ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation

ITU-T Y.3201 (01/2023)

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

Future networks

Fixed, mobile and satellite convergence – Framework for IMT-2020 networks and beyond

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Computing power networks	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	**Y.3000–Y.3499**
CLOUD COMPUTING	Y.3500–Y.3599
BIG DATA	Y.3600–Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.3201

Fixed, mobile and satellite convergence – Framework for IMT-2020 networks and beyond

Summary

Recommendation ITU-T Y.3201 specifies the design considerations, framework, enabling technologies, network function enhancements, procedures, and security considerations of fixed, mobile and satellite convergence (FMSC) in the context of the International Mobile Telecommunications (IMT)-2020 networks and beyond. FMSC is the capability that provides services and applications to end users regardless of the fixed, mobile or satellite access technologies.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3201	2023-01-13	13	11.1002/1000/15239

Keywords

FMSC, framework, IMT-2020, satellite convergence.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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

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

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

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

NOTE

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

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

INTELLECTUAL PROPERTY RIGHTS

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

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

Table of Contents

Recommendation ITU-T Y.3201

Fixed, mobile and satellite convergence – Framework for IMT-2020 networks and beyond

1 Scope

This Recommendation specifies the framework of fixed, mobile and satellite convergence (FMSC) in the context of the International Mobile Telecommunications (IMT)-2020 networks and beyond. Fixed, mobile and satellite convergence is the capability that provides services and applications to end users regardless of the fixed, mobile or satellite access technologies. This Recommendation also specifies the following aspects of fixed, mobile and satellite convergence:

- Design considerations for FMSC;
- Framework of FMSC, including the overall framework, the framework of a land-based converged network, and the framework of a satellite-based converged network;
- Enabling technologies of FMSC;
- Network function enhancements of FMSC;
- Procedures of FMSC, including registration management, connection management, session management, handover, capability exposure and network slicing;
- Security considerations.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.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.3108] Recommendation ITU-T Y.3108 (2019), *Capability exposure function in IMT-2020 networks.*

[ITU-T Y.3131] Recommendation ITU-T Y.3131 (2019), *Functional architecture for supporting fixed mobile convergence in IMT-2020 networks.*

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

[ITU-T Y.3200] Recommendation ITU-T Y.3200 (2022), *Fixed, mobile and satellite convergence – Requirements for IMT-2020 networks and beyond.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 control plane [b-ITU-T Y.2011]: The set of functions that control the operation of entities in the stratum or layer under consideration, plus the functions required to support this control.

3.1.2 data plane [b-ITU-T Y.2011]: The set of functions used to transfer data in the stratum or layer under consideration.

3.1.3 fixed mobile convergence [b-ITU-T Y.3100]: In the context of IMT-2020, the capabilities that provide services and applications to end users regardless of the fixed or mobile access technologies being used and independently of the users' location.

3.1.4 fixed, mobile and satellite convergence [ITU-T Y.3200]: The capabilities that provide services and applications to end users regardless of the fixed, mobile or satellite access technologies being used independently of the users' location.

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

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

3.1.7 network function [b-ITU-T Y.3100]: In the context of IMT-2020, a processing function in a network.

3.1.8 user plane [b-ITU-T Y.2011]: A synonym for data plane.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AF Application Function

AI Artificial Intelligence

ASF Authentication Server Function

CEF Capability Exposure Function

DLT Distributed Ledger Technology

FMC Fixed Mobile Convergence

FMSC Fixed, Mobile and Satellite Convergence

GEO Geostationary Earth Orbit

IMT International Mobile Telecommunications

ML Machine Learning

MNO Mobile Network Operator

MUE Multi-connection User Equipment

NACF Network Access Control Function

NFR Network Function Registry function

NGSO Non-Geostationary Satellite Orbit

NSSF Network Slice Selection Function

PCF Policy Control Function

PDU Protocol Data Unit

QIT Quantum Information Technology

QoS Quality of Service

RAN Radio Access Network

SDN Software-Defined Networking

SMF Session Management Function

TA Tracking Area

UE User Equipment

UPF User Plane Function

USM Unified Subscription Management function

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.

