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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

Framework and protocols for signalling network analysis and optimization in VoLTE

Recommendation ITU-T Q.3646

ITU-T Q-SERIES RECOMMENDATIONS

SWITCHING AND SIGNALLING, AND ASSOCIATED MEASUREMENTS AND TESTS

Recommendation ITU-T Q.3646

Framework and protocols for signalling network analysis and optimization in VoLTE

Summary

Recommendation ITU-T Q.3646 specifies the framework, interfaces, protocols, service procedures, AI/ML-assisted functions and security considerations of signalling network analysis and optimization in the context of voice over long term evolution (VoLTE) network. Signalling network includes the network entities and signalling exchanges that are related to telecommunication services. Analysis and optimization of signalling networks are important methods for network and service related management and operation.

History

Edition	Recommendation	Approval	Study Group	Unique ID[*]
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Keywords

Framework, protocols, signalling network analysis, 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.

FOREWORD

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Table of Contents

Recommendation ITU-T Q.3646

Framework and protocols for signalling network analysis and optimization in VoLTE

1 Scope

This Recommendation specifies the framework and protocols for signalling network analysis and optimization in voice over long term evolution (VoLTE) networks, which are implemented with signalling network analysis and optimization systems. The signalling network analysis and optimization system is a network management system that consists of signalling collecting component, signalling network analysis component, signalling network optimization component, and artificial intelligence (AI) / machine learning (ML) assistance component, aiming to implement signalling collecting and signalling network analysis, perform optimization on network entities and signalling exchange, and provide the results of signalling network analysis and optimization to the user of signalling network analysis and optimization, in the context of VoLTE network.

The following aspects of signalling network analysis and optimization are addressed in this Recommendation:

- Framework which includes the overview and component design of signalling network analysis and optimization system.

- Interfaces (IF) and protocols which include the interfaces and protocols of signalling collecting, signalling network analysis, signalling network optimization, AI/ML and users.

- Service procedures which include the procedures of signalling collecting, signalling network analysis, signalling network optimization, AI/ML and users.

- AI/ML-assisted functions which include the functions of intelligent signalling collecting, intelligent signalling network analysis, intelligent signalling network optimization, intelligent system self-management and self-orchestration, external AI/ML platform connecting and external AI/ML capability mapping.

- Security considerations which include signalling collecting security, signalling network analysis security, signalling network optimization security, AI/ML related 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.3172]   Recommendation ITU-T Y.3172 (2019), *Architectural framework for machine learning in future networks including IMT-2020*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 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.

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

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

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

3.1.5 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.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
API	Application Programming Interface
HTTP	Hypertext Transfer Protocol
IF	Interface
IP	Internet Protocol
LTE	Long Term Evolution
ML	Machine Learning
MML	Man-Machine Language
SDTP	Shared Data Transfer Protocol
SFTP	Secure File Transfer Protocol
TCP	Transmission Control Protocol
VoLTE	Voice over LTE

5 Conventions

In this Recommendation:

