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

Future networks

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

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Recommendation ITU-T Y.3204

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

Summary

The service continuity is the ability for a moving object to maintain ongoing service including maintaining current states, such as user's network environment and session for a service. Fixed, mobile and satellite convergence (FMSC) is the capability that provides services and applications to end users regardless of the fixed, mobile or satellite access technologies. Recommendation ITU-T Y.3204 specifies the scenarios, requirements, enablers, network function enhancements, procedures and security considerations of service continuity for FMSC, in the context of IMT-2020 networks and beyond.

History *

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FMSC, IMT-2020, satellite network, service continuity.

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

1 Scope

This Recommendation specifies the service continuity for fixed, mobile and satellite convergence (FMSC) in IMT-2020 networks and beyond. The service continuity is the ability for a moving object to maintain ongoing service including maintaining current states, such as user's network environment and session for a service. FMSC is the capability that provides services and applications to end users regardless of the fixed, mobile or satellite access technologies.

This Recommendation addresses the following aspects of service continuity for FMSC in IMT-2020 networks and beyond:

- Scenarios of service continuity;
- Requirements of service continuity;
- Enablers for service continuity;
- Network function enhancements of service continuity;
- Procedures of service continuity;
- 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.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.3200] Recommendation ITU-T Y.3200 (2022), *Fixed, mobile and satellite convergence – Requirements for IMT-2020 networks and beyond.*

[ITU-T Y.3201] Recommendation ITU-T Y.3201 (2023), *Fixed, mobile and satellite convergence – Framework for IMT-2020 networks and beyond.*

[ITU-T Y.3202] Recommendation ITU-T Y.3202 (2023), *Fixed, mobile and satellite convergence – Mobility management for IMT-2020 networks and beyond.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 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.

3.1.2 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].

3.1.3 multi-connection [b-ITU-T Y.2251]: The functionality which provides capability to the user equipment (UE) and network to maintain more than one access network connection simultaneously.

3.1.4 multi-connection user equipment (MUE) [b-ITU-T Y.2027]: A user equipment which can support two or more network connections simultaneously under the control of a network enhanced for multi-connection capability.

3.1.5 voice and video call continuity (VCC) [b-ITU-T Y.2255]: When the MUE moves between different access types, the ongoing voice and video call is not impacted and continues to serve the user. The user is not aware of the access transfer.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 service continuity: The ability for a moving object to maintain ongoing service, including maintaining current states such as the user network environment and session.

NOTE – Based on [b-ITU-T Q.1706].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

5QI	5G Quality of service Identifier
AF	Application Function
FMSC	Fixed, Mobile and Satellite Convergence
GBR	Guaranteed Bit Rate
GEO	Geostationary Earth Orbit
IMS	Internet protocol Multimedia Subsystem
MUE	Multi-connection User Equipment
NACF	Network Access Control Function
NF	Network Function
NFR	Network Function Registry function
NGSO	Non-Geostationary Satellite Orbit
PCF	Policy Control Function
QoS	Quality of Service
SMF	Session Management Function
TA	Tracking Area
TAS	Telecommunications Application Server
UE	User Equipment
UPF	User Plane Function
VCC	Voice and video Call Continuity
XR	extended Reality

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 Scenarios of service continuity

6.1 Overview

Service continuity is the ability for a moving object to maintain ongoing service including maintaining current states, such as the user's network environment and session for a service [b-ITU-T Q.1706]. Taking into account the key elements for integration of satellite systems including persistent quality of service (QoS) as specified in [b-ITU-R M.2460-0], this Recommendation specifies the service continuity for FMSC in IMT-2020 networks and beyond. Figure 6-1 presents the overview of service continuity scenarios in the FMSC network, including the following scenarios:

- Scenario 1: Handover between fixed access and mobile access;
- Scenario 2: Handover between fixed access and satellite access;
- Scenario 3: Handover between mobile access and satellite access;
- Scenario 4: Handover between satellite accesses;
- Scenario 5: Inter multi-connection user equipment (MUE) transfer.

This Recommendation mainly addresses the service continuity for scenario 2, scenario 3 and scenario 4, which have been newly introduced in the FMSC network. In the FMSC network, both the service continuity for scenario 1 and scenario 5 also put forward new service requirements and network requirements, which are also specified in this Recommendation.

In the FMSC network, the services requiring service continuity include voice and video services, data services and vertical industry services.

NOTE – The vertical industry services are related to application domains including, but not limited to, smart city, industry, education, transport, health care, agriculture, finance and media [b-ITU-T Y.3114].

