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ITU-T Q.5005 (02/2023)

SERIES Q: Switching and signalling, and associated measurements and tests

Signalling requirements and protocols for IMT-2020 – Signalling requirements and architecture of IMT-2020

Requirements, framework and protocols for signalling network analysis and optimization in IMT-2020

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Recommendation ITU-T Q.5005

Requirements, framework and protocols for signalling network analysis and optimization in IMT-2020

Summary

Recommendation ITU-T Q.5005 specifies the framework, interfaces (IFs) and protocols, as well as service procedures for signalling network analysis and optimization in IMT-2020. The signalling network is the totality of network functions and the signalling exchanges that are related to telecommunication services. Recommendation ITU-T Q.5005 covers aspects including an overview of signalling networks, requirements for signalling collection, requirements for signalling network analysis, requirements for signalling network optimization, framework, IFs and protocols, service procedures, artificial intelligence-assisted functions and general security considerations of signalling network analysis and optimization in IMT-2020.

History

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* 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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Recommendation ITU-T Q.5005

Requirements, framework and protocols for signalling network analysis and optimization in IMT-2020

1 Scope

This Recommendation specifies requirements, framework, interfaces (IFs) and protocols for signalling network analysis and optimization in an IMT-2020 network. The signalling network in IMT-2020 is the totality of network functions and corresponding signalling exchanges that are related to IMT-2020 service procedures. The IMT-2020 signalling network analysis and optimization system is a network management system that consists of components for signalling collection, signalling network analysis, signalling network optimization and artificial intelligence or machine learning (AI/ML) assistance. The IMT-2020 signalling network analysis and optimization system is designed with the characteristics of high efficiency, real time reaction, reliability and intelligence, aimed at application in an IMT-2020 network.

The following aspects of IMT-2020 signalling network analysis and optimization system are addressed in this Recommendation.

- Overview, which presents the main network entities and IFs that are used in IMT-2020 signalling network analysis and optimization systems.
- Requirements for IMT-2020 signalling network analysis and optimization, including general signalling requirements for collection, network analysis and network optimization.
- A framework for IMT-2020 signalling network analysis and optimization systems, including global view, system architecture, external boundary and component design of signalling network analysis and optimization systems.
- IFs and protocols of IMT-2020 signalling network analysis and optimization systems, including internal IFs, external IFs and corresponding protocols.
- Service procedures of signalling interworking between collection, network analysis and network optimization.
- Functions of IMT-2020 signalling network analysis and optimization systems that are provided by an internal AI assistance component or external AI platforms. The architectural framework for an external AI platform is specified in [ITU-T Y.3172].
- Security considerations of IMT-2020 signalling network analysis and optimization systems, including signalling collection security, signalling network analysis security, signalling network optimization security, AI/ML-related security, inter-working security, data transport security and user privacy.

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 Q.3644] Recommendation ITU-T Q.3644 (2019), *Requirements for signalling network analyses and optimization in VoLTE*.

[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.3102] Recommendation ITU-T Y.3102 (2018), *Framework of the IMT-2020 network*.

[ITU-T Y.3104] Recommendation ITU-T Y.3104 (2018), *Architecture of 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-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*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 signalling network [ITU-T Q.3644]: Refers to the network entities and the signalling exchange which are related to telecommunications services.

3.1.2 signalling collection [ITU-T Q.3644]: Refers to signalling collection on the interfaces which are related to the signalling processes of telecommunications services.

3.1.3 signalling network analysis [ITU-T Q.3644]: Refers to analysis on quotas using the information obtained in signalling collecting, and analyses on status information of signalling network.

3.1.4 signalling network optimization [ITU-T Q.3644]: Refers to signalling network optimization on network entities and optimization of signalling exchange between network entities in signalling network, on the basis of signalling network analysis.

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

3.1.6 machine learning (ML) [ITU-T Y.3172]: Processes that enable computational systems to understand data and gain knowledge from it without necessarily being explicitly programmed.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

5G fifth Generation

AI Artificial Intelligence

AF Application Function

AS Application Server

ASF Authentication Server Function

BGCF Breakout Gateway Control Function

CEF Capability Exposure Function

CHF	Charging Function
CU	Centralized Unit
DU	Distributed Unit
DRA	Diameter Routing Agent
EPC	Evolved Packet Core
EPS	Evolved Packet System
EPSFB	Evolved Packet System Fallback
eMSC	enhanced Mobile Switching Centre
eNB	evolved Node B
GMLC	Gateway Mobile Location Centre
gNB	next generation Node B
GTP	General packet radio service Tunnel Protocol
GTP-C	General packet radio service Tunnel Protocol-Control plane
GTP-U	General packet radio service Tunnel Protocol-User plane
HSS	Home Subscriber Server
HTTP	Hypertext Transfer Protocol
IBCF	Interconnection Border Control Function
I-CSCF	Interrogating Call Session Control Function
IF	Interface
IMS	Internet Protocol Multimedia Subsystem
IMT-2020	International Mobile Telecommunication-2020
IP	Internet Protocol
MEP	Mobile Edge Platform
MGCF	Media Gateway Control Function
MME	Mobility Management Entity
ML	Machine Learning
MO	Mobile Originated
MT	Mobile Terminated
NACF	Network Access Control Function
NAF	Network Application Function
NAS	Non-Access Stratum
NFR	Network Function Repository
NGAP	Next Generation Application Protocol
NG-RAN	Next Generation Radio Access Network
NRF	Network Repository Function
NSSF	Network Slice Selection Function
PCF	Policy Control Function

PCRF	Policy and Charging Rules Function
P-CSCF	Proxy Call Session Control Function
PGW	Packet Gateway
PGW-C	Packet Gateway-Control plane
PGW-U	Packet Gateway-User plane
RAT	Radio Access Technology
S1AP	S1 Application Protocol
SBA	Service-Based Architecture
SBC	Session Border Controller
SBI	Service-Based Interface
SCEF	Service Capability Exposure Function
SCP	Service Communication Proxy
S-CSCF	Serving Call Session Control Function
SDTP	Shared Data Transfer Protocol
SGW	Serving Gateway
SIP	Session Initiation Protocol
SMF	Session Management Function
SMSC	Short Message Service Centre
SMSF	Short Message Service Function
TCP	Transmission Control Protocol
UDR	Unified Data Repository
UE	User Equipment
UPF	User Plane Function
USM	Unified Subscription Management
VoLTE	Voice over Long-Term Evolution

5 Conventions

In this Recommendation:

The phrase "is required to" 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.