The keywords "can optionally" indicate an optional requirement which 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/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Design considerations for fixed, mobile and satellite convergence

This clause provides the design considerations for fixed, mobile and satellite convergence (FMSC), in the aspects of scenarios, framework, enabling technologies, network function enhancements, moving radio access network (RAN) enhancements and procedures. The FMSC is the capability that provides services and applications to end users regardless of the fixed, mobile or satellite access technologies. It enables to support a wider coverage than fixed mobile convergence (FMC). The main purpose of the FMSC for a multi-access network is to federate all means of access technologies including fixed, mobile and satellite accesses, providing users with the capability to access the network ubiquitously and enjoy the best service experience under the circumstance. The framework of the FMSC network is based on the framework of the IMT-2020 network [ITU-T Y.3102] and the framework of the FMC network [ITU-T Y.3131] and makes enhancements to achieve multi-access convergence based on the characteristics of satellite communications.

NOTE – With the support of the FMSC, the services and applications are provided to the end user no matter what geographic location the end user is located at, therefore, the FMSC has a wider coverage than an FMC.

The design considerations for FMSC include deployment scenarios, framework, enabling technologies, network function enhancements, moving radio access network (RAN) enhancements, and procedures, as specified below.

- Deployment scenarios of FMSC

There are four deployment scenarios for integrating satellite access and terrestrial access, which can be possible from the mobile network operator (MNO) perspective.

Deployment scenario 1: A MNO-1 has both satellite access and terrestrial access. A user equipment (UE) within the MNO's network can handover between a satellite access and a terrestrial access.

Deployment scenario 2: A MNO-1 has only satellite access and an MNO-2 has only terrestrial access. A UE within the MNO-1's network can handover from the satellite access to the terrestrial access when the coverage of the connected access is short and new access should be connected. On the contrary, A UE within the MNO-2's network can handover from a terrestrial access to a satellite access.

Deployment scenario 3: An MNO-1 has either only a satellite access or a terrestrial access. An MNO-2 has both satellite access and terrestrial access. A UE within the MNO-1's network can handover from a satellite access to a terrestrial access, or a satellite access. The new access can be the same as the old access or not. It may depend on the MNO's policy. On the other hand, a UE within the MNO-2's network can handover either from the satellite access to the terrestrial access or from the terrestrial access to the terrestrial access when the terrestrial access is available in MNO-1. Furthermore, a UE within the MNO-2's network can handover either from the satellite access to the satellite access or from the terrestrial access to the satellite access when the satellite access is available in MNO-1.

Deployment scenario 4: An MNO-1 and an MNO-2 have both satellite access and terrestrial access. Similar action to Scenario 3 can happen here.

- Framework of FMSC

To meet the requirements of the FMSC specified in [ITU-T Y.3200], and to support the deployment methods including transparent transmission, access network on satellite, and core network on satellite, the framework of the FMSC consists of the land-based network and the satellite-based network, both of which consist of access network, core network, service platform, and the data network. The land-based network interacts and cooperates with the satellite-based network to achieve FMSC, and provide converged network capabilities and converged services. In the first phase of the framework, FMSC is achieved with the land-based converged network, in which the land-based core network is enhanced to support satellite access and the FMSC on the basis of the IMT-2020 core network. In the second phase of the framework, FMSC is achieved with the satellite-based converged network, in which the satellite-based core network is newly organized on the basis of the IMT-2020 core network.

- Enabling technologies of FMSC

Considering the characteristics of the satellite-based network, such as low bandwidth, high latency, limited capacity, wide coverage, and high mobility, the enabling technologies of the FMSC may include, but are not limited to, mobility management, session management, connection management, service continuity, traffic scheduling, capability exposure, network slicing, multi-access edge computing, network self-organizing, artificial intelligence (AI) / machine learning (ML), distributed ledger technology (DLT), and quantum information technology (QIT); in which the enabling technologies mobility management, session management, connection management, and service continuity are required for an FMSC network, while other enabling technologies are optional.