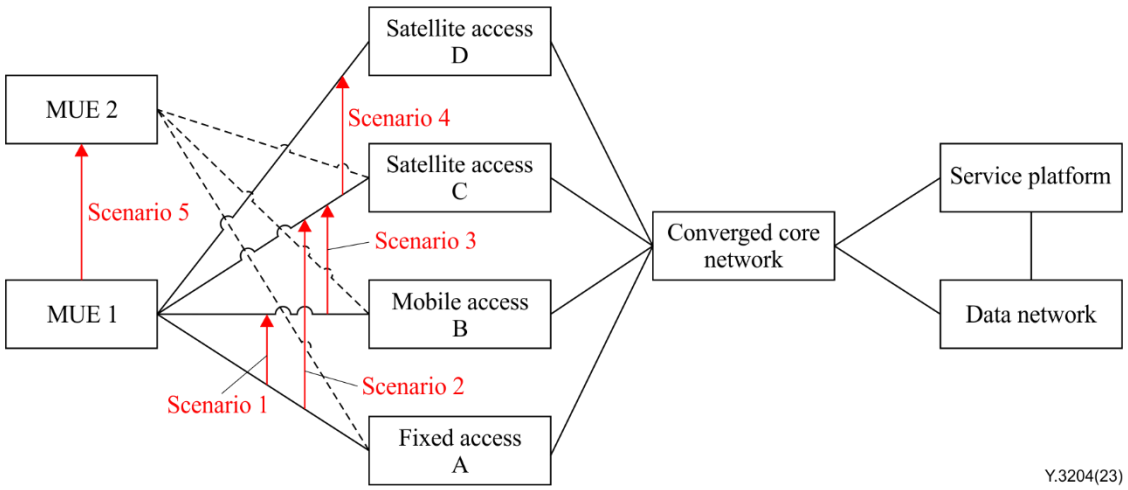

Figure 6-1 – Overview of service continuity scenarios in the FMSC network

6.2 Handover between fixed access and mobile access

In this scenario, the MUE establishes a communications session over fixed access/mobile access. While the communications session is going on, the MUE moves to an environment with weak and/or low-speed fixed coverage/mobile coverage, but with strong and/or high-speed mobile coverage/fixed coverage. With the support of service continuity related mechanisms, the communications session can hand over from fixed access to mobile access/from mobile access to fixed access seamlessly, and the service continuity can be guaranteed.

NOTE – Fixed coverage refers to the area where UE can connect to the fixed access network.

6.3 Handover between fixed access and satellite access

In this scenario, the MUE establishes a communications session over fixed access/satellite access. While the communications session is going on, the MUE moves to an environment with weak and/or low-speed fixed coverage/satellite coverage, but with strong and/or high-speed satellite coverage/fixed coverage. With the support of service continuity related mechanisms, the communications session can handover from fixed access to satellite access/from satellite access to fixed access seamlessly, and the service continuity can be guaranteed.

6.4 Handover between mobile access and satellite access

In this scenario, the MUE establishes a communications session over mobile access/satellite access. While the communications session is going on, the MUE moves to an environment with weak and/or low-speed mobile coverage/satellite coverage, but with strong and/or high-speed satellite coverage/mobile coverage. With the support of service continuity related mechanisms, the communications session can handover from mobile access to satellite access/from satellite access to mobile access seamlessly, and the service continuity can be guaranteed.

6.5 Handover between satellite accesses

In this scenario, the MUE establishes a communications session over satellite access. While the communications session is going on, the MUE moves to an environment with weak and/or low-speed satellite-1 coverage, but with strong satellite-2 coverage. With the support of service continuity related mechanisms, the communications session can handover from satellite-1 access to satellite-2 access seamlessly, and the service continuity can be guaranteed.

6.6 Inter MUE transfer

Inter MUE transfer is the transfer of communications session between different devices of the same user (subscriber). In this scenario, the user (subscriber) has subscribed to a multi-device service.

MUE establishes a communications session over a specific access (fixed access, mobile access or satellite access). With the support of service continuity related mechanisms, while the communications session is going on, the user (subscriber) can transfer the communications session to other device(s) of the user (subscriber) seamlessly, and the service continuity can be guaranteed.

7 Requirements of service continuity

This clause specifies the requirements of service continuity for FMSC in IMT-2020 networks and beyond, including service requirements and network requirements.

7.1 Service requirements of service continuity

7.1.1 Service requirements of VCC

In the FMSC network, considering the access transfer between fixed access, mobile access and satellite access, voice and video services require mechanisms to support service continuity.

The service requirements of VCC in the FMSC network are as follows:

- The ongoing session of voice and video service is required to be maintained when there is the handover specified in this Recommendation.
- The latency of service handover related to access transfer is required to meet the requirements of voice and video service.
- It is required to support the handover policy specified by the network.
- It is required to support the voice and video service policy.
- It is required to support non-guaranteed bit rate (non-GBR) QoS for voice and video service.

  NOTE 1 – The non-GBR QoS corresponds to the 5G QoS Identifier (5QI) of resource type non-GBR, which includes the 5QI values 5, 6, 7, 8, 9, 10, 69, 70, 79 and 80, as specified in [b-3GPP TS 23.501].
- It is recommended to support GBR QoS for voice and video service.

  NOTE 2 – The GBR QoS corresponds to the 5QI of resource type GBR, which includes the 5QI values 1, 2, 3, 4, 65, 66, 67, 71, 72, 73, 74, 75 and 76, as specified in [b-3GPP TS 23.501].

7.1.2 Service requirements of data service continuity

In the FMSC network, considering the access transfer between fixed access, mobile access and satellite access, real-time data services, which include, but are not limited to, extended reality (XR), cloud gaming and interactive live programme, require mechanisms to support service continuity.

The service requirements of real-time data service continuity in the FMSC network are as follows:

- The ongoing session of real-time data service is required to be maintained when there is the handover specified in this Recommendation.
- The latency of service handover related to access transfer is required to meet the requirements of real-time data service.
- The data rate during handover is required to meet the requirements of real-time data service in the use cases which require high data rate.
- It is required to support the handover policy specified by the network.
- It is required to support the real-time data service policy.
- It is required to support non-GBR QoS for real-time data service.
- It is recommended to support GBR QoS for real-time data service.

7.1.3 Service requirements of vertical industry service continuity

In the FMSC network, considering the access transfer between fixed access, mobile access and satellite access, vertical industry services, which include, but are not limited to, vehicular networking, smart manufacturing and remote surgery operation, require mechanisms to support service continuity.

The service requirements of vertical industry service continuity in the FMSC network are as follows:

- The ongoing session of vertical industry service is required to be maintained when there is the handover specified in this Recommendation.
- The latency of service handover related to access transfer is required to meet the requirements of vertical industry service.
- The data rate during handover is required to meet the requirements of vertical industry service in the use cases which require high data rate.
- It is required to support the handover policy specified by the network.
- It is required to support the vertical industry service policy.
- It is required to support non-GBR QoS for vertical industry service.
- It is recommended to support GBR QoS for vertical industry service.

7.2 Network requirements of service continuity

7.2.1 Network requirements of VCC

The network requirements of VCC in the FMSC network are as follows:

- The converged core network and converged voice network are required to support the handover management and session management functions.
- The converged voice network is required to support the capabilities and procedures of service continuity.
- The converged voice network is required to manage the user preference on voice and video service.
- The converged core network is required to map the user preference into service policy for voice and video service.
- The converged core network is required to support MUE with high mobility (which may introduce frequent handover).
- The converged core network is recommended to utilize the satellite ephemeris for voice and video service in handover related to satellite access.

