/download capacity, jitter, maximum latency, network availability and the other parameters dedicated to specific service requirements.)

Based on techniques on big data analysis and AI-assisted feature mining, the AI-assisted analysis functional entity gives the data analysis results, it includes, but not limited to what are listed in Table 8-1.

Table 8-1 – Examples of input and output of AI-assisted analysis

Analysis task	Input data	Output results	Description
Template design	– Service requirements (e.g., service types (URLLC, eMBB, MMTC, V2X), QoE requirements) – Resource usage data – Configuration parameters – Basic slice templates	Customized slice template including reasonable sub network slice templates for access, transport and core networks, and resource planning	Perform the mapping of QoE requirements and slice template parameters. Applicable AI techniques for this task are deep learning and supervised learning.
Traffic prediction	Past and present traffic data	Traffic at the next moment	Predict the trend of load. Applicable AI techniques is deep learning such as sequence prediction algorithm.
Resources optimization on re-allocation	– Resource usage of NSIs – Attributes of NSI – The number of end-users	Slice resource scheduling scheme	Optimize resources within and between NSI(s). Applicable AI techniques for this task are the combination of mathematical programming and reinforcement learning.
Alarm root cause analysis	– Alarm data – Resource usage data – Topology data	Identified root cause including its physical/logical location	Automated RCA and diagnosis. Applicable AI techniques for this task is using the combination of supervised learning and an RCA model such as Bayesian network.

8.2 Relations with automated slice M&O

[ITU-T Y.3324] introduces high-level autonomic management and control architecture for IMT-2020 network slice life cycle management. Figure 8-2 illustrates possible connections between an autonomic network slice M&O defined in [ITU-T Y.3324] and an AI-assisted analysis functional entity.