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

6 Framework of signalling network analysis and optimization

Figure 6-1 depicts the framework of signalling network analysis and optimization in VoLTE network. Network entities are the network functions that are related to the signalling processes of VoLTE services. Signalling exchanges are the interfaces and signalling transfers between the network entities. The signalling network analysis and optimization system interacts with the network entities and signalling exchange in the VoLTE network to implement signalling collecting. Signalling network analysis perform optimization on network entities and signalling exchange and provide the results of signalling network analysis and optimization to the user of the signalling network analysis and optimization. The external AI/ML platform is a recommended external system which provides AI/ML related capabilities to the signalling network analysis and optimization system, the external AI/ML platform is recommended to support the high-level architectural requirements specified in [ITU-T Y.3172].
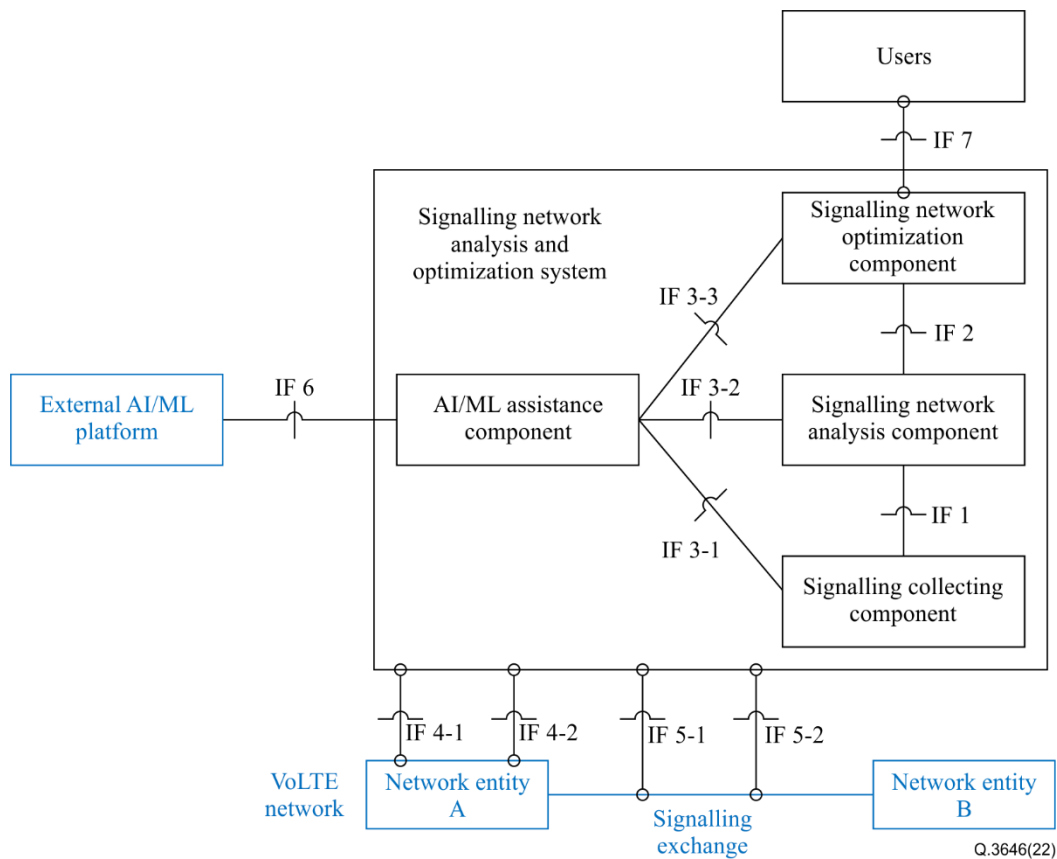
Figure 6-1 – Framework of signalling network analysis and optimization

The signalling network analysis and optimization system consists of signalling collecting component, signalling network analysis component, signalling network optimization component, and AI/ML assistance component which are as follows.

- Signalling collecting component: A required component that performs signalling collecting on the signalling exchange and network status collecting on the network entities which are related to the signalling processes of VoLTE services. The interfaces to be collected and related requirements are specified in clause 7 of [ITU-T Q.3644].

- Signalling network analysis component: A required component that performs analysis on the quotas of VoLTE signalling network using the signalling data obtained in signalling collecting, and analysis on status information of VoLTE signalling network using the network status data obtained in signalling collecting. The quotas and status information to be analysed and related requirements are specified in clause 8 of [ITU-T Q.3644].

- Signalling network optimization component: A required component that performs optimization on network entities and optimization of signalling exchange between network entities in VoLTE signalling network on the basis of signalling network analysis. The requirements for signalling network optimization are specified in clause 9 of [ITU-T Q.3644].

- AI/ML assistance component: A recommended component that acts on signalling collecting component, signalling network analysis component, and signalling network optimization component to provide AI/ML related capabilities in the processes of VoLTE signalling network analysis and optimization. It is recommended for AI/ML assistance component to use the AI/ML related capabilities of the external AI/ML platform with invoking interfaces. AI/ML assistance component which takes the role of an internal overlay as specified in [ITU-T Y.3172], is required to support the high-level architectural requirements specified in [ITU-T Y.3172].

In addition to the components above, the signalling network analysis and optimization system also provides common management and orchestration functions, which may follow the standards of management and orchestration of ITU-T and other SDOs.

