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SERIES Q: SWITCHING AND SIGNALLING, AND  
ASSOCIATED MEASUREMENTS AND TESTS

Signalling requirements and protocols for the NGN –  
VoLTE/ViLTE network signalling

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**Requirements for signalling network analyses  
and optimization in VoLTE**

Recommendation ITU-T Q.3644



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# Recommendation ITU-T Q.3644

## Requirements for signalling network analyses and optimization in VoLTE

### Summary

Recommendation ITU-T Q.3644 specifies the requirements for signalling network analyses and optimization in voice over LTE (VoLTE) in which the signalling network refers to the network entities and the signalling exchange which are related to telecommunications services. This Recommendation covers the aspects including an overview of a signalling network, requirements for signalling collecting, requirements for signalling network analyses, requirements for signalling network optimization and general security considerations in VoLTE.

### History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.3644	2019-12-14	11	<a href="http://handle.itu.int/11.1002/1000/14143">11.1002/1000/14143</a>

### Keywords

IMS, signalling collecting, signalling network analyses, signalling network optimization, VoLTE.

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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.3644

## Requirements for signalling network analyses and optimization in VoLTE

### 1 Scope

This Recommendation presents the requirements for signalling collecting, signalling network analyses and signalling network optimization in a voice over LTE (VoLTE) network.

The signalling network refers to the network entities and the signalling exchange which are related to telecommunications services. Making use of the information obtained in signalling collecting on interfaces, signalling network analyses and optimization can be implemented on a VoLTE network.

### 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 Recommendation 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.

- |                   |   |
|-------------------|---|
| [ETSI TS 123 216] | ETSI TS 123 216 V14.0.0 (2017-05), <i>Single Radio Voice Call Continuity (SRVCC)</i> .  |
| [ETSI TS 123 218] | ETSI TS 123 218 V15.0.0 (2018-06), <i>IP Multimedia (IM) session handling; IM call model</i> .  |
| [ETSI TS 123 228] | ETSI TS 123 228 V14.6.0 (2018-01), <i>IP Multimedia Subsystem (IMS)</i> .   |
| [ETSI TS 123 401] | ETSI TS 123 401 V14.10.0 (2018-12), <i>General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access</i> . |

### 3 Definitions

#### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

None.

#### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 signalling network:** Refers to the network entities and the signalling exchange which are related to telecommunications services.

**3.2.2 signalling collecting:** Refers to signalling collecting on the interfaces which are related to the signalling processes of telecommunications services.

**3.2.3 signalling network analyses:** Refers to analyses on quotas using the information obtained in signalling collecting, and analyses on status information of signalling network.

**3.2.4 signalling network optimization:** Refers to signalling network optimization on network entities and optimization of signalling exchange between network entities in a signalling network, on the basis of signalling network analyses.

#### 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
AS	Application Server
BGCF	Breakout Gateway Control Function
BICC	Bearer Independent Call Control
BSF	Bootstrapping Server Function
CS	Circuit Switched
CSCF	Call Session Control Function
eNodeB	evolved Node B
GTP	GPRS Tunnel Protocol
HLR	Home Location Register
HSS	Home Subscriber Server
IBCF	Interconnection Border Control Function
I-CSCF	Interrogating Call Session Control Function
IMS	IP Multimedia Subsystem
IP-SM-GW	IP Short Message Gateway
LTE	Long Term Evolution
MAP	Mobile Application Part
MGCF	Media Gateway Control Function
MME	Mobility Management Entity
MO	Mobile Originated
MRFC	Multimedia Resource Function Controller
MSC	Mobile Switching Center
MT	Mobile Terminated
NAF	Network Application Function
PCRF	Policy and Charging Rules Function
P-CSCF	Proxy Call Session Control Function
PGW	Packet Gateway
PS	Packet Switched
S-CSCF	Serving Call Session Control Function
SGW	Serving Gateway
SIP	Session Initiation Protocol
SRVCC	Single Radio Voice Call Continuity
UE	User Equipment
VoLTE	Voice over LTE
XCAP	Extensible Markup Language Configuration Access Protocol