The phrase "can optionally" indicates an optional requirement that 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 or service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Overview of the IMT-2020 signalling network

The IMT-2020 signalling network is required to be analysed and optimized, in order to support and maintain the IMT-2020 network services specified in [ITU-T Y.3102], in addition to the IMT-2020 network functions specified in [ITU-T Y.3104]. The IMT-2020 signalling network is the totality of network functions and interfaces that are related to the signalling processes of IMT-2020 services in the Internet protocol multimedia subsystem (IMS), evolved packet system (EPS), and IMT-2020 domain. Compared with the baseline of voice over long-term evolution (VoLTE) signalling network, the following main network functions and interfaces of IMT-2020 signalling network are introduced.

The network entities in an IMS domain include a serving call session control function (S-CSCF), interrogating call session control function (I-CSCF), proxy call session control function (P-CSCF) and application server (AS); network entities in an EPS domain include mobility management entity (MME), serving gateway (SGW) and policy and charging rules function (PCRF).

The network functions in an IMT-2020 domain include a network access control function (NACF), session management function (SMF), policy control function (PCF), user plane function (UPF), unified subscription management (USM) function, network slice selection function (NSSF) and authentication server function (ASF).

The interfaces in IMS and EPS domains include Cx, Rx, Sh, Gm, ISC, Mw, S11 and S1-MME, which exchange signalling between network IMS and EPS entities based on a session initiation protocol (SIP), diameter protocol, general packet radio service tunnel protocol-control plane (GTP-C) and S1 application protocol (S1AP).

The service-based interfaces (SBIs) in an IMT-2020 signalling network include Nnacf, Nsmf, Npcf, Nusm and Nnssf. The reference points in an IMT-2020 signalling network include N1, N2, N3, N5, N6, N7, N8, N10, N11, N14, N15, N22, N26, etc. The SBIs and reference points exchange signalling between IMT-2020 network functions. The interfaces in an IMT-2020 signalling network are based on the hypertext transfer protocol (HTTP).

The network entities and interfaces in IMS and EPS domains are inherited from a VoLTE signalling network and used to help trace and analyse voice service, such as an EPS fallback procedure. Packet gateway-control plane (PGW-C) and SMF as well as packet gateway-user plane (PGW-U) and UPF are converged network functions for interworking between IMT-2020 and an evolved packet core (EPC). Figure 6-1 shows the main network functions and interfaces of an IMT-2020 signalling network, which are for further study.

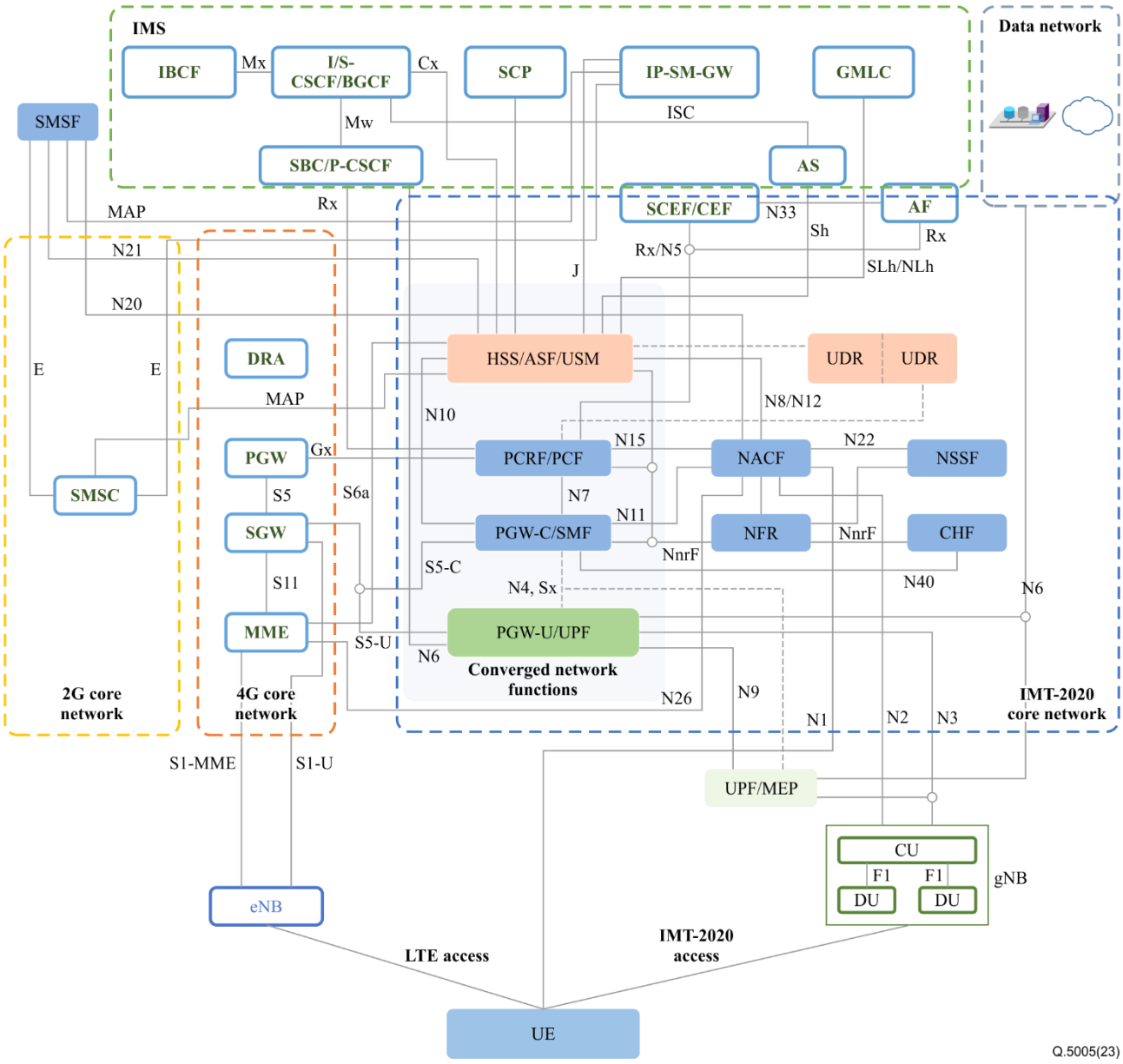

Figure 6-1 – The main network functions and interfaces of IMT-2020 signalling network

The hard data collection mode is used for control plane data collection in IMT-2020. A different data collection method could be chosen according to integration deployment, including acquisition by vSwitch image or spectrometer.