- Network function enhancements of FMSC

To meet the requirements of the FMSC specified in [ITU-T Y.3200], and to enable the land-based core network and the satellite-based core network, all of the network functions of the control plane and user plane of the IMT-2020 core network need to be enhanced. The core network functions of the FMSC network include the network access control function (NACF), session management function (SMF), policy control function (PCF), capability exposure function (CEF), network function registry function (NFR), unified subscription management function (USM), network slice selection

function (NSSF), authentication server function (ASF), application function (AF), as well as the user plane function (UPF) for fixed access, mobile access and satellite access; in which the network functions NACF, SMF, USM, and UPF are required for the satellite-based core network, while other network functions are optional for the satellite-based core network.

- Moving RAN enhancements of FMSC

A RAN is moving when a satellite installing the RAN orbits the Earth in a non-geostationary satellite orbit (NGSO). It may affect the policy of cell allocation and tracking area (TA) allocation. The methods of cell allocation and TA allocation are determined according to the operator's policy.

- Procedures of FMSC

Based on the framework and network function enhancements of FMSC, all the procedures of the IMT-2020 core network need to be enhanced. In addition, considering the high mobility of satellite-based networks relative to land-based networks, the procedure of network organization needs to be addressed. The procedures of the FMSC network include registration management procedure, connection management procedure, session management procedure, handover procedure, capability exposure procedure, and network slicing procedure.

7 Framework of fixed, mobile and satellite convergence

This clause specifies the framework of fixed, mobile and satellite convergence, including the overall framework, framework of a land-based converged network, and framework of a satellite-based converged network.

7.1 Overall framework

The framework of fixed, mobile and satellite convergence consists of the land-based network and the satellite-based network, in support of the deployment methods including transparent transmission, access network on satellite, and core network on satellite. Figure 7-1 depicts the overall framework of fixed, mobile and satellite convergence in IMT-2020 networks and beyond.

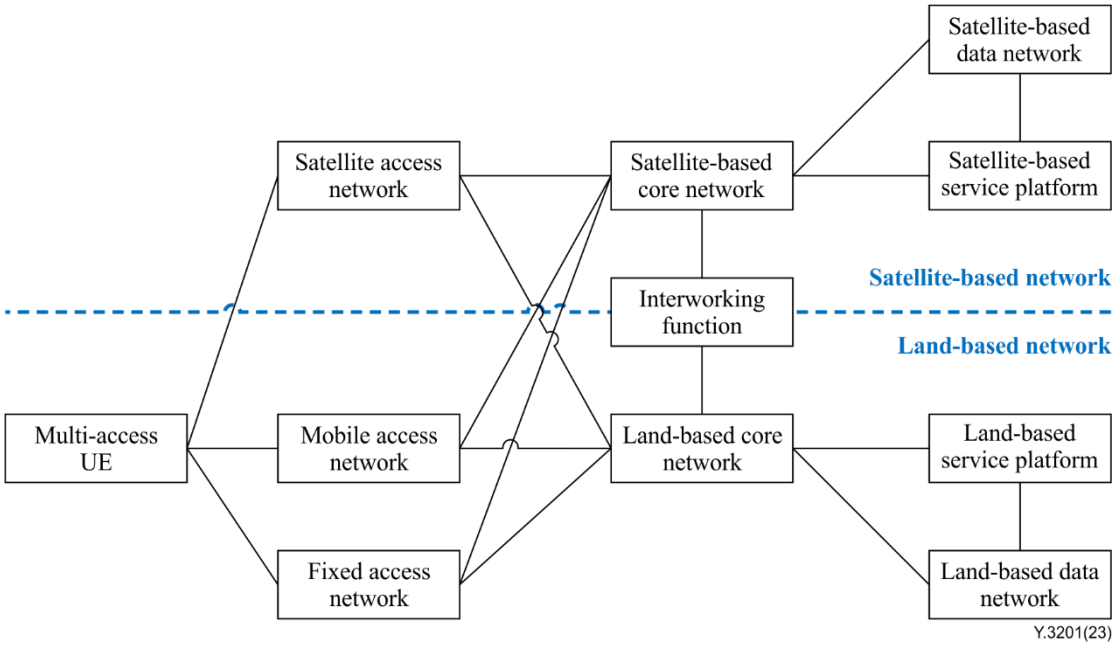

Figure 7-1 – Overall framework of fixed, mobile and satellite convergence

In the overall framework of the FMSC, the satellite-based network consists of a satellite access network, satellite-based core network, satellite-based service platform, and satellite-based data