## 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 Overview of signalling network in VoLTE

The signalling network in voice over LTE (VoLTE) refers to the network entities and interfaces which are related to the signalling processes of VoLTE services in IP multimedia subsystem (IMS), packet switched (PS) and circuit switched (CS) domains. The network entities in a VoLTE signalling network include serving call session control function (S-CSCF), interrogating call session control function (I-CSCF), proxy call session control function (P-CSCF), application server (AS), home subscriber server (HSS), IP short message gateway (IP-SM-GW), interconnection border control function (IBCF), breakout gateway control function (BGCF), media gateway control function (MGCF), multimedia resource function controller (MRFC), policy and charging rules function (PCRF), mobility management entity (MME), etc. The interfaces in VoLTE signalling network include Cx, Rx, Sh, Gm, ISC, Mw, Sv, etc., which exchange signalling between network entities. The interfaces in a VoLTE signalling network are based on the protocols of Diameter, session initiation protocol (SIP), GTP-C, etc. Figure 1 shows the main network entities and interfaces of a signalling network in VoLTE.

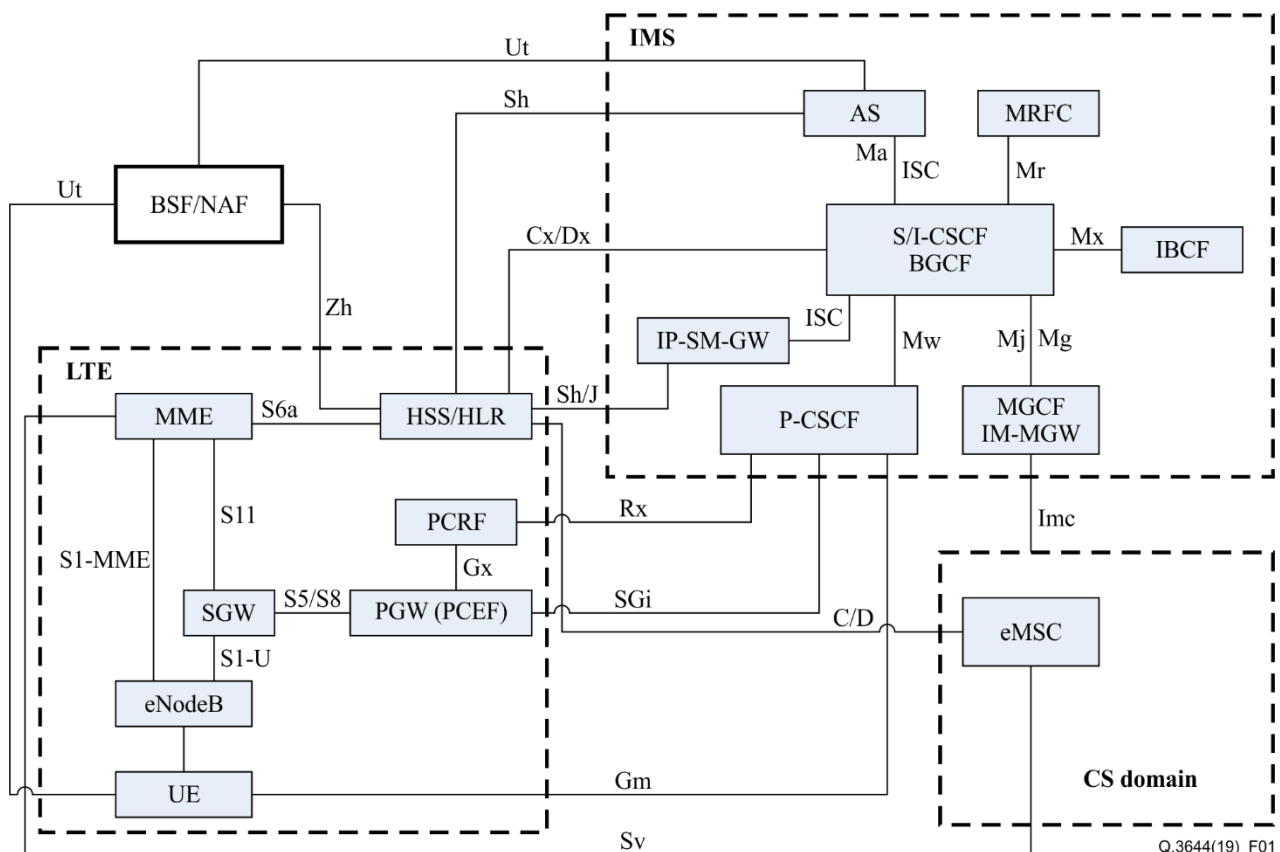


Figure 1 – The main network entities and interfaces of a signalling network in VoLTE

## **7 Requirements for signalling collecting in VoLTE**

### **7.1 General requirements for signalling collecting in VoLTE**

This clause presents the general requirements for signalling collecting on the interfaces which are related to the signalling processes of VoLTE services.