Original data from the N3 interface is collected by hard data collection mode, splitting the beam on the UPF side.

7 Requirements for IMT-2020 signalling network analysis and optimization

The general requirements for IMT-2020 signalling network analysis and optimization are inherited from those for VoLTE, specified in [ITU-T Q.3644]. Additional general requirements for IMT-2020 signalling network analysis and optimization include signalling collection, signalling network analysis and optimization on SBIs plus reference points between different IMT-2020 network functions, as well as interworking between EPCs and IMT-2020. In addition, different quotas and status information are proposed in IMT-2020 signalling network analysis; service procedures of optimization on signalling exchange and network function running status are specified in IMT-2020 signalling network optimization.

7.1 Requirements for signalling collection in IMT-2020

This clause presents requirements for signalling collection on interfaces that are related to signalling processes of services in IMT-2020.

The IFs to be collected in an IMT-2020 signalling network are divided into the following categories:

- IFs based on diameter protocol, e.g., Cx, Rx, Sh;
- IFs based on SIP, e.g., Gm, ISC, Mw;
- IFs based on the general packet radio service tunnel protocol or general packet radio service tunnel protocol-control plane (GTP/GTP-C), e.g., Sv, S11;
- IFs based on S1AP, e.g., S1-MME;
- IFs based on extensible markup language configuration access protocol, e.g., Ut;
- IFs based on HTTP protocol, e.g., N11, N15;
- SBIs, e.g., Npcf, Nsmf;
- IFs based on non-access stratum (NAS) protocol, e.g., N1.

The requirements of a signalling collection function are as follows:

- Signalling collection is required from all IFs shown in Figure 6-1 for end-to-end signalling analysis.
- Specified signalling can be collected for one IF or signalling exchanges between two network entities.
- A signalling collection function is required to support all the IFs and protocols to be collected.
- Signalling collection information is required to be configurable.
- Signalling collection information is required to be as accurate and brief as possible.
- A signalling collection function is required to cache the information obtained for subsequent processing.
- A signalling collection function is required to support a flexible extension capability to meet new requirements of operators and to adapt to the evolution of the IMT-2020 network.
- A signalling collection function is required not to influence the functions of the network entities related to the collected IFs.
- A signalling collection function is required to avoid the impact on the performance of the network entities related to collected IFs.
- A signalling collection function is required not to affect the service procedure and maintenance of the IMT-2020 network. The collected original data can be encapsulated into a formatted packet for an AI assistance component or AI platform to use.
- A signalling collection function is required to decode and synthesize the original data, and correlate the original data with a corresponding protocol.
- A signalling collection function is required to backfill the user plane information, then generate the complete data structure for analysis.
- A signalling collection function is required to encapsulate the collected data, according to the standard of IF.
- A signalling collection function is required to fill the collecting time and data number, and integrate a multi-segment original code stream base on the data number.
- It is recommended to use AI/ML technologies to assist in signalling collection.

The IFs to be collected and corresponding protocols, as well as connected network entities in the IMT-2020 signalling network, are listed in Table 1. Based on network status, calculation requirements

and capabilities of the signalling collection system, the collected IFs can be customized by the operator.

Table 1 – Interfaces to be collected in IMT-2020 signalling network

Interface	Protocol	Connected network entities
S6a	Diameter	MME and home subscriber server (HSS)
Gx	Diameter	Packet gateway (PGW) and PCRF
Rx	Diameter	P-CSCF and PCRF
Cx	Diameter	S/I-CSCF and HSS
Sh	Diameter	AS and HSS
Zh	Diameter	Bootstrapping server function and HSS
ISC	SIP	S-CSCF and AS
Ma	SIP	I-CSCF and AS
Mg	SIP	S/I-CSCF and media gateway control function (MGCF)
Mj	SIP	Breakout gateway control function (BGCF) and MGCF
Mw	SIP	P-CSCF and S/I-CSCF; S/I-CSCF and S/I-CSCF; S/I-CSCF and enhanced mobile switching centre (eMSC)
Mx	SIP	S/I-CSCF and interconnection border control function (IBCF); BGCF and IBCF
Mr	SIP	S-CSCF and multimedia resource function controller
Gm	SIP	User equipment (UE) and P-CSCF
Sv	GTP-C	MME and eMSC
S1-MME	S1AP	MME and evolved nodeB
S11	GTP-C	MME and SGW
S5/S8	GTP-C and General packet radio service tunnel protocol user plane (GTP-U)	SGW and PGW
Sh/J	Diameter/mobile application part	HSS and Internet protocol (IP) short message gateway
Imc	Bearer independent call control /SIP/integrated services digital network user part	MGCF and entities in the circuit-switched domain
N1/N2	Next generation application protocol/NAS	UE/next generation radio access network (NG-RAN) and NACF
N4	Packet forwarding control protocol	UPF and SMF
N7	HTTP2	SMF and PCF
N8	HTTP2	USM and AMF
N10	HTTP2	USM and SMF
N11	HTTP2	NACF and SMF
N12	HTTP2	NACF and ASF
N14	HTTP2	Between two NACFs
N15	HTTP2	PCF and NACF

Table 1 – Interfaces to be collected in IMT-2020 signalling network

Interface	Protocol	Connected network entities
N16	HTTP2	Between two SMFs
N22	HTTP2	NACF and NSSF
N40	HTTP2	SMF and charging function (CHF)
N5	HTTP2	PCF and AF
N24	HTTP2	PCF in home network and visited network
N26	HTTP2	NACF and MME
N3	GTP-U	NG-RAN and UPF
Namf	SBI	SBI exhibited by NACF
Nsmf	SBI	SBI exhibited by SMF
Nnef	SBI	SBI exhibited by NEF
Npcf	SBI	SBI exhibited by PCF
Nudm	SBI	SBI exhibited by USM
Naf	SBI	SBI exhibited by AF
Nnrf	SBI	SBI exhibited by network repository function (NRF)
Nnssaa	SBI	SBI exhibited by network slice-specific authentication and authorization function
Nnssf	SBI	SBI exhibited by NSSF
Nausf	SBI	SBI exhibited by ASF
Nchf	SBI	SBI exhibited by CHF