network; while the land-based network consists of mobile access network, fixed access network, land-based core network, land-based service platform, and land-based data network. With the support of a converged core network, the land-based network interacts and cooperates with the satellite-based network to achieve FMSC and provide converged network capabilities and converged services for multi-access UEs and corresponding users. The interworking function may be necessary between the land-based core network and the satellite-based core network.

In the overall framework of the FMSC, the land-based converged network is the first phase of FMSC, in which the land-based core network is enhanced to support satellite access and the FMSC on the basis of the IMT-2020 core network. While the satellite-based converged network is the second phase of FMSC, in which the satellite-based core network is newly organized on the basis of the IMT-2020 core network, deployed on NGSO satellites and/or geostationary Earth orbit (GEO) satellites. The overall framework of FMSC is required to support the service requirements and network capability requirements specified in [ITU-T Y.3200]; and is required to support the scenarios for integrating satellite access and terrestrial access, as specified in this Recommendation.

7.2 Framework of land-based converged network

Figure 7-2 depicts the framework of the land-based converged network in IMT-2020 networks and beyond, in which fixed, mobile and satellite convergence is mainly achieved with the land-based core network.

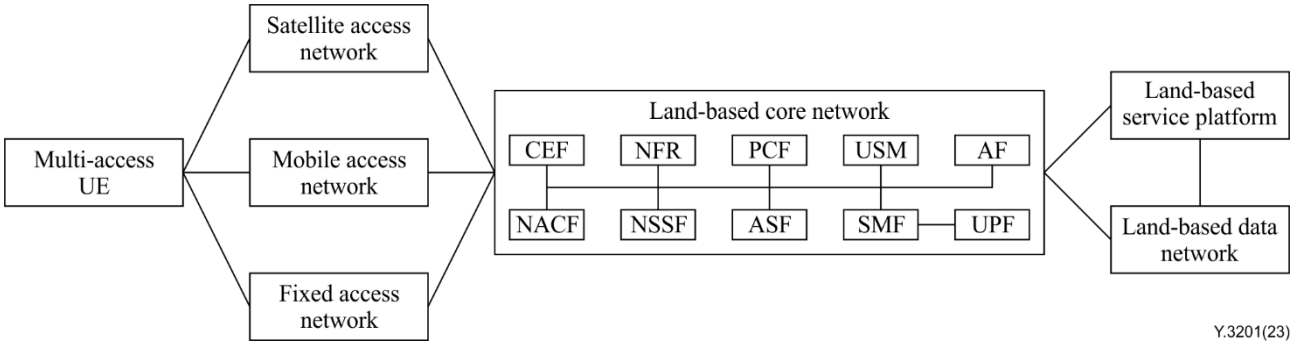

Figure 7-2 – Framework of land-based converged network

In the land-based converged network, the land-based core network connects to a fixed access network, mobile access network, and satellite access network, and provides all of the IMT-2020 core network functions, including NACF, SMF, PCF, CEF, NFR, USM, NSSF, ASF, AF, and UPF for fixed access, mobile access and satellite access, each of which requires enhancements to support FMSC. The land-based core network also connects to land-based service platforms and land-based data networks to enable converged services and applications. The land-based core network supports interworking with the satellite-based core networks, including the core network for public users and the core network for vertical industries.

7.3 Framework of a satellite-based converged network

Figure 7-3 depicts the framework of a satellite-based converged network in IMT-2020 networks and beyond, in which fixed, mobile and satellite convergence is mainly achieved with the satellite-based core network.