7.2.2 Network requirements of data service continuity

The network requirements of data service continuity in the FMSC network are as follows:

- The converged core network and application domain are required to support the handover management and session management functions.
- The application domain is required to support the capabilities and procedures of service continuity.
- The application domain is required to manage the user preference on real-time data service.
- The converged core network is required to map the user preference into service policy for real-time data service.
- The converged core network is required to support MUE with high mobility (which may introduce frequent handover).

- The converged core network is recommended to utilize the satellite ephemeris for real-time data service in handover related to satellite access.
- The converged core network is required to consider the network requirements for MUE with different traffic demands.
- The converged core network is required to consider QoS related mechanisms for different traffic characteristics.
- The converged core network is required to support traffic switching, splitting and steering between fixed, mobile and satellite accesses, when the MUE moves between different tracking areas (TAs), different public land mobile networks (PLMNs) and different access technologies.

7.2.3 Network requirements of vertical industry service continuity

The network requirements of vertical industry service continuity in the FMSC network are as follows:

- The dedicated core network and application domain are required to support the handover management and session management functions.
- The application domain is required to support the capabilities and procedures of service continuity.
- The application domain is required to manage the user preference on vertical industry service.
- The dedicated core network is required to map the user preference into service policy for vertical industry service.
- The dedicated core network is required to support MUE with high mobility (which may introduce frequent handover).
- The dedicated core network is recommended to utilize the satellite ephemeris for vertical industry service in handover related to satellite access.

NOTE – The dedicated core network is designed for vertical industries with common requirements, adopting the architecture and network functions of IMT-2020 network specified in [ITU-T Y.3102], [ITU-T Y.3104] and [b-ITU-T Y.3114].

7.2.4 Requirements of handover policy

The requirements of handover policy in the FMSC network are as follows:

- It is required to support the handover policy producing mechanism for scenarios of service continuity specified in this Recommendation.
- It is required to support the handover policy implementation mechanism for scenarios of service continuity specified in this Recommendation.
- It is required to support the handover policy conflict control mechanism for scenarios of service continuity specified in this Recommendation.

8 Enablers for service continuity

8.1 Overview

The enablers for service continuity for fixed, mobile and satellite convergence (FMSC) are as follows:

- Support of access transfer: Connection capability evaluation, network paging, utilization of satellite ephemeris and utilization of service information are introduced as enablers for service continuity.

- Support of VCC: Voice and video communications capability classification, user preference on voice and video service, voice and video service policy mapping, and service continuity operation during access transfer are introduced as enablers for service continuity.
- Support of data service continuity: Data service capability classification, user preference on data service, data service policy mapping and service continuity operation during access transfer are introduced as enablers for service continuity.
- Support of vertical industry service continuity: Vertical industry service capability classification, user preference on vertical industry service, vertical industry service policy mapping, and service continuity operation during access transfer are introduced as enablers for service continuity.
- Support of handover policy: Handover can be triggered by the network, MUE and user. Handover policy producing, handover policy implementation and handover policy conflict control are introduced as enablers for service continuity.

8.2 Support of access transfer

The converged core network is responsible for the support of access transfer. The methods in support of access transfer in the FMSC network are as follows:

- Connection capability evaluation

The connection capability includes, but is not limited to, signal intensity, bandwidth, latency, availability and reliability. The converged core network evaluates the connection capability of each available access network to determine the potential scenario of access transfer. The access network with the best connection capability may be configured as the target access network during access transfer. The converged core network may use the method of network paging to determine the connection capability of each access network.

- Utilization of satellite ephemeris

The satellite ephemeris contains the information about the availability of satellite access. The converged core network utilizes the satellite ephemeris to facilitate the determination of the time and target access network for access transfer.

- Utilization of service information

The service information contains the information about the service requirements. The converged core network utilizes the service information to facilitate the determination of the time and target access network for access transfer.

8.3 Support of VCC

In the FMSC network, considering the difference in coverage and connection data rate of fixed access, mobile access and satellite access in different geographical areas, in some use cases, especially the use cases related to satellite access and 2G mobile access, the original media type (voice or video) and data rate of voice and video communications could not be maintained during access transfer. Therefore, it is required to introduce voice and video service policy for access transfer, which is aiming to choose the best-suited voice and video communications capability class for specific user based on user preference, and implement service continuity operation during access transfer. The methods of voice and video service policy in support of VCC are as follows:

- Voice and video communications capability classification

In a converged voice network, voice and video communications capability classification is performed based on media type and data rate class. Voice and video capability component is recommended to be introduced in the converged voice network to perform voice and video communications capability classification.

NOTE 1 – The example of voice and video communications capability classes is as follows: Voice communications capability classes include Voice Class 1 (voice of low data rate), Voice Class 2 (voice of medium data rate), and Voice Class 3 (voice of high data rate). Video communications capability classes include Video Class 1 (video of low data rate), Video Class 2 (video of medium data rate), and Video Class 3 (video of high data rate).

- User preference on voice and video service

The user configures user preference on voice and video service at the MUE. The user preference includes user-acceptable voice communications capability classes, user-acceptable video communications capability classes, user priority on voice and video communications capability classes and media type maintaining option. The media type maintaining option refers to set maintaining the media type as a high priority during access transfer. The user preference on voice and video service is synchronized from the MUE to the voice and video capability component of the converged voice network.

NOTE 2 – The example of user preference on voice and video service is as follows: For user A and MUE 1, all the voice and video communications capability classes are supported; user-acceptable voice communications capability classes include Voice Class 1, Voice Class 2 and Voice Class 3; user-acceptable video communications capability classes include Video Class 2 and Video Class 3; user priority on voice and video communications capability classes is Video Class 3, Video Class 2, Voice Class 3, Voice Class 2 and Voice Class 1 (from high priority to low priority); the media type maintaining option is closed.