7.2 Requirements for signalling network analysis in IMT-2020

7.2.1 General functional requirements for signalling network analysis in IMT-2020

The requirements of signalling network analysis function are as follows:

- Signalling from different IFs is required to be related for the same call or session, in order to form end-to-end signalling procedures for quota calculating and fault fixing.
- Services with the same failure code are required to be counted, such as voice call, short message, user registration. Furthermore, end-to-end signalling for a specified call failure can be presented.
- Quotas that are needed by operators to examine the quality of an IMT-2020 can optionally be obtained by signalling network analysis.
- The methods and quotas of signalling network analysis in IMT-2020 are required to support customization to meet the various requirements of different operators.
- Status information about network entities and signalling exchanges between them is also recommended to be obtained and analysed in the processes of signalling network analysis, which can be used in quota analysis and subsequent signalling network optimization processes.
- A signalling network analysis function is required to receive the data reported by the data collection function, and synthesize complete end-to-end procedure information from the original data collected by a single IF.

- A signalling network analysis function is required to analyse original data and then report the analytical result to the signalling network optimization function.
- A signalling network analysis function is required to determine the reason for failure, including that due to service selection or signalling feedback.
- It is recommended that AI/ML technologies be used to assist in signalling network analysis.

7.2.2 Quota requirements for signalling network analysis in IMT-2020

Key quota requirements for signalling network analysis in IMT-2020 follow.

- Call set-up success rate

$$\text{call set-up success rate} = \frac{\text{S-CSCF call set-up request success times}}{\text{S-CSCF call set-up request times received}} \times 100\%$$

where

S-CSCF call set-up request times received is the number of times an S-CSCF receives invite messages;

S-CSCF call set-up request success times is the number of times an S-CSCF sends ringing messages corresponding to the invite messages that were received by an S-CSCF in a specified period.

- Mobile originated (MO) call set-up success rate

$$\text{MO call set-up success rate} = \frac{\text{P-CSCF original call set-up request success times}}{\text{P-CSCF original call set-up request times}} \times 100\%$$

where

P-CSCF original call set-up request times is the number of times P-CSCF sends invite messages;

P-CSCF original call set-up request success times is the number of times P-CSCF receives ringing messages corresponding to the invite messages that were sent by a P-CSCF in a specified period.

- Mobile terminated (MT) call set-up success rate

$$\text{MT call set-up success rate} = \frac{\text{S-CSCF MT call set-up request success times}}{\text{S-CSCF MT call set-up request times received}} \times 100\%$$

where

S-CSCF MT call set-up request times is the number of times S-CSCF receives invite messages;

S-CSCF MT call set-up request success times is the number of times S-CSCF sends ringing messages corresponding to the invite messages that were received by an S-CSCF in a specified period.

- Call answer rate

$$\text{call answer rate} = \frac{\text{S-CSCF call answer times}}{\text{S-CSCF call set-up request times received}} \times 100\%$$

where

S-CSCF call set-up request times received is the number of times S-CSCF receives invite messages;

S-CSCF call answer times is the number of times S-CSCF sends 200 OK messages corresponding to the invite messages that were received by an S-CSCF in a specified period.

- Average call set-up latency

average call set-up latency = average of interval between SIP message 180 and invite in P-CSCF

Interval between SIP message 180 and invite in P-CSCF is the time that a P-CSCF receives a ringing message minus the time that P-CSCF sends an invite message for the same session.

NOTE – A prerequisite is user access from a wireless IMT-2020 network, when the above quotas are calculated.

- Evolved packet system fallback (EPSFB) success rate with N26

$$\text{EPSFB success rate with N26} = \frac{\text{EPSFB success times with N26}}{\text{EPSFB request times received}} \times 100\%$$

where

EPSFB request times received is the number of times next generation node B (gNB) makes its EPS fallback configuration decision to reject the fifth generation quality of service identifier, 5QI = 1 wireless resource establishment that the NACF sends, returns the PDU session resource modification response, and the rejection reason value is "IMS voice EPS fallback or radio access technology (RAT) fallback triggered";

EPSFB success times with N26 is the number of times the MME returns the tau accept to the evolved node B (eNB).

- EPSFB average latency with N26

EPSFB average latency with N26= average of interval between timer of EPSFB success and EPSFB request with N26

Interval between timer of EPSFB success and EPSFB request is the time that gNB returns the PDU session resource modification response, and the rejection reason value is "IMS voice EPS fallback or RAT fallback triggered" by the time that MME returns the tau accept to the eNB.

- IMT-2020 initial registration rate

$$\text{IMT-2020 initial registration rate} = \frac{\text{IMT-2020 registration success times}}{\text{IMT-2020 registration received times}} \times 100\%$$

where

IMT-2020 registration received times is the number of times a gNB sends a registration request (initial registration) to a NACF;

IMT-2020 registration success times is the number of times gNB receives a registration accept (initial registration) from the NACF.

7.2.3 Status information requirements for signalling network analysis in IMT-2020

Status information about IMT-2020 signalling network is recommended to be obtained and analysed. This clause presents the common status information to be obtained.

- Status information about network entities in IMT-2020 signalling network includes hardware capacity, software capacity, real-time load, computing resources, storage resources, network resources and signalling process configuration.
- Status information about signalling exchange between network entities, which refers to the status information of all signalling exchanges in an IMT-2020 signalling network, includes the signalling route mechanism, signalling transmission mechanism, signalling messages and their parameters, as well as fault code.

7.3 Requirements for signalling network optimization in IMT-2020

This clause presents the requirements for optimization of an IMT-2020 signalling network that is implemented based on the results of signalling network analysis.