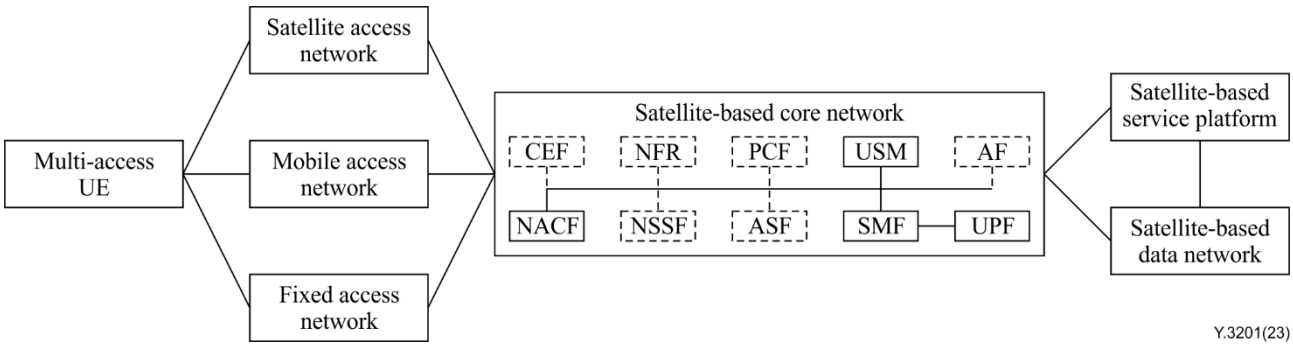

Figure 7-3 – Framework of satellite-based converged network

In the satellite-based converged network, the satellite-based core network connects to a fixed access network, mobile access network, and satellite access network. The satellite-based core network provides a simplified set of the IMT-2020 core network functions, in which NACF, SMF, USM and UPF are required; while PCF, CEF, NFR, NSSF, ASF and AF are optional. The above core network functions require enhancements to support the FMSC. The network functions of the satellite-based core network are customized to adapt to the capabilities and resources of the NGSO and/or GEO satellites, in the aspects of functionalities, interfaces, protocols and procedures. The satellite-based core network also connects to the satellite-based service platforms and satellite-based data networks to enable converged services and applications. The satellite-based core network supports interworking with the land-based core networks which make the FMSC enhancements. The core networks (land-based core network and satellite-based core network) within a specific geographic region share the communications load, with the support of awareness of the network status of each other.

8 Enabling technologies of fixed, mobile and satellite convergence

The general considerations on enabling technologies of fixed, mobile and satellite convergence in the context of the IMT-2020 networks and beyond are as follows.

- Mobility management

It is required to support the requirements and technical enablers of mobility management specified in [ITU-T Y.3200].

The mobility management is implemented in the FMSC network with satellite access or satellite backhaul. The enabling technologies of mobility management for FMSC include a unified access control, unified registration management, unified location management, unified handover management, unified selection of network functions, inter-satellite handover, and inter-access handover.

NOTE – The enabling technologies of mobility management are implemented for both UE and the satellite.

- Session management

It is required to support the requirements and technical enablers of session management specified in [ITU-T Y.3200].

The enabling technologies of session management for the FMSC include the unified session life cycle management, unified address allocation, unified routing selection, and unified session continuity.

Unified session life cycle management includes control of protocol data unit (PDU) session tunnel establishment, modification, and release.

Unified address allocation provides the capability to allocate the address by using the same method in the FMSC network.

Unified routing selection includes selecting the access network(s) to transport traffic (traffic steering), dividing traffic into multiple pieces which are transported through access networks (traffic splitting), moving traffic from one access network to another access network (traffic switching), on both the network side and the user equipment side.

Unified session continuity provides the capability for a user to maintain the continuity of ongoing sessions.

- Connection management

It is required to support the requirements and technical enablers of connection management specified in [ITU-T Y.3200].

The enabling technologies of connection management for FMSC include connection status management, control plane connection management, and user plane connection management.

Connection status management includes connection status handling and connection information transfer.

Control plane connection management includes signalling connection management on the control plane. On the control plane, signalling connection management is used to establish, migrate, and release a signalling connection between the UE and the NACF.

User plane connection management includes activating, reactivating, and deactivating the user plane connections.

In connection scenarios involving dual-connectivity, connection management needs to manage secondary user plane connection, and connection information can transfer between different access networks or different NGSO-satellites.