- Voice and video service policy mapping

The user preference on voice and video service is synchronized from voice and video capability component of the converged voice network to service handover component of the converged core network. The access types of MUE and the corresponding access data rate are synchronized from the MUE to service handover component of the converged core network. The service handover component of converged core network maps user preference on voice and video service into a user-specific voice and video service policy for access transfer originated from the user side and network side, on the basis of access types of the MUE and corresponding access data rate.

NOTE 3 – The example of voice and video service policy mapping is as follows: MUE 1 supports fixed access, 2G mobile access, 4G mobile access, 5G mobile access and satellite access. Based on user A's preference for voice and video service, MUE 1's voice and video service policy is as follows: If the target access type is fixed access, the target voice/video communications capability class is Video Class 3. If the target access type is 2G mobile access, the target voice/video communications capability class is Voice Class 1. If the target access type is 4G mobile access, the target voice/video communications capability class is Video Class 2. If the target access type is 5G mobile access, the target voice/video communications capability class is Video Class 3. If the target access type is satellite access, the target voice/video communications capability class is Voice Class 3.

- Service continuity operation during access transfer

When the access transfer is originated from the user side or network side, the converged core network receives the event of MUE access transfer. The service handover component of the converged core network determines the target of access transfer for the event of MUE access transfer, and produces the voice/video service handover instruction for the target of access transfer based on the user-specific voice and video service policy. The voice/video service handover instruction includes target media type and target data rate class. The service handover component of the converged core network synchronizes the voice/video service handover instruction to the converged voice network, the converged voice network synchronizes the voice/video service handover instruction to voice and video service platform, and then the service handover component synchronizes the voice/video service handover instruction to the MUE. The MUE, converged core network, converged voice network, and voice and video service platform use the voice/video service handover instruction to perform service handover, and then perform voice and video communications.

8.4 Support of data service continuity

In the FMSC network, considering the difference in coverage and in the connection data rate of fixed access, mobile access and satellite access in different geographical area, in some use cases, especially those related to satellite access, the original data rate of data service could not be maintained during access transfer. Therefore, it is required to introduce data service policy for access transfer, which is aiming to choose the best-suited access type and data service capability class for specific user based on user preference, and implement service continuity operation during access transfer. The methods of data service policy in support of data service continuity are as follows:

- Data service capability classification

The FMSC network is recommended to support multiple data rates for data service.

NOTE 1 – The examples of data service capability classes include super speed, high speed, middle speed and low speed. The corresponding data service capability classes of various access types are as follows:

– 5G mobile access: Super speed, high speed, middle speed and low speed;

– 4G mobile access and satellite access: middle speed and low speed;

– Fixed access: High speed, middle speed and low speed.

- User preference on data service

The user configures the customized user configuration (including access type priority) on data service on the converged core network (in the data service capability component), and the converged core network stores the customized user configuration. The MUE stores this customized user configuration for determining the acceptable data service capability class and handover domain.

NOTE 2 – The examples of customized user configurations are as follows:

– Customized user configuration according to the handover frequency of access network: 4G mobile access, 5G mobile access, fixed access and satellite access;

– Customized user configuration according to the data rate provided by access network: 5G mobile access, fixed access, 4G mobile access and satellite access.

– Data service policy mapping

The data service capability component in the converged core network is responsible for storing the customized user configuration and sending it to the MUE, when the MUE initially registers in converged core network. The MUE detects its current access type (fixed access, mobile access or satellite access) and synchronizes the connection data rate to the data service capability component in converged core network. The data service capability component maps the customized user configuration into data service policy, which could be executed by the MUE, access network and converged core network during the handover process.

- Data service continuity operation during access transfer

The MUE detects the signal intensity of the access networks and available access types, and reports the relevant information to the data service capability component of the converged core network. The data service capability component generates the data service policy, according to the available access types reported by the MUE and customized user configuration. The data service capability component synchronizes the data service policy to the service handover component, the service handover component generates the service handover instruction (including the access type transfer instruction) according to the data service policy, and issues the service handover instruction to the network access control function (NACF), session management function (SMF) and MUE. Then the service handover information and data rate adjustment information are synchronized between the MUE, access network and converged core network.

8.5 Support of vertical industry service continuity

In the FMSC network, considering the difference in coverage and in the connection data rate of fixed access, mobile access and satellite access in different geographical area, in some use cases, especially the those related to satellite access, the original data rate of vertical industry service could not be maintained during access transfer. Therefore, it is required to introduce a vertical industry service policy for access transfer, which is aiming to choose the best-suited access type and vertical industry service capability class for a specific user based on user preference, and implement service continuity operation during access transfer.

The methods of vertical industry service continuity take the same approach as the methods of data service policy, in which the dedicated core network in support of vertical industry service takes the role of the converged core network in support of data service.

8.6 Support of handover policy

In the FMSC network, the service handover component of the converged core network is responsible for the producing, implementation and conflict control of handover policy, for scenarios of service continuity specified in this Recommendation.

- Handover policy production

On receiving the user preference on service, the service handover component maps user preference on service into a user-specific service policy for access transfer originated from user side and network side, on the basis of the access types of the MUE and the corresponding access data rate.

- Handover policy implementation

When the access transfer is originated from the user side or network side, the service handover component produces a service handover instruction (optionally including the access type transfer instruction) based on a scenario of access transfer and user-specific service policy. The service handover component synchronizes the service handover instruction to the network and MUE. The network and MUE perform service by using the information contained in the service handover instruction.

- Handover policy conflict control

When the user subscribes multiple services requiring service continuity, the priority of each service is configured on the service handover component. In a case where the service policies of different services have some conflict (for example, service A requires the access type of the MUE to change to satellite access, while service B requires the access type of the MUE to change to 4G mobile access), the service handover component produces a service handover instruction based on the requirement of the service with the highest priority.