The requirements of signalling network optimization function are as follows:

- By adjusting the configuration of network entities related to the signalling processes of IMT-2020 services, the performance of IMT-2020 signalling network can be improved.
- By dynamically increasing resources for computing, storage and network of bottleneck network entities related to the signalling processes of IMT-2020 network services, their performance can be improved.
- Optimization of the signalling exchange between the network entities is achieved by:
  - adjusting signalling mechanisms for route selection, route fail-over and fallback, route re-selection and re-transmission;
  - removing unnecessary or optional parameters in signalling exchange messages.
- By locating overloaded or malfunctioning network entities in advance, disaster and fallback operations can be avoided in some cases; in this way, IMT-2020 signalling network performance can be improved.
- A signalling network optimization function is required to support both manual and automatic operation based on optimization instructions.
- A signalling network optimization function is required to support flexible extension capability to meet the various requirements of operators and adapt to the evolution of the IMT-2020 network. Both forward and backward compatibility issues are required to be addressed.
- A signalling network optimization function is required not to influence the functions of the network entities in an IMT-2020 signalling network, also it is required to have no negative effects on the performance of the IMT-2020 signalling network.
- A signalling network optimization function is required to locate the cause of an IMT-2020 signalling network malfunction, and adjust IMT-2020 signalling network configuration according to the reason for malfunction.
- It is recommended that AI/ML technologies be used to assist in signalling network optimization.

Operation of signalling network optimization has the following preconditions.

- The quotas of a signalling network, status information about network entities and signalling exchange between network entities, which can reflect the network status and assist in the generation of optimization instructions, have been obtained by signalling network analysis.
- Optimization instructions are machine- and human-readable messages that contain operational details, generated according to information from the signalling network analysis.
- The network entities support dynamic configuration based on optimization instructions.
- Signalling exchange between network entities supports dynamic configuration based on the optimization instructions.
- The network entities and signalling exchange between them support a fallback mechanism if signalling network optimization fails or is invalid.
- The network entities support the automatic generation of signalling network optimization reports for future reference or manual intervention.

8 Framework of IMT-2020 signalling network analysis and optimization

Figure 8-1 depicts a framework for signalling network analysis and optimization in an IMT-2020 network. The signalling network analysis and optimization system interacts with network entities and signalling exchange to implement for signalling, collection, network analysis and further network optimization. The results of signalling network analysis and optimization can be provided to users for

IMT-2020 network maintenance or other uses. The AI platform is a recommended external system that provides AI capabilities to the signalling network analysis and optimization system. The architectural framework of AI platforms is specified in [ITU-T Y.3172].

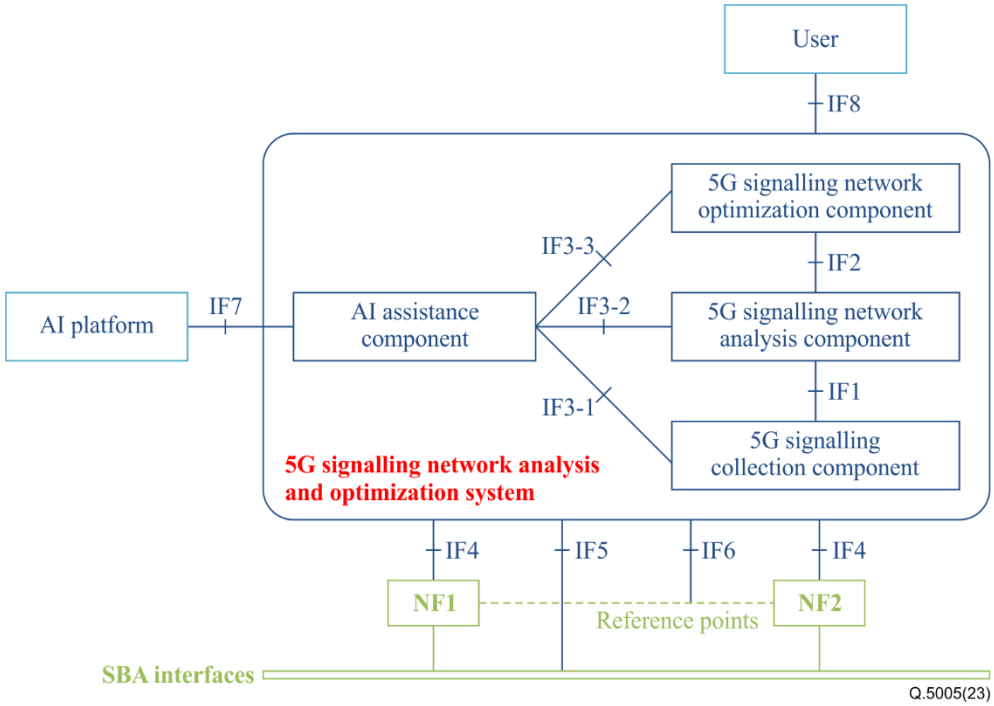

Figure 8-1 – Framework of IMT-2020 signalling network analysis and optimization

In the framework, the IMT-2020 signalling network analysis and optimization system mainly consists of the following components.

- IMT-2020 signalling collection component: A required component, which performs signalling collection on the IFs that are related to the signalling processes of IMT-2020 services, including SBIs and reference points between different network functions. It also collects the network statuses of network entities to ascertain their running conditions.
- IMT-2020 signalling network analysis component: A required component, which performs analysis according to quotas, and executes network entities running status analysis. The input information for a signalling network analysis component is the information obtained in signalling collection. An IMT-2020 signalling network analysis component analyses information about the IMT-2020 signalling network based on operator-customized settings.
- IMT-2020 signalling network optimization component: A required component, which performs IMT-2020 signalling network optimization on network functions and optimization of signalling exchange between network functions in an IMT-2020 signalling network, on the basis of signalling network analysis.
- AI assistance component: A recommended component, which acts on an IMT-2020 signalling collection component, IMT-2020 signalling network analysis component and IMT-2020 signalling network optimization component to provide AI capabilities. It is recommended for an AI assistance component to use the AI capabilities of external AI platform with invoking IFs.

In addition to the preceding components, the signalling network analysis and optimization system also provides common management and orchestration functions that comply with standards of management and orchestration elaborated by ITU-T and other standards development organizations.