- Service continuity

It is required to support the requirements and technical enablers of service continuity specified in [ITU-T Y.3200].

Service continuity is the ability of a moving object to maintain ongoing service over including current states, such as the user's network environment and the session for a service [b-ITU-T Q.1706]. In the FMSC network, service continuity is performed on handover between fixed access and mobile access, on handover between fixed access and satellite access, on handover between mobile access and satellite access, and on handover between satellite accesses. The enabling technologies of service continuity for the FMSC include support of access transfer, support of voice and video call continuity, support of data service continuity, support of vertical industry service continuity, and support of handover policy.

- Traffic scheduling

It is required to support the requirements and technical enablers of traffic scheduling specified in [ITU-T Y.3200].

Traffic scheduling is the network capability to make scheduling policies to optimize the traffic forwarding performance, through network operations including traffic steering, traffic engineering, and traffic offloading, based on information collected from networks and applications. In the FMSC network, traffic scheduling is performed among satellite-based core networks, among satellite-based core networks and land-based core networks, among satellite-based data networks and land-based data networks, among satellite-based service platforms, and among satellite-based service platforms and land-based service platforms. The enabling technologies of traffic scheduling for FMSC include traffic information collection, traffic scheduling management, and support of traffic scheduling policies.

- Capability exposure

It is required to support the requirements and technical enablers of capability exposure specified in [ITU-T Y.3200].

Capability exposure provides the functionalities for network functions to expose their capabilities to third parties (e.g., users or other operators). In the FMSC network, capability exposure is implemented in the scenarios of capabilities converged in a land-based core network, capabilities converged in a satellite-based core network, and capabilities distributed in the land-based and satellite-based core network.

- Network slicing

It is required to support the requirements and technical enablers of network slicing specified in [ITU-T Y.3200].

A network slice is a logical network that provides specific network capabilities and network characteristics [b-ITU-T Y.3100]. In the FMSC network, network slicing is implemented in scenarios of different business types, security isolation and operator division.

- Multi-access edge computing

It is required to support the requirements and technical enablers of multi-access edge computing specified in [ITU-T Y.3200].

Multi-access edge computing is to migrate cloud infrastructure, network capabilities, and service capabilities from the centralized location to the edge location and provide multi-access and heterogeneous computing for a user equipment (UE). In the FMSC network, multi-access edge computing is implemented in the scenarios of land-based converged networking, satellite-based converged networking, airborne converged networking, and shipborne converged networking.

- Network self-organizing

It is required to support the requirements and technical enablers of network self-organizing specified in [ITU-T Y.3200]. Network self-organizing is to enable a group of network entities to cooperate with the core network functions based on the available network capabilities and resources. The enabling technologies of network self-organizing for FMSC include ad hoc networking, clustering networking, and software-defined networking (SDN).

- AI / ML

It is required to support the requirements and technical enablers of AI / ML specified in [ITU-T Y.3200] and [b-ITU-T Y.3172]. In the FMSC network, AI / ML is implemented in the aspects of enhancing mobility management, connection management, subscription management, policy control, capability exposure, network self-organizing, and management and orchestration.

- Distributed ledger technology (DLT)

It is required to support the requirements and technical enablers of the DLT specified in [ITU-T Y.3200]. In the FMSC network, DLT is implemented in the aspects of enhancing mobility management, session management, connection management, authentication and authorization, and network self-organizing.

- Quantum information technology (QIT)

It is required to support the requirements of QIT specified in [ITU-T Y.3200]. In the FMSC network, QIT is implemented in the aspects of enhancing authentication and authorization, including the authentication and authorization of land to satellite, satellite to land and inter-satellite.

9 Network function enhancements of fixed, mobile and satellite convergence

The general considerations on network function enhancements of fixed, mobile and satellite convergence in the context of IMT-2020 networks and beyond are as follows. The detailed aspects of network function enhancements for each enabling technology are out of the scope of this Recommendation.