The interfaces to be collected in VoLTE signalling network are divided into the following categories:

- Interfaces based on Diameter protocol, e.g., Cx, Rx, Sh;
- Interfaces based on SIP protocol, e.g., Gm, ISC, Mw;
- Interfaces based on GTP/GTP-C protocol, e.g., Sv, S1-MME, S11;
- Interfaces based on extensible markup language configuration access protocol (XCAP), e.g., Ut;
- Interfaces based on mobile application part (MAP) protocol, e.g., C/D, J;
- Interfaces based on BICC/ISUP protocol, e.g., Imc.

The signalling collecting function is required to meet the requirements as follows:

- Signalling is required to be collected from all the interfaces shown in Figure 1 for end-to-end signalling analyses.
- Specified signalling can be collected for one interface or signalling exchange between two network entities.
- Signalling collecting function is required to support all the interfaces and protocols to be collected.
- The information to be collected in signalling collecting is required to be configurable.
- The information collected in signalling collecting is required to be accurate and brief as possible.
- Signalling collecting function is required to cache the information obtained in signalling collecting for subsequent information processing.
- Signalling collecting function is required to support flexible extension capability to meet the new requirements of operators and adapt to the evolution of VoLTE network.
- Signalling collecting function is required to not influence the functions of the network entities related to the collected interfaces.
- Signalling collecting function is required to avoid the impact on the performance of the network entities related to the collected interfaces.
- It is recommended to use artificial intelligence (AI) technologies to assist in signalling collecting.

### **7.2 Interfaces to be collected in VoLTE signalling network**

The interfaces to be collected and corresponding protocols and connected network entities in VoLTE signalling network are listed in Table 1. Based on the network status and capabilities of signalling collecting system, the collected interfaces can be customized by the operator.

**Table 1 – Interfaces to be collected in VoLTE signalling network**

<b>Interface</b>	<b>Protocol</b>	<b>Connected network entities</b>
S6a	Diameter	MME and HSS
Gx	Diameter	PGW and PCRF
Rx	Diameter	P-CSCF and PCRF
Cx	Diameter	S/I-CSCF and HSS
Sh	Diameter	AS and HSS
Zh	Diameter	BSF and HSS
ISC	SIP	S-CSCF and AS
Ma	SIP	I-CSCF and AS
Mg	SIP	S/I-CSCF and MGCF
Mj	SIP	BGCF and MGCF
Mw	SIP	P-CSCF and S/I-CSCF; S/I-CSCF and S/I-CSCF; S/I-CSCF and eMSC
Mx	SIP	S/I-CSCF and IBCF; BGCF and IBCF
Mr	SIP	S-CSCF and MRFC
Gm	SIP	UE and P-CSCF
Sv	GTP	MME and eMSC
S1-MME	GTP-C	MME and eNodeB
S11	GTP-C	MME and SGW
S5/S8	GTP-C	SGW and PGW
Ut	XCAP	UE and BSF; UE and NAF; NAF and AS
C/D	MAP	HLR and eMSC
Sh/J	Diameter/MAP	HSS and IP-SM-GW
Imc	BICC/SIP/ISUP	MGCF and Entities in CS Domain

## **8 Requirements for signalling network analyses in VoLTE**

### **8.1 General functional requirements for signalling network analyses in VoLTE**

The following functions can be supported by signalling network analyses:

- Signalling from different interfaces can be related for the same call to form end to end signalling procedures for quota calculating and fault fixing. In addition, signalling can be interpreted for specified interface.
- Calls with the same failure code can be counted. In addition, end-to-end signalling for specified failure call can be presented.
- Quotas which are needed by operators to exam quality of VoLTE can be obtained by signalling network analyses.
- The methods and quotas of signalling network analyses in VoLTE need to support customization to meet the various requirements of different operators.
- The status information of network entities and signalling exchange between network entities is also recommended to be obtained and analysed in the processes of signalling

network analyses, which can be used in analyses of quotas, also in the following processes of signalling network optimization.