7 Interfaces and protocols of signalling network analysis and optimization

7.1 General descriptions of interfaces

In the framework of signalling network analysis and optimization, there are five internal interfaces and six external interfaces of signalling network analysis and optimization system to be addressed in this Recommendation, which are as follows.

- IF 1 (Interface 1): A required interface between the signalling network analysis component and signalling collecting component.

- IF 2: A required interface between the signalling network optimization component and signalling network analysis component.

- IF 3-1: A recommended interface between the signalling collecting component and AI/ML assistance component.

- IF 3-2: A recommended interface between the signalling network analysis component and AI/ML assistance component.

- IF 3-3: A recommended interface between the signalling network optimization component and AI/ML assistance component.

- IF 4-1: A required interface between the signalling collecting component and network entity in VoLTE network.

- IF 4-2: A required interface between the signalling network optimization component and network entity in VoLTE network.

- IF 5-1: A required interface between the signalling collecting component and signalling exchange between network entities in VoLTE network.

- IF 5-2: A required interface between the signalling network optimization component and signalling exchange between network entities in VoLTE network.

- IF 6: A recommended interface between the AI/ML assistance component and external AI/ML platform.

- IF 7: A required interface between the signalling network optimization component and the user of signalling network analysis and optimization.

7.2   Signalling collecting interfaces and protocols

IF 4-1 is the interface between the signalling collecting component and the network entity, which is used for the raw data collection on network entities of VoLTE signalling network, including hardware capacity, software capacity, real-time load, computing resources, storage resources, network resources, and signalling process configuration, as specified in [ITU-T Q.3644].

IF 5-1 is the interface between the signalling collecting component and the signalling exchange between network entities, which is used for the raw data collection on signalling exchange of VoLTE signalling network, including S6a, Gx, Rx, Cx, Sh, Zh, ISC, Ma, Mg, Mj, Mw, Mx, Mr, Gm, Sv, S1-MME, S11, S5/S8, Ut, C/D, Sh/J, and Imc, as specified in [ITU-T Q.3644].

IF 4-1 and IF 5-1 could be decoupled with the VoLTE signalling network or integrated with VoLTE signalling network, depending on the deployment demands.

The protocols of IF 4-1 and IF 5-1 could be a shared data transfer protocol (SDTP), secure file transfer protocol (SFTP), or other trustable protocols which are required to ensure the data integrity and security of raw data collection.

7.3   Signalling network analysis interfaces and protocols

IF 1 is the interface between the signalling network analysis component and the signalling collecting component, which is used for uploading the single data and synthetic data of the signalling network generated by the signalling collecting component to the signalling network analysis component.

IF 2 is the interface between the signalling network optimization component and the signalling network analysis component, which is used for uploading the quotas and status information of the signalling network generated by the signalling network analysis component to the signalling network optimization component.

IF 1 and IF 2 are required to support the function of data reverse query for facilitating the tracking of signalling processes.

The protocols of IF 1 and IF 2 could be SDTP, SFTP or other trustable protocols, which are required to ensure data integrity and the security of signalling network analysis.

7.4   Signalling network optimization interfaces and protocols

IF 4-2 is the interface between the signalling network optimization component and the network entity, which is used for sending the optimization instructions to network entities in the VoLTE network and receiving the effect of optimization.

IF 5-2 is the interface between the signalling network optimization component and the signalling exchange, which is used for sending the optimization instructions to the signalling exchange between network entities in the VoLTE network and receiving the effect of optimization.

The protocols of IF 4-2 and IF 5-2 could be man-machine language (MML) or other protocols depending on the deployment demands.

7.5   AI/ML related interfaces and protocols

IF 3-1 is the interface between the signalling collecting component and the AI/ML assistance component, which is used for providing AI/ML related capabilities in the processes of signalling collecting.

IF 3-2 is the interface between the signalling network analysis component and the AI/ML assistance component, which is used for providing AI/ML related capabilities in the processes of signalling network analysis.

IF 3-3 is the interface between signalling network optimization component and the AI/ML assistance component, which is used for providing AI/ML related capabilities in the processes of signalling network optimization.

IF 6 is the interface between the AI/ML assistance component and the external AI/ML platform, which is used for providing the AI/ML related capabilities of the external AI/ML platform to signalling network analysis and optimization systems.