9 Network function enhancements of service continuity

This clause specifies the network function enhancements of service continuity for FMSC in IMT-2020 networks and beyond, including the enhancements to access network, core network control plane, core network user plane and IP multimedia subsystem (IMS).

9.1 Enhancements to access network

The mobility of base stations deployed on satellites, such as non-geostationary satellite orbit (NGSO) satellites, will bring challenges to the base station handover procedure. The core network needs to know the current location and current load state of the on-board base station, so as to select the appropriate target base station in the handover procedure.

The enhancements to access network for service continuity are as follows:

- Support of reporting the next period constellation trajectory information of on-board base station to the core network.
- Support of requesting the available target base station list from the core network.
- Support of awareness of nearby available target base stations of the ground or on-board base station.

9.2 Enhancements to core network control plane

9.2.1 Enhancements to the NACF

The basic capabilities of the NACF are specified in [ITU-T Y.3102], [ITU-T Y.3104], [ITU-T Y.3201] and [ITU-T Y.3202], including obtaining information about the access type and backhaul type, selecting a proper network slice, delivering information to the SMF and providing functionalities of mobility management.

The enhancements to the NACF for service continuity are as follows:

- Support of session continuity during access transfer in the following scenarios: between fixed/mobile access and satellite access, between satellite accesses and inter-MUE transfer.
- Support of the awareness of MUE location information: The NACF can process a MUE location report received from geostationary earth orbit (GEO) positioning satellite or access network to choose an appropriate access type to ensure service continuity.
- Support the execution of handover policies from the policy control function (PCF). For example, changing the priority of different access types according to unserviceable information from the application function (AF).
- Support of dynamic redirection policy and redirection mechanism based on transmission delay or unserviceable information from the AF.

  NOTE 1 – The transmission delay between ground base stations and on-board base stations or between on-board base stations will change with time. When moving away from MUE, the transmission delay will increase and may fail to satisfy the service continuity requirements. In addition, during the handover procedure, if the target base station is moving away, the longer delay may cause handover failure.
- Support of sensing or calculating the transmission delay between base stations. Choose a target base station based on the transmission delay and ensure that the transmission delay meets the requirements during the handover procedure, so as to avoid the effect on service continuity caused by the jitter of transmission delay.
- Support of calculating and updating the connection maintenance time between the MUE and base station based on information received, including location information, tracking area (TA), etc. Choose a target base station based on the connection maintenance time, and ensure that the target base station can provide enough service time for the MUE after handover, so as to avoid the effect on QoS caused by frequent handover.

  NOTE 2 – The connection maintenance time refers to the time window in which the user can maintain the connection and transmit data with the target base station after the handover is completed.
- Support of receiving base station status information from base stations, including constellation trajectory, load information, etc.

  NOTE 3 – The mobility of an on-board base station causes the distance between this base station and nearby base stations to change, and also causes nearby base stations to be replaced by other base stations, affecting the delay between them. In order to ensure service continuity when base station handover occurs, NACF enhancements are needed for handover between base stations.

- Support of storing base station status information, calculating the handover priority of the base stations, storing and sending the handover priority of nearby base stations to each base station.
- Support of updating base station status information and handover priority according to base station status information from base stations, and sending the updated handover priority of nearby base stations to each base station.

9.2.2 Enhancements to the SMF

The basic capabilities of the SMF are specified in [ITU-T Y.3102], [ITU-T Y.3104] and [ITU-T Y.3201]. The movement of on-board user plane function (UPF) will lead to the change of the established session, and the large data transmission delay caused by the long data transmission path of the user plane will lead to the inability of meeting the requirements of services, and even the interruption of communication. The SMF should sense the current location of UPF, in order to select the appropriate target UPF for MUE in the handover procedure to maintain session continuity. Considering the support for different capability classes of voice, video, data and vertical industry service, the SMF should select appropriate UPF during handover procedure.

The enhancements to the SMF for service continuity are as follows:

- Support of receiving and processing the information from the on-board UPF to maintain an available list of UPF, in which the information may include the current position and the trajectory of the satellite.

  NOTE – The current location of UPF is used to calculate the transmission delay, and this delay has an effect on the capability classes the current UPF satisfies. In addition, according to the current framework, the SMF is the only network function (NF) which can communicate with UPF; other NFs do not have a related reference point or interface. If other NFs need to obtain the UPF location information, they can subscribe to the information from the SMF.
- Support of storing and updating the capability classes of voice, video, data service and vertical industry service supported by UPF.
- Support of sensing whether the current UPF satisfies the capability classes that ensure service continuity for the MUE.
- Support of storing and updating the load status of UPF.
- Support of selecting a UPF during handover procedure to ensure service continuity, based on the capability classes supported by the UPF and the load status of the UPF.

9.2.3 Enhancements to the PCF

The basic capabilities of the PCF are specified in [ITU-T Y.3102], [ITU-T Y.3104] and [ITU-T Y.3201]. The communication link between the MUE and satellite is vulnerable to meteorological changes. The rain attenuation of some spectra is significant, which will cause communication interruption in case of a rainstorm. The communication equipment in outer space can easily be affected by the change of electromagnetic state, resulting in equipment failure or temporary interruption.

The enhancements to the PCF for service continuity are as follows:

- Support of direct or indirect interaction with the AF delivering unserviceable information.
- Support of dynamically generating policies based on MUE location information, constellation trajectory, unserviceable information and other information to ensure service continuity.

  NOTE – For example, the NACF triggers MUE transferring from satellite access to fixed/mobile access in advance, or transferring between different satellite accesses in advance.
- Support of updating policies to the NACF to ensure service continuity.

9.2.4 Enhancements to the NFR

The basic capabilities of network function registry function (NFR) are specified in [ITU-T Y.3102], [ITU-T Y.3104], [ITU-T Y.3201] and [ITU-T Y.3202]. Considering when all or part of core network functions are deployed on the satellite, the change of satellite location leads to the change of transmission delay between network functions, the NFR could sense the transmission delay between network functions. Considering the mobility of NF may cause the NF to move away from the NFR physically, resulting in a long transmission delay between the NF and NFR, so that in the subsequent service discovery process, the NFR may direct service requests to the NF that is leaving or have left the service zone of the NFR, thus impacting service continuity.