9 Interfaces and protocols of IMT-2020 signalling network analysis and optimization

In the framework of IMT-2020 signalling network analysis and optimization system, five internal and five external IFs are addressed in this Recommendation, as follows:

Internal IFs:

- IF1: A required IF exists between an IMT-2020 signalling network analysis component and an IMT-2020 signalling collection component.
- IF2: A required IF exists between an IMT-2020 signalling network optimization component and an IMT-2020 signalling network analysis component.
- IF3-1: A recommended IF exists between an IMT-2020 signalling collection component and an AI assistance component.
- IF3-2: A recommended IF exists between an IMT-2020 signalling network analysis component and an AI assistance component.
- IF3-3: A recommended IF exists between an IMT-2020 signalling network optimization component and an AI assistance component.

External IFs:

- IF4: A required IF exists between an IMT-2020 signalling network analysis and optimization system, and network functions.
- IF5: A required IF exists between an IMT-2020 signalling network analysis and optimization system, and SBIs between different network functions.
- IF6: A required IF exists between an IMT-2020 signalling network analysis and optimization system, and reference points between different network functions.
- IF7: A recommended IF exists between an AI assistance component of an IMT-2020 signalling network analysis and optimization system, and an external AI platform.
- IF8: A required IF between an IMT-2020 signalling network analysis and optimization system, and the user, who will use result of signalling collection, signalling network analysis, and signalling network optimization.

9.1 Signalling collection interfaces

Signalling collection IFs include IF4, IF5 and IF6, described as follows:

- IF4 is the IF between a signalling collection component and a network entity, which is used for raw data collection on network entities of an IMT-2020 signalling network, including hardware capacity, software capacity, real-time load, computing resources, storage resources, network resources and signalling process configuration.
- IF5 is the IF for service-based signalling collection and signalling exchange between network entities.
- IF6 is the IF between a signalling collection component and signalling exchange between network entities, which is used for raw data collection from signalling exchanges in an IMT-2020 signalling network.
- The protocols of IF4, IF5, and IF6 could be shared data transfer protocol (SDTP) or other trusted protocols, which are required to ensure data integrity and security of raw data collection.

IF4, IF5 and IF6 could be decoupled from an IMT-2020 signalling network or integrated with IMT-2020 signalling network entities, depending on different deployment demands.

9.2 Signalling processing interfaces

Signalling processing IFs include IF1 and IF2, and IF3-x, IF7, IF8, described as follows:

- IF1 is the required IF between a signalling network analysis component and signalling collection component, which is used to upload decoding data, synthetic, and backfill data of a signalling network generated by the signalling collection component to the signalling network analysis component.
- IF2 is the required IF between a signalling network optimization component and signalling network analysis component, which is used to upload the quotas and status information about a signalling network generated by the signalling network analysis component to the signalling network optimization component.
- IF1 and IF2 are required to support the function of data reverse query. The protocol of these two IFs could be SDTP or other trustable protocols.
- IF3-1, IF3-2 and IF3-3 are the recommended IFs between an AI/ML assistance component and other components in a IMT-2020 signalling analysis and optimization system, which are used for providing AI/ML-related capabilities in the processes of an IMT-2020 signalling analysis and optimization system.
- IF7 is the recommended IF between an AI/ML assistance component and an external AI/ML platform, which is used to provide AI/ML-related capabilities of the external AI/ML platform to a signalling network analysis and optimization system.
- IF3-1, IF3-2, IF3-3 and IF7 are recommended to adopt the protocol stack of HTTP, transmission control protocol (TCP) or IP to facilitate the invocation of external AI/ML-related capabilities.
- IF8 is the required IF between an IMT-2020 signalling network analysis and optimization system and the user, who will use the results of signalling collection, signalling network analysis and signalling network optimization.
- IF8 is recommended to adopt a user-friendly IF and protocol, such as an application programming IF or graphical IF, which adopts the protocol stack of HTTP, TCP or IP.

10 Service procedures for IMT-2020 signalling network analysis and optimization

After having collected original data of signalling and network status, the signalling collection component then generates raw data, including the single data, padding data and synthetic data of a complete IMT-2020 session. The signalling collection component then uploads the raw data to the signalling network analysis component, which uses it to process and analyse data. The signalling network analysis component then uploads the resulting quotas and status information to the signalling network optimization component, which uses that information to recognize the operational status of the signalling network, such as signalling fault and network entity breakdown, in order to develop corresponding solutions and instructions to optimize the IMT-2020 signalling network.

The three components described in the previous paragraph interact with the AI assistance component to perform intelligent signalling collection, intelligent signalling network analysis, intelligent signalling network optimization, and intelligent self-management and self-orchestration.

The signalling network analysis and optimization system provides the results of signalling collection, signalling network analysis, and signalling network optimization to users, if necessary.

10.1 Signalling collection procedures

The signalling collection procedures are as follows:

Raw data collection from signalling exchange of an IMT-2020 signalling network is performed on IF5; the related IFs and detail network functions appear in clause 7.1.

Raw data collection from network entities of an IMT-2020 signalling network is performed on IF4; related data includes hardware capacity, software capacity, real-time load, computing resources, storage resources, network resources, signalling process configuration and alarm information.

Synthetic data is generated from raw data derived from a whole service session that is collected from different IFs.

10.2 Signalling network analysis procedures

The signalling network analysis procedures are as follows:

Raw and synthetic data are uploaded to the signalling network analysis component by signalling collection component, using IF1.

The signalling network analysis component generates the quotas, calculation results and analysis of status information about the IMT-2020 signalling network. It then uploads these data to the signalling network optimization component by using IF2.

The quota and status requirements for signalling network analysis appear in clauses 7.2 and 7.3.

10.3 Signalling network optimization procedures

The signalling network optimization procedures are as follows:

- Signalling network optimization on network entities.

The signalling network optimization component dynamically adjusts the configuration of network entities according to the results of the analysis of their running status (including resource usage and alarm information). The reliability and stability of the IMT-2020 signalling network can be improved by dynamic adjustment of the configuration of network entities, increasing computing and storage resources appropriately and optimizing the mechanism of routing automatically. Furthermore, Figure 10-1 shows the process of signalling network optimization on network entities.