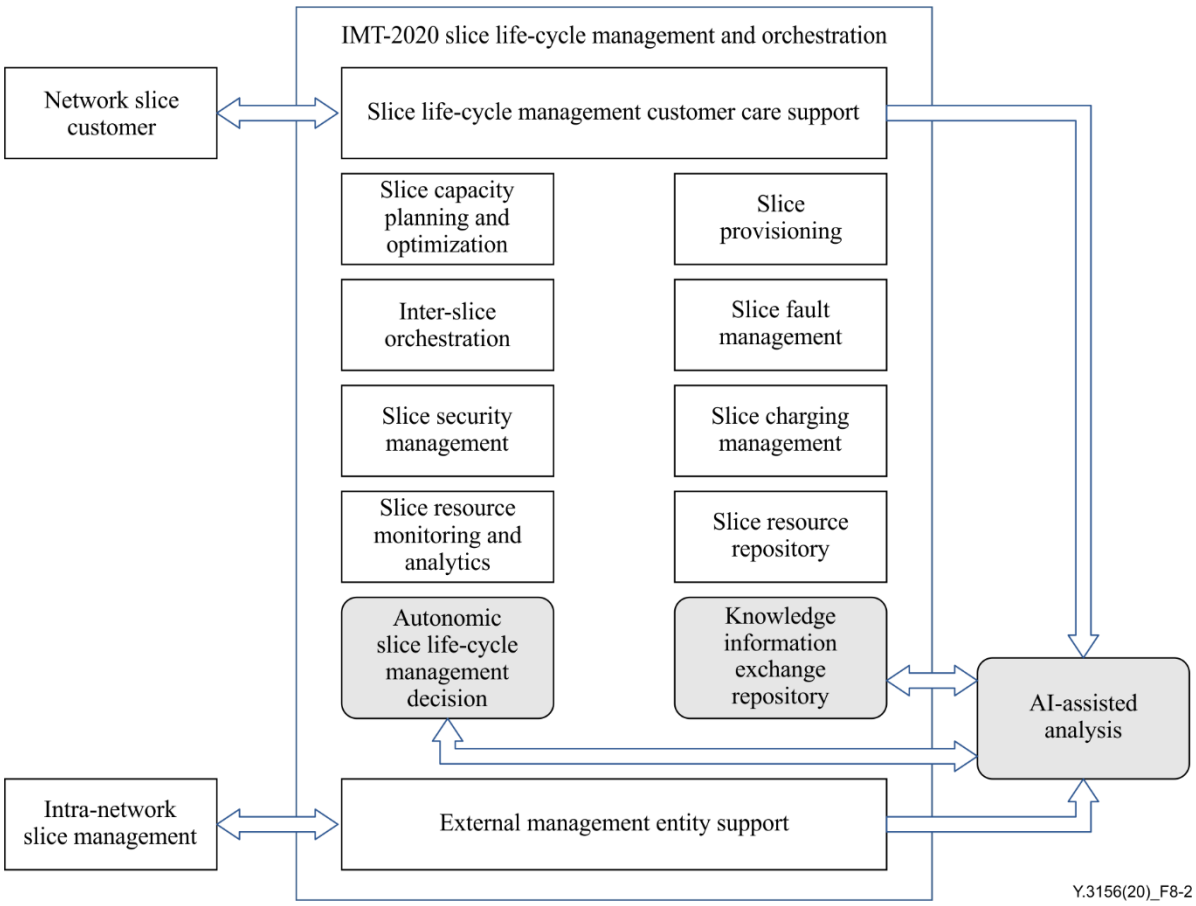

Figure 8-2 – Relations between and AI-assisted analysis and autonomic slice management and orchestration

In Figure 8-2, grey boxes "autonomic slice lifecycle management decision" and "knowledge information exchange repository", are main autonomic functional entities in the network slice M&O. These two entities interact with an AI-assisted analysis functional entity.

– Autonomic slice life-cycle management decision functional entity: provides autonomic capabilities for an overall network slice life-cycle management perspective, which is highest-level automaticity effecting on network-wide self-management policy decisions, a single NSI self-management and control actions.

– Knowledge information exchange repository functional entity: provides capabilities to store the network slice life-cycle management-wide self-management policy information.

A network slice customer and an intra-network slice management are data origins for AI-assisted analysis:

– Network slice customer: requests network services by using network slicing and provides QoE information;

– Intra-network slice management: is a management support functional entity provided for each NSI and provides NSI information.

The AI-assisted analysis functional entity is assumed to collect the data indirectly via the following customer care support and external management entity support defined in [ITU-T Y.3111]:

– Slice lifecycle management customer care support: provides a standard interface to the slice lifecycle M&O to interact with network slice customers and applications. It supports requesting and receiving management operations and associated information in the slice M&O;

– External management entity support: provides an interface to external management systems including network slice management.

NOTE – Details of the other functional entities in Figure 8-2 are introduced in [ITU-T Y.3111].

9 Security consideration

The IMT-2020 network is subject to security and privacy measures. Sensitive information should be protected as a high priority in order to avoid leaking and unauthorized access. The security requirements are based on [ITU T Y.3111], [b-ITU-T Y.2701]. The types of generic threat to IMT-2020 network slicing with AI-assisted analysis are as follows:

– Information destruction;

– Information corruption or modification;

– Information theft, removal or loss;

– Information disclosure;

– Service interruption.

The major security requirements for IMT-2020 network slicing with AI-assisted analysis are listed in the following:

[REQ S-1]: The AI-assisted analysis functional entity is required to ensure that corresponding measures are taken to deal with relevant attacks when the above-mentioned security threats occur.

NOTE – For example, the AI-assisted analysis functional entity will determine whether network traffic belongs to a malicious distributed denial of service (DDoS) attack based on a deep learning algorithm, so as to quickly decide to deploy appropriate countermeasures.

[REQ S-2]: The AI-assisted analysis functionality is required to prevent unauthorized access and data leakage, no matter whether they are malicious or not, by implementing mechanisms related to authentication and authorization, external attack protection, etc. [ITU T Y.3172].

[REQ S-3]: The AI-assisted analysis functionality is recommended to analyse the traffic, log and other information to separate and identify the abnormal traffic and user behaviour in the network, and on this basis, design the flow and behaviour pattern recognition model, so as to identify potential risks (such as unknown malicious code / file, phishing, hidden Trojan horse, abnormal operation behaviour, etc.) and increase network security.

[REQ S-4]: The AI-assisted analysis functionality is recommended to evaluate the security levels of an automatically generated NSI to determine if it can provide customized security services (such as integrity protection, confidentiality protection, hardware isolation, software isolation, anti DDoS attack, anti-virus and anti-malware).

Bibliography

[b-ITU-R M.1645] Recommendation ITU-R M.1645 (2003), *Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000.*

[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*.

[b-ITU-T Y.3100] Recommendation ITU-T Y.3100 Corrigendum 1 (2018), *Terms and definitions for IMT-2020 network.*

[b-ITU-T Y.3103] Recommendation ITU-T Y.3103 (2018), *Business role-based models in IMT-2020.*

[b-ITU-T Y.3151] Recommendation ITU-T Y.3151 (2019), High level technical characteristics of network slice support for IMT-2020 – part: SDN.

[b-ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014) | ISO/IEC 17788:2014, *Information technology – Cloud computing – Overview and vocabulary.*

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

Printed in Switzerland
Geneva, 2020