The enhancements to the NFR for service continuity are as follows:

- Support of interaction with other NFs through link and status maintenance messages to obtain the current status of NFs and calculating the delay between the NFR and NFs.

  NOTE 1 – The mobility of NF causes communication delay to change between NFs, affecting the interaction between them. The NFR has the function of service discovery, and the network elements need to register with the NFR, so the NFR can be responsible for managing mobility of NFs. The NFR should have the ability to sense the NF state, when processing a service discovery request, the NFR monitors the delay between itself and NF to ensure that NF is still in the service zone of the NFR, so as to avoid the NFR's directing service requests to an inappropriate service producer NF. Therefore, NFR enhancements are needed.

  NOTE 2 – Link and status maintenance messages are messages used to maintain the current communication link and sense each other's status.

  NOTE 3 – NF heart-beat messages have been described in [b-3GPP TS 29.510], where the NFR senses the state of NFs and the link status which the NF is connected with; however, mobility of NFs is not considered. In the FMSC network, it is necessary to calculate the delay between the NFR and NFs to ensure that the NF is still in the NFR's service zone, avoiding the NFR's directing service requests to an inappropriate service producer NF, such as an NF which is far from the service zone, resulting in an impact on service continuity.
- Support of dynamic update of association relationship between the change of satellite coverage and TA.
- Support of sensing the transmission delay between network functions.
- Support of sensing whether NF is moving away from or out of the service zone of the NFR, and making preparations for the subsequent process.

NOTE 4 – The examples include preparing to trigger the deregister process of the NF, and reporting error information to the gateway. The service zone can be customized by the operator.

NOTE 5 – It is necessary to enhance the NFR's capability to manage the mobility of the NF. Just as the NACF manages the mobility of UEs in the current terrestrial network, the NFR should also have a service zone and have the ability to sense whether NFs enter or leave the service zone. Based on the sensed results, the NFR may prepare to trigger the corresponding service deregister process of the NF.

9.2.5 Enhancements to the AF

The basic capabilities of the AF are specified in [ITU-T Y.3102], [ITU-T Y.3104] and [ITU-T Y.3201]. The enhancements to the AF for service continuity are as follows:

- Support of providing MUE with geolocation information, so that the core network can formulate relevant policies or complete relevant configurations or processes in advance.
- Support of generating unserviceable information, so that the core network can formulate relevant policies or complete relevant configurations or processes in advance.

NOTE – Unserviceable information includes, but is not limited to, a TA list, access node list, unserviceable timers and could be generated from real-time weather information by a weather monitoring centre or electromagnetic conditions in outer space by an outer space environment monitoring centre.

9.2.6 Enhancements to the service handover component

The service handover component of the converged core network is proposed for service continuity for VCC, data service and vertical industry service. The enhancements to the service handover component for service continuity are as follows:

- The service handover component is enhanced to support handover policy production. On receiving the user preference on service, the service handover component maps user preference on service into a user-specific service policy for access transfer originating from user side and network side, on the basis of access types of the MUE and corresponding access data rate.
- The service handover component is enhanced to support handover policy implementation. When the access transfer originates from the user side or network side, the service handover component produces a service handover instruction (optionally including the access type transfer instruction) based on the scenario of access transfer and the user-specific service policy and synchronizes the service handover instruction to the network and MUE.
- The service handover component is enhanced to support handover policy conflict control. When the user subscribes to multiple services requiring service continuity, the service handover component configures the priority of each service. In a case where the service policies of different services have some conflict, the service handover component produces a service handover instruction based on the requirement of the service with the highest priority.

NOTE – The service handover component can be a stand-alone network function or integrated into the NACF.

9.3 Enhancements to the core network user plane

The basic capabilities of UPF are specified in [ITU-T Y.3102], [ITU-T Y.3104], and [ITU-T Y.3201]. When UPF is deployed on the satellite, it is required to avoid service interruption caused by the mobility of UPF, which will impact the connection status and delay between UPF and the access network.

The enhancements to UPF for service continuity are as follows:

- Support of reporting the current position and the trajectory of the satellite within a period of time in the information between the UPF and SMF.

9.4 Enhancements to the IMS

The enhancements to the IMS for service continuity are as follows:

- Considering satellite access is a new access type in addition to traditional fixed access and mobile access, the IMS needs to be enhanced to support satellite access, and support the registration, authentication, authorization, connection management and session management for MUE using the satellite access.
- Considering the differences in communications capabilities and resources between fixed access, mobile access and satellite access, the IMS needs to support the classification of service capabilities for each access type, and identify the QoS for each service capability. This enhancement can be provided at the voice and video capability component.
- The MUE and service platforms have different mechanisms of coding and decoding, and different data rate for voice and video services. The IMS needs to support the processing and management of user preference on voice and video service, in order to guarantee service continuity and QoS for voice and video services. This enhancement can be provided at the voice and video capability component.

- The IMS needs to support the synchronization of user preference on voice and video service; and support the use of target media type and target data rate class contained in the voice/video service handover instruction to perform service handover, and then perform voice and video communications. This enhancement can be provided at the voice and video capability component.
- Considering the mobility of the NGSO, when UPF is on-board, the IMS needs to support receiving and maintaining the on-board UPF cycle list, in order to achieve VCC during the process of MUE handover related to satellite access.

NOTE – The voice and video capability component can be a stand-alone application server or integrated into the telecommunications application server (TAS).

10 Procedures of service continuity

This clause specifies the procedures of service continuity for FMSC in IMT-2020 networks and beyond, including the procedures of access transfer, VCC, data service continuity and vertical industry service continuity.