1) The system dynamically and periodically monitors the analytical results of network functions in the IMT-2020 signalling network.
2) The system compares the analytical results of the signalling network with threshold requirements, which are preconfigured in the signalling network optimization component. If analytical results satisfy threshold requirements, the system continues to monitor. If they do not, the system initiates the optimization of the signalling network on network entities.
3) The system generates the optimization instructions for different network entities, e.g., modifying the signalling processing configuration, initiating the overload control mechanism and dynamically increasing the computing resources.
4) The network entities execute the optimization instructions.
5) The system checks the effect after optimization instructions have been executed on network entities. If quotas have been improved, the signalling network optimization ends this procedure and generates a success report. Then the system continues to monitor the analysis result. If they have not, the system instructs the appropriate network entities to fall back to their previous status and generates a failure report for manual operation. The system then continues to monitor the analytical results.

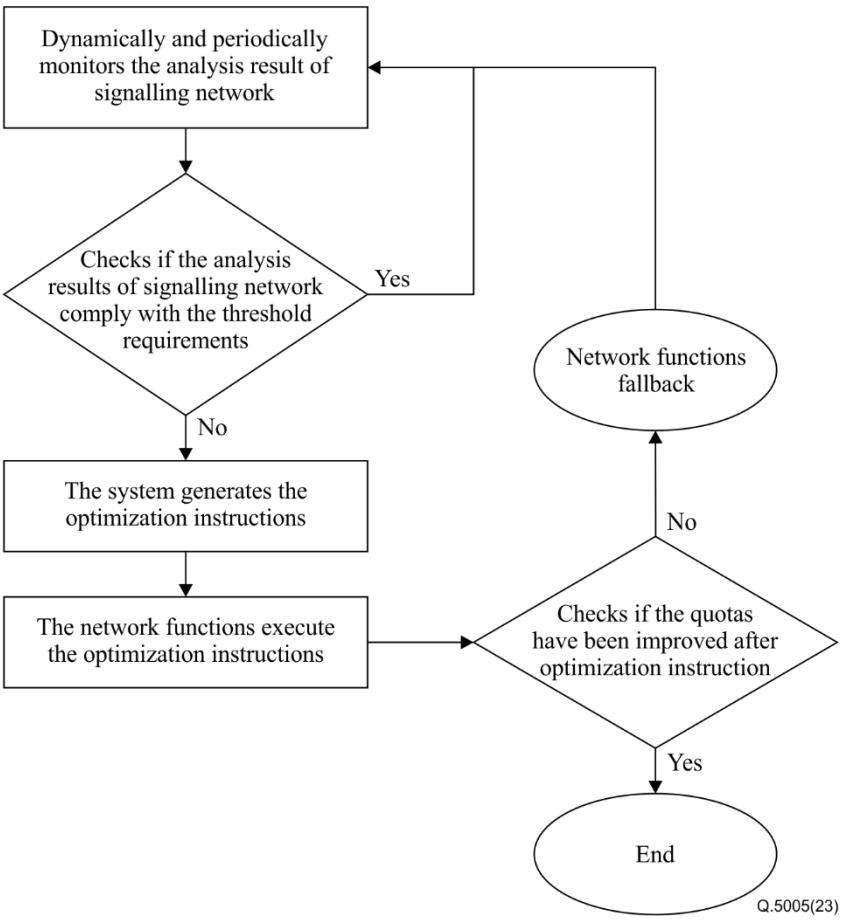

Figure 10-1 – The process of signalling network optimization on network functions

- Optimization of signalling exchange between network entities

Information about exchange signalling is collected and analysed by the signalling collection component and signalling network analysis component, respectively. The optimization instructions are generated by the signalling network optimization component and applied to signalling exchange between network entities in IMT-2020 network; the corresponding effect of optimization is received by using IF5 and IF6. Figure 10-2 depicts the process of optimization of signalling exchange between network entities.

1) The system of signalling network optimization dynamically and periodically monitors the analytical results of the signalling network analysis component.

2) The system compares the analytical results with threshold requirements that have been configured in the system. If quotas satisfy the threshold requirements, the system continues to monitor. If they do not, the system determines aspects for improvement and initiates the corresponding operation of optimization for signalling exchange between network entities.

3) The system generates the optimization instructions for related signalling exchange, e.g., adjusting the signalling route selection mechanism, adjusting the signalling re-transmission mechanism and removing unnecessary or optional parameters in signalling messages.

4) The network entities that are related to the signalling exchange perform optimization based on the optimization instructions.

5) The system checks the effect of optimization of signalling exchange between network entities. If quotas have been improved, the signalling network optimization ends this procedure and generates a success report. Then the system continues to monitor the analysis result. If they have not, the system instructs the appropriate network entities to fall back to

their previous status, and generates a failure report for manual operation, then the system continues to monitor the analytical results.