- It is recommended to use AI technologies to assist in signalling network analyses.

## 8.2 Quota requirements for signalling network analyses in VoLTE

The following quotas can be obtained by signalling network analyses:

- IMS registration success rate

IMS registration success rate = (P-CSCF initial registration request success times/P-CSCF initial registration request times) \*100%

According to the registration information flow described in [ETSI TS 123 228], the P-CSCF initial registration request times means the times P-CSCF sends Register messages and the P-CSCF initial registration request success times means the times P-CSCF receives 200 OK messages corresponding to the Register messages in a specified period.

- call setup success rate

call setup success rate = (S-CSCF call setup request success times/S-CSCF call setup request times received) \*100%

According to the origination procedures and termination procedures described in [ETSI TS 123 228], S-CSCF call setup request times received means the times S-CSCF receives Invite messages and S-CSCF call setup request success times means the times S-CSCF sends Ringing messages corresponding to the Invite messages which were received by S-CSCF in a specified period.

- MO call setup success rate

MO call setup success rate = (P-CSCF original call setup request success times/P-CSCF original call setup request times) \*100%

According to the origination procedures described in [ETSI TS 123 228], P-CSCF original call setup request times means the times P-CSCF sends Invite messages and P-CSCF original call setup request success times means the times P-CSCF receives Ringing messages corresponding to the Invite messages which were sent by P-CSCF in a specified period.

- MT call setup success rate

MT call setup success rate = (S-CSCF MT call setup request success times/S-CSCF MT call setup request times) \*100%

According to the origination procedures described in [ETSI TS 123 228], S-CSCF MT call setup request times means the times S-CSCF receives Invite messages and S-CSCF MT call setup request success times means the times S-CSCF sends Ringing messages corresponding to the Invite messages which were received by S-CSCF in a specified period.

- speech call setup success rate

speech call setup success rate = (S-CSCF speech call setup request success times/S-CSCF speech call setup request times received) \*100%

According to the origination procedures and termination procedures described in [ETSI TS 123 228], S-CSCF speech call setup request times received means the times S-CSCF receives Invite messages with SDP only speech included and S-CSCF speech call setup request success times means the times S-CSCF sends Ringing messages corresponding to the Invite messages with SDP only speech included which were received by S-CSCF in a specified period.

- video call setup success rate

video call setup success rate = (S-CSCF video call setup request success times/S-CSCF video call setup request times received) \*100%

According to the origination procedures and termination procedures described in [ETSI TS 123 228], S-CSCF video call setup request times received means the times S-CSCF receives Invite messages with SDP speech and video included and S-CSCF video call setup request success times means the times S-CSCF sends Ringing messages corresponding to the Invite messages with SDP speech and video included which were received by S-CSCF in a specified period.

- call answer rate

call answer rate = (S-CSCF call answer times/S-CSCF call setup request times received) \*100%

According to the origination procedures and termination procedures described in [ETSI TS 123 228], S-CSCF call setup request times received means the times S-CSCF receives Invite messages and S-CSCF call answer times means the times S-CSCF sends 200 OK messages corresponding to the Invite messages which were received by S-CSCF in a specified period.

- average call setup latency

average call setup latency = average of interval between SIP message 180 and Invite in P-CSCF

According to the origination procedures described in [ETSI TS 123 228], Interval between SIP message 180 and Invite in P-CSCF means the time that P-CSCF receives Ringing message subtracted by the time that P-CSCF sends Invite message for the same session.

- IMS dedicated bearer setup success rate

IMS dedicated bearer setup success rate = (SAE GW IMS dedicated bearer setup success times/SAE GW IMS dedicated bearer setup times) \*100%

According to dedicated bearer activation described in [ETSI TS 123 401], SAE GW IMS dedicated bearer setup times means the times SAE GW sends Create Bearer Request for IMS dedicated bearer and SAE GW IMS dedicated bearer setup success times means the times SAE GW receives Create Bearer Response with EPS Bearer Identity, S5/S8-TEID and User Location Information (ECGI) corresponding to the Create Bearer Request which were sent by SAE GW in a specified period.