10.1 Procedure of access transfer

The procedure of access transfer in the FMSC network is as follows:

1) The converged core network evaluates the connection capability (including the signal intensity, bandwidth, latency, availability and reliability) of each available access network. The method of network paging may be used in connection capability evaluation.
2) The converged core network configures the access network with the best connection capability as the target access network for a specific scenario of access transfer. The configuration of access transfer can be synchronized to the MUE.
3) At a specific time, a specific scenario of access transfer is triggered; the converged core network or MUE initiates the access transfer to the target access network based on the configuration of access transfer.

10.2 Procedure of VCC

Figure 10-1 depicts the procedure of VCC with voice and video service policy in the FMSC network.

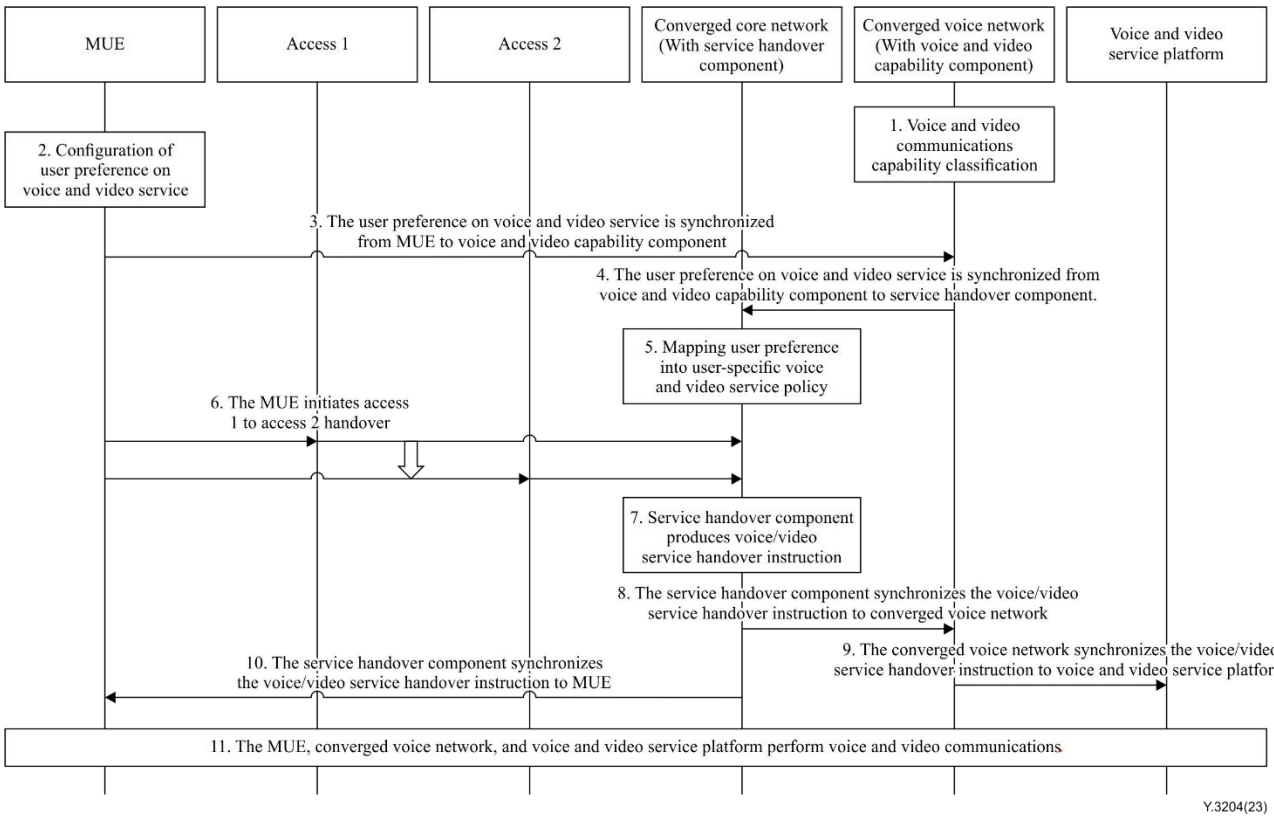

Figure 10-1 – Procedure of VCC with voice and video service policy in the FMSC network

1) The voice and video capability component of the converged voice network performs a voice and video communications capability classification, based on media type and data rate class.
2) The user configures user preference on voice and video service at the MUE.
3) The user preference on voice and video service is synchronized from the MUE to the voice and video capability component of converged voice network.
4) The user preference on voice and video service is synchronized from the voice and video capability component of the converged voice network to the service handover component of the converged core network.
5) The service handover component of converged core network maps user preference on voice and video service into user-specific voice and video service policy for access transfer.
6) The MUE initiates access 1 to access 2 transfer.
7) The service handover component of converged core network produces voice/video service handover instruction based on a scenario of access transfer and user-specific voice and video service policy.
8) The service handover component of the converged core network synchronizes the voice/video service handover instruction to the converged voice network.
9) The converged voice network synchronizes the voice/video service handover instruction to the voice and video service platform.
10) The service handover component of the converged core network synchronizes the voice/video service handover instruction to the MUE.
11) The MUE, converged core network, converged voice network, and voice and video service platform use the target media type and target data rate class contained in the voice/video

service handover instruction to perform service handover, and then perform voice and video communications.

10.3 Procedure of data service continuity

Figure 10-2 depicts the procedure of data service continuity with data service policy in the FMSC network.