IF 3-1, IF 3-2, IF 3-3, and IF 6 are recommended to adopt the protocol stack of hypertext transfer protocol (HTTP) [b-IETF RFC 7540] / transmission control protocol (TCP) / Internet protocol (IP) for facilitating the invoking of external AI/ML related capabilities.

7.6   User interfaces and protocols

IF 7 is the interface between the signalling network optimization component and the user of signalling network analysis and optimization, which is used for providing the results of signalling network analysis and optimization to the user of the signalling network analysis and optimization. IF 7 is recommended to adopt a user-friendly interface and protocol, such as an application programming interface (API) or graphical interface, which adopts the protocol stack of HTTP [b-IETF RFC 7540] / TCP / IP.

8   Service procedures of signalling network analysis and optimization

8.1   General descriptions of service procedures

The signalling collecting component initiates the original signalling collection and network status collection and generates the raw data including the signalling data and the network status data, of which the signalling data includes the single data and synthetic data of a complete VoLTE session. The signalling collecting component then uploads the raw data to the signalling network analysis component for subsequent signalling network analysis.

The signalling network analysis component uses the raw data including the signalling data and network status data to perform data processing and data analysis. The signalling network analysis component then uploads the quotas and status information as the results of the data processing and data analysis to the signalling network optimization component for subsequent signalling network optimization.

The signalling network optimization component uses the quotas and status information to recognize the operation status of the signalling network, such as signalling fault and network entity break down, with which signalling network optimization component could develop corresponding solutions and instructions to optimize the VoLTE signalling network.

The above three components interact with the AI/ML assistance component to perform intelligent signalling collecting, intelligent signalling network analysis, intelligent signalling network optimization, and intelligent self-management and self-orchestration.

In the end, the signalling network optimization component provides the results of signalling network analysis and optimization to the user of signalling network analysis and optimization.

8.2   Signalling collecting procedures
The signalling collecting procedures are as follows.

- The raw data collection on signalling exchange of VoLTE signalling network is performed on IF 5-1, the related interfaces include S6a, Gx, Rx, Cx, Sh, Zh, ISC, Ma, Mg, Mj, Mw, Mx, Mr, Gm, Sv, S1-MME, S11, S5/S8, Ut, C/D, Sh/J, and Imc, as specified in [ITU-T Q.3644].

- The raw data collection on network entities of VoLTE signalling network is performed on IF 4-1, the related network status includes hardware capacity, software capacity, real-time

load, computing resources, storage resources, network resources, and signalling process configuration, as specified in [ITU-T Q.3644].

8.3 Signalling network analysis procedures

The signalling network analysis procedures are as follows.

- The single data and synthetic data of signalling network generated by the signalling collecting component are uploaded to the signalling network analysis component by using IF 1.

- The signalling network analysis component performs analysis on quotas and status information of the VoLTE signalling network.

- The quotas and status information of the signalling network generated by the signalling network analysis component are uploaded to the signalling network optimization component by using IF 2.

8.4 Signalling network optimization procedures

The signalling network optimization procedures are as follows.

- The process of signalling network optimization on network entities is performed, as specified in [ITU-T Q.3644].

- The process of optimization of signalling exchange between network entities is performed, as specified in [ITU-T Q.3644].

- The optimization instructions are sent to the network entities in the VoLTE network, and the corresponding effect of optimization is received by using IF 4-2.

- The optimization instructions are sent to the signalling exchange between the network entities in the VoLTE network, and the corresponding effect of optimization is received by using IF 5-2.

8.5 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 collecting with the support of the AI/ML assistance component by using IF 6 and IF 3-1.

- The AI/ML related capabilities are invoked, mapped, and utilized in the processes of signalling network analysis with the support of the AI/ML assistance component by using IF 6 and IF 3-2.

- The AI/ML related capabilities are invoked, mapped, and utilized in the processes of signalling network optimization with the support of the AI/ML assistance component by using IF 6 and IF 3-3.

8.6 User related procedures

The user related procedures are as follows.

- The results of the signalling network analysis are translated into user-friendly data which includes the information required by a specific user in signalling network optimization component. The signalling network optimization component then provides the user-specific data of the signalling network analysis to the user of the signalling network analysis and optimization by using IF 7.