- SRVCC handover success rate

SRVCC handover success rate = (SRVCC handover complete times received by MME/SRVCC handover request times sent by MME) \*100%

According to the SRVCC handover procedures described in [ETSI TS 123 216], SRVCC handover request times sent by MME means the times MME sends PS to CS handover request messages to eMSC in a specified period, and SRVCC handover complete times received by MME means the times MME receives PS to CS handover complete messages from eMSC in a specified period.

- SRVCC handover latency

SRVCC handover latency = average of interval between MME receiving SRVCC handover complete message and MME sending SRVCC handover request message

According to the SRVCC handover procedures described in [ETSI TS 123 216], interval between MME receiving SRVCC handover complete message and MME sending SRVCC handover request messages means the time MME receives PS to CS handover complete message from eMSC subtracted by the time MME sends PS to CS handover request message to eMSC for the same SRVCC handover session.

### **8.3 Status information requirements for signalling network analyses in VoLTE**

The status information of VoLTE signalling network is recommended to be obtained and analysed in signalling network analyses. This clause presents the common status information to be obtained.

- The status information of network entities, which refers to the status information of all the network entities in VoLTE signalling network, which includes hardware capacity, software capacity, real-time load, computing resources, storage resources, network resources, signalling process configuration, etc.
- The status information of signalling exchange between network entities, which refers to the status information of all the signalling exchange in VoLTE signalling network, which includes signalling route mechanism, signalling transmission mechanism, signalling messages and their parameters, etc.

## **9 Requirements for signalling network optimization in VoLTE**

### **9.1 General requirements for signalling network optimization in VoLTE**

This clause presents the general requirements for optimization of VoLTE signalling network, which is implemented based on the results of signalling network analyses.

The signalling network optimization function is required to meet the requirements as follows:

- By adjusting the configuration of the network entities related to the signalling processes of VoLTE services, the performance of VoLTE signalling network can be improved.
- By dynamically increasing the computing resources, storage resources and network resources of the bottle-neck network entities related to the signalling processes of VoLTE services, the performance of the bottle-neck network entities and VoLTE signalling network can be improved.
- Optimization of the signalling exchange between the network entities by:
  - Adjusting the mechanisms of signalling route selection, signalling route failover and failback, signalling route reselection, signalling retransmission, etc.
  - Removing the unnecessary or optional parameters in signalling messages of signalling exchange.
- By locating the overloaded network entities or malfunction network entities in advance, the disaster failover and failback operations can be avoided in some cases, in this way the performance of VoLTE signalling network can be improved.
- Signalling network optimization function is required to support both manual operation and automatic operation based on optimization instructions.
- Signalling network optimization function is required to support flexible extension capability to meet the various requirements of operators and adapt to the evolution of VoLTE network. Both the forward compatibility issues and the backward compatibility issues are required to be addressed.
- Signalling network optimization function is required to not influence the functions of the network entities in VoLTE signalling network, also it is required to have no negative effects on the performance of VoLTE signalling network.
- It is recommended to use AI technologies to assist in signalling network optimization.