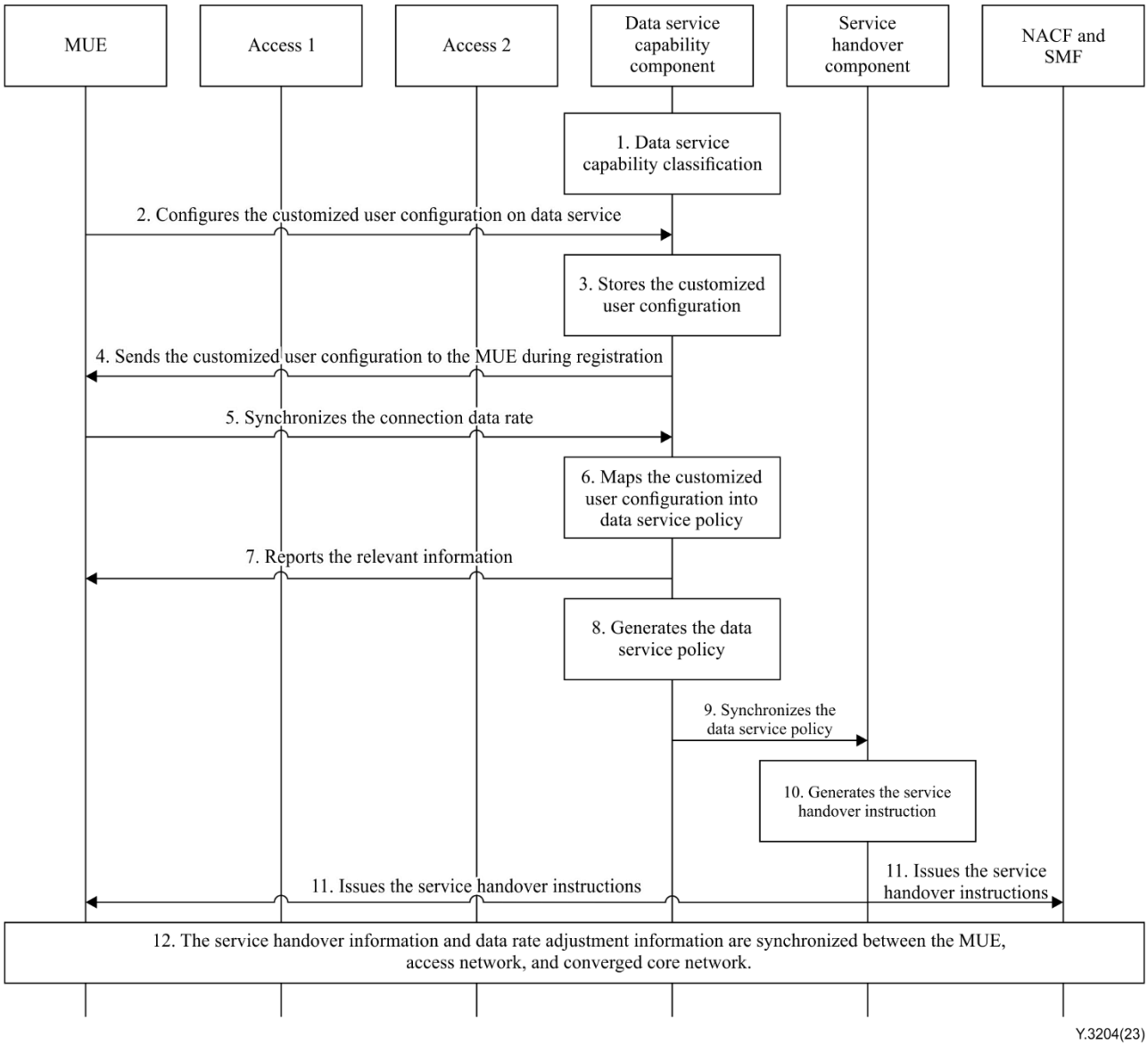

Figure 10-2 – Procedure of data service continuity with data service policy in the FMSC network

1) The data service capability component of the converged core network performs the data service capability classification (determining the data service capability classes for various access types).
2) The user configures the customized user configuration (including access type priority) on data service in the converged core network.
3) The data service capability component in the converged core network stores the customized user configuration.

4) The data service capability component sends the customized user configuration to the MUE, when the MUE initially registers in the converged core network.

5) The MUE detects its current access type (fixed access, mobile access or satellite access) and synchronizes the connection data rate to the data service capability component in the converged core network.

6) The data service capability component maps the customized user configuration into the data service policy, which could be executed by the MUE, access network and converged core network during the handover process.

7) The MUE detects the signal intensity of the access networks and available access types, and reports the relevant information to the data service capability component of the converged core network.

8) The data service capability component generates the data service policy, according to the available access types reported by the MUE and customized user configuration.

9) The data service capability component synchronizes the data service policy to the service handover component.

10) The service handover component generates the service handover instruction according to the data service policy.

11) The service handover component issues the service handover instructions to the NACF, SMF and MUE.

12) The service handover information and data rate adjustment information are synchronized between the MUE, access network and converged core network.

10.4 Procedure of vertical industry service continuity

In the FMSC network, the procedure of vertical industry service continuity takes the same approach as the procedure of data service continuity in which the dedicated core network in support of vertical industry service takes the role of the converged core network in support of data service.

11 Security considerations

The security and privacy considerations on service continuity for FMSC in IMT-2020 networks and beyond include the following aspects:

1) Network security

- Network information security

The network information related to service continuity should be prevented from leakage, unauthorized access and misuse by the application of mature technologies of access control, authentication and authorization, transmission security and data encryption.

- Network entity security

The network entities related to service continuity should provide effective security and confidentiality measures to ensure the safety of network functions and the entire system and to prevent the illegal intrusion of network resources.

- Network operation security

The network operations related to service continuity should not influence the functionalities of access network, core network and IMS. In addition, the network operations related to service continuity should not have negative effects on the performance of the entire system, including the network entities and signalling exchange between network entities.

2) Service security

The services related to service continuity include VCC, data service and vertical industry service. In terms of service provision, the relevant security mechanisms should be provided to guarantee the security of the service platform, service function and service information.

3) User privacy

The privacy protection mechanisms need to be supported in the access network, core network and IMS, which could store, cache and process user data related to privacy. To protect user privacy, it is required to generate different levels of real-time notification and alarm for those actions requesting user data related to privacy.

In addition, the security and privacy considerations on service continuity for FMSC should be aligned with the requirements specified in [ITU-T Y.3200], [b-ITU-T Y.3101] and [b-ITU-T Y.2701].

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