- The results of the signalling network optimization are translated into user-friendly data which includes the information required by specific users in the signalling network optimization component. Then the signalling network optimization component provides the

user-specific data of signalling network optimization to the user of signalling network analysis and optimization, by using IF 7.

9 AI/ML-assisted functions of signalling network analysis and optimization

9.1 General descriptions of AI/ML-assisted functions

The AI/ML-assisted functions of the signalling network analysis and optimization which are provided by the AI/ML assistance component, act on the signalling collecting component, signalling network analysis component, and signalling network optimization component to provide AI/ML related capabilities. The AI/ML-assisted functions are as follows.

- Intelligent signalling collecting functions.
- Intelligent signalling network analysis functions.
- Intelligent signalling network optimization functions.
- Intelligent system self-management and self-orchestration functions.
- External AI/ML platform connecting functions.
- External AI/ML capability mapping functions.

9.2 Intelligent signalling collecting functions

The intelligent signalling collecting functions are as follows.

- To manage the facilities of data collection and data storage to ensure high reliability and high efficiency.
- To process and store mass raw data collected from the VoLTE signalling network.
- To search the signalling data related to the analysed VoLTE service procedure.
- To search the network status data related to the analysed VoLTE service procedure.

9.3 Intelligent signalling network analysis functions

The intelligent signalling network analysis functions are as follows.

- To chain the signalling related to the VoLTE service procedure for some given inputs.
- To specify the VoLTE service procedures related to the given optimization target.
- To specify the existing network problems based on the analysis of the status information of the VoLTE signalling network.

9.4 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 and/or optimization records.

9.5 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 signalling network analysis and optimization system.

- To achieve self-management of internal interfaces and external interfaces of signalling network analysis and optimization system.
- To achieve self-orchestration of hardware resources and software resources of signalling network analysis and optimization system.
- To customize the capabilities of signalling network analysis and optimization systems on demand.

9.6 External AI/ML platform connecting functions

The external AI/ML platform connecting functions are as follows.

- To provide the interfaces for external AI/ML platforms connecting to the signalling network analysis and optimization systems.
- To manage the available external AI/ML platform(s) and the external AI/ML related capabilities.
- To invoke the external AI/ML related capabilities based on the requirements of signalling collecting component, signalling network analysis component, and signalling network optimization component.
- To receive the optimized policies or solutions from the external AI/ML platforms which are authorized.
- To choose the best-suited external AI/ML platform for specific AI/ML related capability, when multiple external AI/ML platforms are available.
- To choose the best policies or solutions to achieve the optimization target which was reconfigured by the operator or the user.

9.7 External AI/ML capability mapping functions

The external AI/ML capability mapping functions are as follows.

- To manage the relations of the external AI/ML platform, signalling network analysis and optimization system in the aspects of protocols and AI/ML related capabilities.
- To perform protocol transition between the external AI/ML platform and the components of the signalling network analysis and optimization system.
- To perform AI/ML related capability mapping between the external AI/ML platform and the components of signalling network analysis and optimization system.

10 Security considerations

The security and privacy considerations of the signalling network analysis and optimization include the following aspects.

- Signalling collecting security, which includes the considerations on signalling data collecting security and network status data collecting security.
- Signalling network analysis security, which includes the considerations on quotas analysis security and status information analysis security.
- Signalling network optimization security, which includes the considerations on the optimization of network entities and optimization of signalling exchange.
- AI/ML related security, which includes the security considerations on intelligent signalling collecting security, intelligent signalling network analysis security, intelligent signalling network optimization security, intelligent self-management and self-orchestration, external AI/ML platform connecting and external AI/ML capability mapping.

- User privacy, which includes the privacy considerations on the end user and the user of signalling network analysis and optimization.

In addition, the security and privacy considerations of signalling network analysis and optimization should be aligned with the requirements specified in [b-ITU-T Y.2701], [b-ITU-T Y.3101], and [b-ISO/IEC 18033-1].

Bibliography

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

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

[b-IETF RFC 7540]   IETF RFC 7540 (2020), *Hypertext Transfer Protocol Version 2 (HTTP/2)*.

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[b-ISO/IEC 18033-1] ISO/IEC 18033-1:2015, *Information technology – Security techniques – Encryption algorithms – Part 1: General*.

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Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
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Series H	Audiovisual and multimedia systems
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