9.1 Satellite access/backhaul type

From the introduction of satellites in the IMT-2020 network, a new access type is required to distinguish the satellite access and the terrestrial access. Satellite access has a longer delay and limited bandwidth compared to terrestrial access. The network functions are capable to identify the access type when the UE connects to the RAN since the access types support different quality of service (QoS) classes. The network functions are capable to recognize whether the backhaul type is satellite or not when it is used for the backhaul.

NACF: The NACF can have information about the access type as well as the backhaul type when the UE requests to make a PDU session. The information is derived from RAN or pre-configuration. NACF is able to select a proper network slice considering the access type and/or backhaul type. The NACF delivers this information to the SMF during the PDU session establishment procedure.

SMF: The SMF can handover to different satellite access/backhaul types or terrestrial types when the UE is moving. SMF reports this information to the policy control function (PCF) during the PDU session establishment procedure.

PCF: The PCF may take this information into account for the policy decision.

Therefore, the mentioned functions above are enhanced to recognize satellite access/backhaul type for UEs.

9.2 Ephemeris of an NGSO-satellite

The ephemeris of an NGSO-satellite includes the accurate location, trajectory, and connection capabilities (including signal quality, communications data rate, communications delay, and communications reliability) of an NGSO-satellite. The ephemeris of NGSO-satellites can be used in the procedures related to mobility management and service continuity, such as choosing the best-suited serving NGSO-satellite.

NACF: The NACF stores and periodically updates the ephemeris of NGSO-satellites. The NACF can use the ephemeris of NGSO-satellites in the procedures of initial registration, location update, and NGSO-satellite handover.

USM: The USM stores and periodically updates information about the ephemeris of NGSO-satellites. The USM can refer to information about the ephemeris of NGSO-satellites to identify the availability of NGSO-satellites and corresponding multi-connection user equipment (MUEs) in a specific geographic area.

9.3 Lightweight customization of network function

Considering the relatively scarce capabilities and resources of satellite-based core networks when compared to land-based core networks, lightweight customization is needed for network functions deployed on the satellite. The lightweight customization can be implemented in a manner of functionalities, interfaces, protocols and procedures.

NACF: The NACF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures.

SMF: The SMF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures.

PCF: The PCF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures. The functionalities of PCF can be integrated into USM.

CEF: The CEF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures. The functionalities of CEF can be integrated into USM.

NFR: The NFR is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures. The functionalities of NFR can be integrated into NACF.

USM: The USM is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures.

NSSF: The NSSF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures. The functionalities of NSSF can be integrated into NACF.

ASF: The ASF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures. The functionalities of ASF can be integrated into USM.

AF: The AF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures. The applications provided by the AF can also be customized to a lightweight version. The functionalities of AF can be integrated into USM.

UPF: The UPF is customized to a lightweight version for deploying on the satellite, in the aspects of functionalities, interfaces, protocols and procedures.

10 Procedures of fixed, mobile and satellite convergence

Based on the framework and the enabling technologies of fixed, mobile and satellite convergence specified in this Recommendation, this clause specifies the procedures of fixed, mobile and satellite convergence in the context of IMT-2020 networks and beyond as follows:

- Each of the basic network procedures specified in [ITU-T Y.3104], i.e., registration management, connection management, session management and handover;
- Capability exposure procedure specified in [ITU-T Y.3108];
- Network slicing procedure specified in [ITU-T Y.3153].

10.1 Registration management procedure

The registration management procedure of the FMSC conforms to the registration management procedure of the IMT-2020 network specified in [ITU-T Y.3104], except that:

- The network functions NACF, NFR, NSSF, USM, ASF, and PCF may be integrated into one physical network entity (namely network entity A), while SMF and UPF may be integrated into another physical network entity (namely network entity B) when they are deployed on the satellite. The satellite may be the same or different. In this case, the procedures inside of network entity A and inside of network entity B can be customized to a lightweight version to improve the efficiency.
- The access network may be a fixed access network, mobile access network, or satellite access network, where the UE is a multi-access UE.