### **9.2 Preconditions of signalling network optimization**

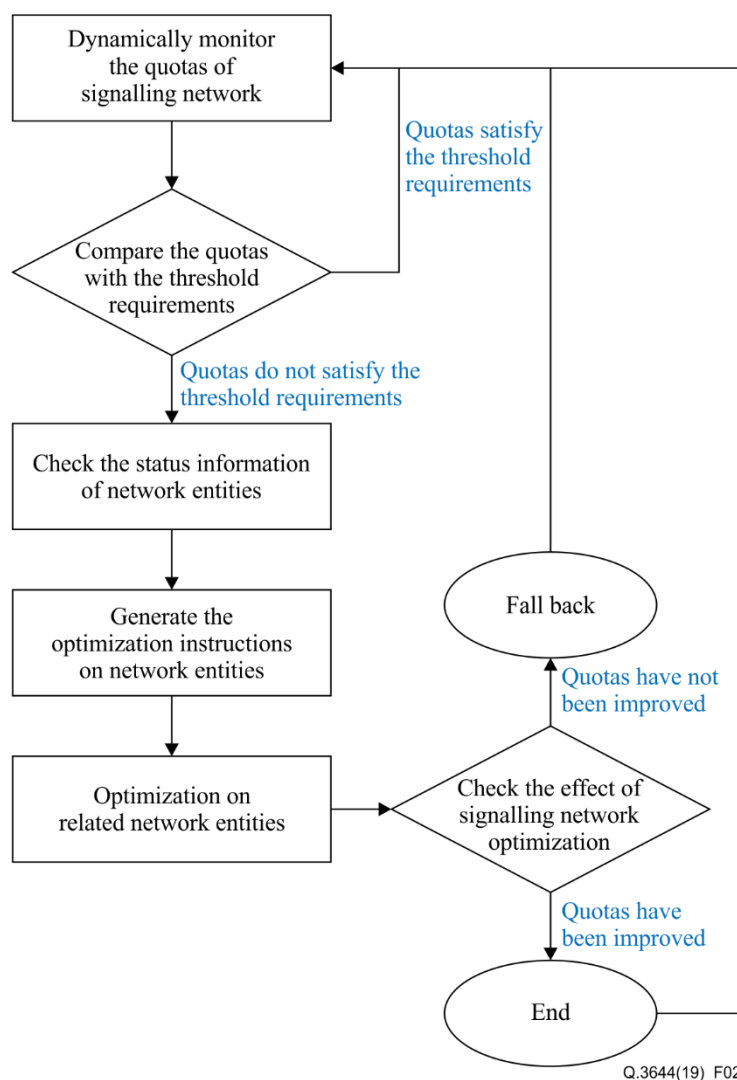
The operation of signalling network optimization has the preconditions as follows:

- The quotas of signalling network which can reflect the network status have been obtained in the processes of signalling network analyses.

- The status information of network entities and signalling exchange between network entities, which can assist in the generation of optimization instructions, has been obtained in the processes of signalling network analyses.
- The quotas of signalling network can be translated to the optimization instructions with the assistance of the status information of VoLTE signalling network. The optimization instructions are machine-readable and human-readable messages which contain operational details.
- The network entities support dynamic configuration based on the optimization instructions.
- The signalling exchange between network entities supports dynamic configuration based on the optimization instructions.
- The network entities and the signalling exchange between network entities support fallback mechanism in case of failed or invalid signalling network optimization.
- The network entities support the automatic generation of signalling network optimization reports for future reference or manual intervention.

### 9.3 Requirements for signalling network optimization on network entities

On the basis of quotas of signalling network and status information of network entities, the signalling network optimization on network entities is implemented. Figure 2 describes the process of signalling network optimization on network entities.



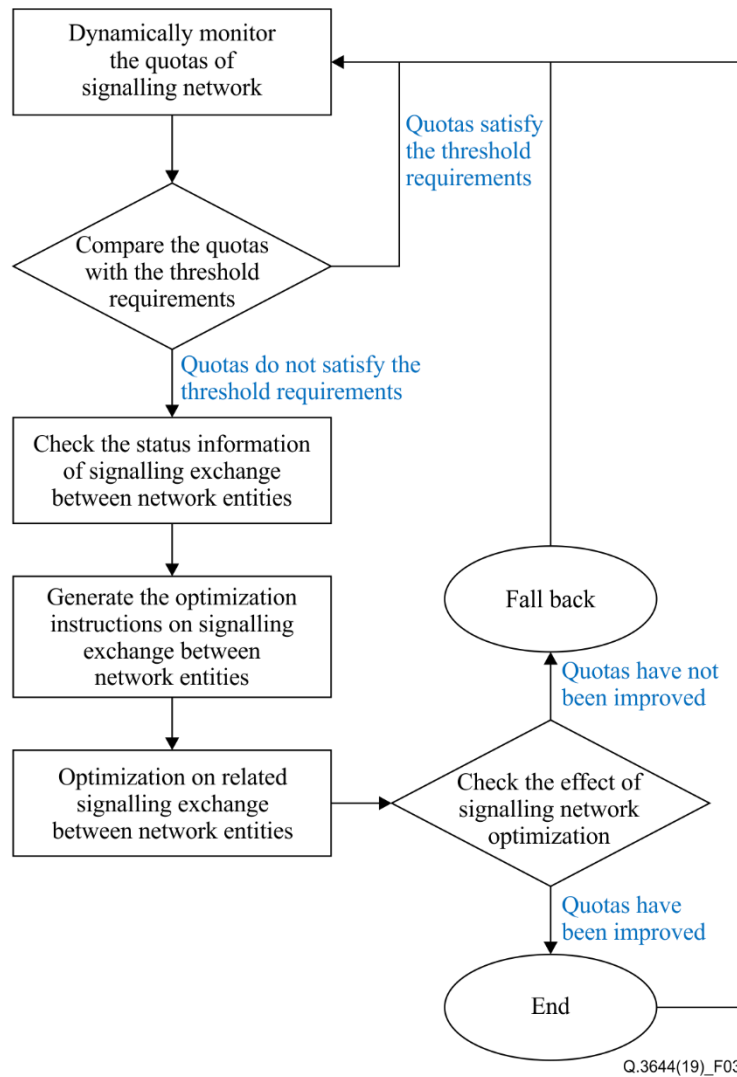
**Figure 2 – The process of signalling network optimization on network entities**