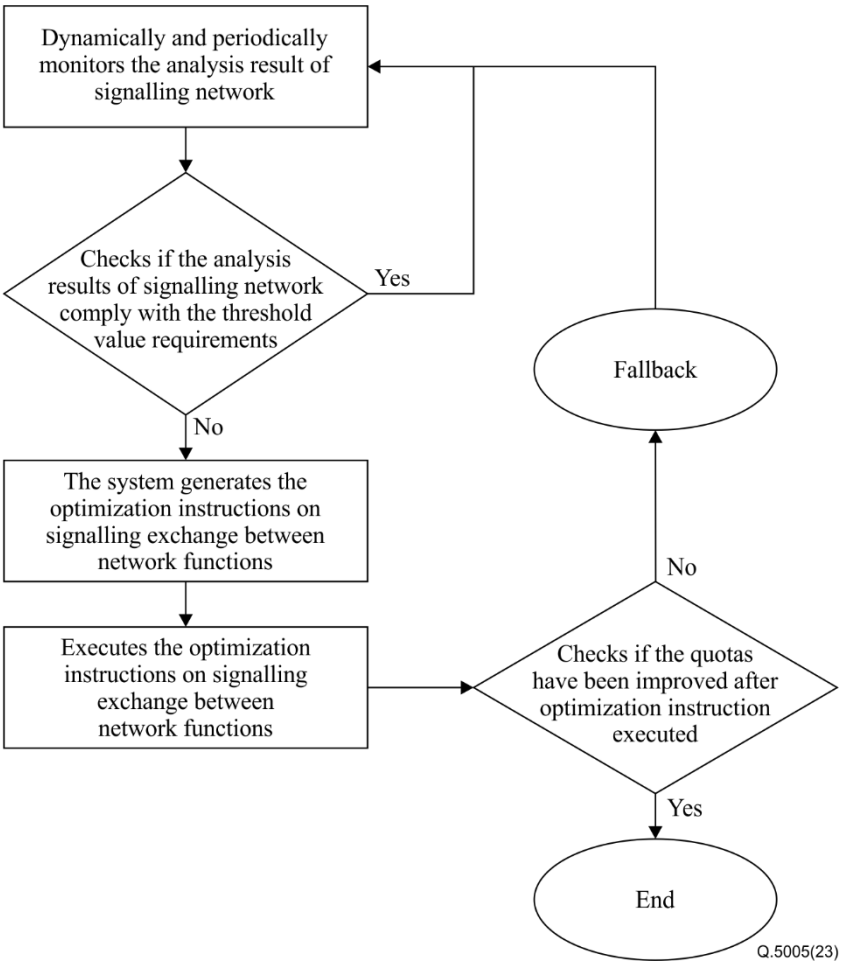

Figure 10-2 – The process of optimization of signalling exchange between network functions

10.4 AI/ML-related procedures

The AI/ML-related procedures are as follows:

- The AI/ML-related capabilities are invoked, mapped and utilized in the processes of signalling collection with the support of the AI assistance component by using IF7 and IF3-1.
- The AI/ML-related capabilities are invoked, mapped and utilized in the processes of signalling network analysis with the support of the AI assistance component by using IF7 and IF3-2.
- The AI/ML-related capabilities are invoked, mapped and utilized in the processes of signalling network optimization with the support of the AI assistance component, by using IF7 and IF3-3.

11 AI-assisted functions of IMT-2020 signalling network analysis and optimization

The AI-assisted functions are provided by newly deployed AI capabilities contained in the AI assistance component of the IMT-2020 signalling network analysis and optimization system, or by existing AI capabilities contained in external AI platform. The requirements for AI capabilities are as follows:

11.1 Requirements for AI capabilities provided by the AI assistance component

The requirements for AI capabilities provided by the AI assistance component are as follows:

- intelligent signalling collection functions;
- intelligent signalling network analysis functions;
- intelligent signalling network optimization functions;
- intelligent system self-management and self-orchestration functions.

11.1.1 Intelligent signalling collection functions

The intelligent signalling collection functions are as follows:

- to manage the facilities of data collection and date storage to ensure high reliability and high efficiency;
- to collect the signalling data and network status information related to the IMT-2020 service procedure for some given inputs;
- to process and store mass raw data collected from the IMT-2020 signalling network;
- to search the signalling data related to the analysed IMT-2020 service procedure;
- to search the network status data related to the analysed IMT-2020 service procedure.

11.1.2 Intelligent signalling network analysis functions

The intelligent signalling network analysis functions are as follows:

- to chain the signalling related to the IMT-2020 service procedure for some given inputs;
- to specify the IMT-2020 service procedures related to a given optimization target;
- to support the definition and self-learning of the data model for specific network problems;
- to specify the existing network problems based on the data model and the analysis of collected signalling data and status information of IMT-2020 signalling network.

11.1.3 Intelligent signalling network optimization functions

The intelligent signalling network optimization functions are as follows:

- to provide the optimization solutions and corresponding optimization instructions to solve the existing network problems or for the given optimization target;
- to predict the results of the given optimization solutions and corresponding optimization instructions;
- to choose the best optimization solution based on the experience of experts or optimization records.

11.1.4 Intelligent self-management and self-orchestration functions

The intelligent self-management and self-orchestration functions are as follows:

- to achieve self-management of components of the signalling network analysis and optimization system;
- to achieve self-management of internal IFs and external IFs of the signalling network analysis and optimization system;
- to achieve self-orchestration of hardware resources and software resources of the signalling network analysis and optimization system;
- to customize the capabilities of the signalling network analysis and optimization system on demand.

11.2 Requirements for AI capabilities provided by external AI platform

The requirements for AI capabilities provided by external AI platform are as follows:

- Function of connecting with an external AI platform

Providing the IFs for interacting with external AI/ML platforms.

Managing the available external AI/ML platform(s) and external AI/ML-related capabilities.

Invoking the external AI/ML-related capabilities based on the requirements of the signalling collection component, signalling network analysis component, and signalling network optimization component.

Receiving the optimized policies or solutions from external AI/ML platforms that are authorized.

Choosing the best-suited external AI/ML platform for a specific AI/ML-related capability, when multiple external AI/ML platforms are available.

- Function mapping with external AI platform

Adapting the protocol that is used for interaction with an external AI/ML platform.

Managing the functions of an external AI/ML platform, which is used for extension, or use the capabilities of the signalling network analysis and optimization system.

Performing protocol transition between components of the signalling network analysis and optimization system.

12 Security considerations

Security considerations of the IMT-2020 signalling network analysis and optimization system are as follows:

- Information security

To ensure information security for both user and network, the information obtained in the processes of signalling collection, signalling network analysis and signalling network optimization in IMT-2020 should be protected from leakage, unauthorized access and misuse, with the application of mature technologies of access control, authentication and authorization, transport security and data encryption.

- Network operation security

To ensure the security of telecommunications network operation, the functions of the network entities in an IMT-2020 signalling network should not be influenced in the processes of signalling collection, signalling network analysis and signalling network optimization. In addition, signalling network optimization should not have negative effects on the performance of a VoLTE signalling network, both on network entities themselves and signalling exchange between them.

- Equipment security

The equipment shall provide effective safety and confidentiality measures: to ensure the safety of the system and data resources; and to prevent the illegal intrusion into system resources.

- System component security

Signalling collection security considers signalling data collection security and network status data collection security.

Signalling network analysis security considers quota analysis security and network status information analysis security.

Signalling network optimization security considers security of optimization on network entities and optimization on signalling exchange.

AI/ML-related security considers on intelligent signalling collection security, intelligent signalling network analysis security, intelligent signalling network optimization security, intelligent self-management and self-orchestration security, external AI/ML platform connecting security and external AI/ML capability mapping security.

The security and privacy considerations of signalling network analysis and optimization should be aligned with the requirements specified in [ITU-T Y.2701] and [ITU-T Y.3101].

Bibliography

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

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