10.2 Connection management procedure

The connection management procedure of the FMSC conforms to the connection management procedure of the IMT-2020 network specified in [ITU-T Y.3104], except that:

- The network functions NACF, NFR and ASF may be integrated into one physical network entity (namely network entity A), while SMF and UPF may be integrated into another physical network entity (namely network entity B) when they are deployed on the satellite. In this case, the procedures inside of network entity A and inside of network entity B can be customized to a lightweight version to improve the efficiency.
- The access network may be a fixed access network, mobile access network, or satellite access network, where the UE is a multi-access UE.

10.3 Session management procedure

The session management procedure of the FMSC conforms to the session management procedure of the IMT-2020 network specified in [ITU-T Y.3104], except that:

- The network functions NACF, USM and PCF may be integrated into one physical network entity (namely network entity A), while SMF and UPF may be integrated into another physical network entity (namely network entity B) when they are deployed on the satellite. In this case, the procedures inside of network entity A and inside of network entity B can be customized to a lightweight version to improve the efficiency.
- The access network may be a fixed access network, mobile access network, or satellite access network, where the UE is a multi-access UE.

10.4 Handover procedure

The handover procedure of the FMSC conforms to the handover procedure of the IMT-2020 network specified in [ITU-T Y.3104], except that:

- The network functions SMF and UPF may be integrated into one physical network entity (namely network entity B) when they are deployed on the satellite. In this case, the procedures inside of network entity B can be customized to a lightweight version to improve the efficiency.
- The access network may be a fixed access network, mobile access network, or satellite access network, where the UE is a multi-access UE.

10.5 Capability exposure procedure

The capability exposure procedure of the FMSC conforms to the capability exposure procedure of the IMT-2020 network specified in [ITU-T Y.3108], except that:

- The network functions NACF, USM, PCF, CEF and AF may be integrated into one physical network entity (namely network entity A) when they are deployed on the satellite. In this case, the procedures inside network entity A can be customized to a lightweight version to improve the efficiency.
- The third-party application may subscribe to two CEFs, in the scenario of capabilities distributed in land-based and satellite-based core networks.

10.6 Network slicing procedure

The network slicing procedure of the FMSC conforms to the network slicing procedure of the IMT-2020 network specified in [ITU-T Y.3153], except that:

- The network functions NSSF, CEF and AF may be integrated into one physical network entity (namely network entity A) when they are deployed on the satellite. In this case, the

procedures inside network entity A can be customized to a lightweight version to improve the efficiency.

- The third-party application may subscribe to two CEFs, in the scenario of capabilities distributed in land-based and satellite-based core networks.

11 Security considerations

The security and privacy considerations on a framework, enabling technologies, network function enhancements, and procedures of fixed, mobile and satellite convergence in IMT-2020 networks and beyond include the following aspects:

- Security aspects related to the framework of FMSC, including the overall framework, the framework of a land-based converged network, and the framework of a satellite-based converged network.
- Security aspects related to the enabling technologies of FMSC, including mobility management, session management, connection management, service continuity, traffic scheduling, capability exposure, network slicing, multi-access edge computing, network self-organizing, AI/ML, DLT and QIT.
- Security aspects related to the network function enhancements of FMSC, including the enhancements on NACF, SMF, PCF, CEF, NFR, USM, NSSF, ASF, AF, UPF for fixed access, UPF for mobile access, and UPF for satellite access.
- Security aspects related to the procedures of FMSC, including registration management, connection management, session management, handover, capability exposure, and network slicing.
- Privacy aspects related to the FMSC network. The privacy protection mechanisms need to be supported in the enhanced core network functions and service platforms of the FMSC network, which can store, cache and process user data related to privacy.

In addition, the security and privacy considerations of the FMSC should be aligned with the requirements specified in [ITU-T Y.3101] and [b-ITU-T Y.2701].

Bibliography

[b-ITU-T Q.1706] Recommendation ITU-T Q.1706/Y.2801 (2006), *Mobility management requirements for NGN.*

[b-ITU-T Y.2011] Recommendation ITU-T Y.2011 (2004), *General principles and general reference model for Next Generation Networks.*

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

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

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

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

SERIES OF ITU-T RECOMMENDATIONS

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

Printed in Switzerland
Geneva, 2023