- 1) The system dynamically monitors the quotas of signalling network, the monitor process is executed periodically.
- 2) The system compares the quotas of signalling network with the preconfigured threshold requirements. If quotas satisfy the threshold requirements, the system continues to monitor the quotas. If quotas do not satisfy the threshold requirements, the system initiates the operation of signalling network optimization on network entities.
- 3) The system checks the status information of network entities to find out the possible aspects to be improved, e.g., configuration of network entities, performance of network entities.
- 4) The system generates the optimization instructions on related network entities, e.g., modifying the signalling processing configuration of network entity A, initiating the overload control mechanism on network entity B, dynamically increasing the computing resources of network entity C.
- 5) The related network entities perform optimization based on the optimization instructions.
- 6) The system checks the effect of signalling network optimization on network entities. If quotas have been improved, the signalling network optimization ends successfully with a success report been generated, and the system continues to monitor the quotas. If quotas have not been improved, the system instructs related network entities to fall back to the previous status, a failure report calling for manual intervention is generated, and the system continues to monitor the quotas.

#### **9.4 Requirements for optimization of signalling exchange between network entities**

On the basis of quotas of signalling network and status information of signalling exchange, the optimization of signalling exchange between network entities is implemented. Figure 3 describes the process of optimization of signalling exchange between network entities.





**Figure 3 – The process of optimization of signalling exchange between network entities**

- 1) The system of signalling network optimization dynamically monitors the quotas of signalling network, the monitor process is executed periodically.
- 2) The system compares the quotas of signalling network with the preconfigured threshold requirements. If quotas satisfy the threshold requirements, the system continues to monitor the quotas. If quotas do not satisfy the threshold requirements, the system initiates the operation of optimization of signalling exchange between network entities.
- 3) The system checks the status information of signalling exchange between network entities to find out the possible aspects to be improved, e.g. signalling route mechanism, signalling messages and their parameters.
- 4) The system generates the optimization instructions on related signalling exchange, e.g. adjusting the signalling route selection mechanism of signalling exchange A-B, adjusting the signalling retransmission mechanism of signalling exchange B-C, removing the unnecessary or optional parameters in signalling messages of signalling exchange A-C.
- 5) The network entities which are related to the signalling exchange perform optimization based on the optimization instructions.
- 6) The system checks the effect of optimization of signalling exchange between network entities. If quotas have been improved, the signalling network optimization ends successfully with a success report been generated, and the system continues to monitor the quotas. If quotas have not been improved, the system instructs related signalling exchange

to fall back to the previous status, a failure report calling for manual intervention is generated, and the system continues to monitor the quotas.

NOTE 1 – Signalling network optimization on network entities and optimization of signalling exchange between network entities can be implemented simultaneously or separately, depends on the strategy configured by the operator.

NOTE 2 – AI technologies are recommended to be applied in signalling network optimization on network entities and optimization of signalling exchange between network entities.

## **10 General security considerations**

The general security considerations about signalling collecting, signalling network analyses and signalling network optimization in VoLTE are as follows:

- Information security

To ensure the user information security and network information security, the information obtained in the processes of signalling collecting, signalling network analyses and signalling network optimization in VoLTE 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 VoLTE signalling network should not be influenced in the processes of signalling collecting, signalling network analyses and signalling network optimization. In addition, the signalling network optimization should not have negative effects on the performance of VoLTE signalling network, both on network entities and signalling exchange between network entities.



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