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International Telecommunication Union
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Recommendation

ITU-T Y.3202 (05/2023)

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

Future networks

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

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Recommendation ITU-T Y.3202

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

Summary

Recommendation ITU-T Y.3202 specifies the mobility management requirements, architecture, procedures and security considerations for fixed, mobile and satellite convergence (FMSC) in 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.3202	2023-05-14	13	11.1002/1000/15535

Keywords

FMSC, IMT-2020, mobility management, satellite network.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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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.

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

1 Scope

This Recommendation specifies the mobility management architecture for fixed, mobile and satellite convergence (FMSC) in IMT-2020 networks and beyond. This Recommendation covers the following aspects:

- requirements of mobility management to support FMSC;
- the architecture of mobility management for FMSC;
- service procedures of mobility management for FMSC.

2 References

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

[ITU-T Q.1762] Recommendation ITU-T Q.1762/Y.2802 (2007), *Fixed-mobile convergence general requirements*.

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

[ITU-T Y.3130] Recommendation ITU-T Y.3130 (2018), *Requirements of IMT-2020 fixed mobile convergence*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 cell [b-ITU-T Q.1741.7]: Radio network object that can be uniquely identified by a user equipment from a (cell) identification that is broadcasted over a geographical area from one UTRAN or GERAN access point. A Cell in UTRAN is either FDD or TDD mode.

3.1.2 fixed, mobile and satellite convergence [b-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.

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

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 tracking area: The area where user equipment can be tracked in the IMT-2020 network. The tracking area for the non-geostationary satellite orbit satellite access is the Earth fixed and preconfigured by the operator based on the geographic area.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACK	Acknowledgement
AF	Application Function
AN	Access Network
ASF	Authentication Server Function
CN	Core Network
FDD	Frequency Division Duplex
FMSC	Fixed, Mobile and Satellite Convergence
GEO	Geostationary Earth Orbit
GERAN	Global system for mobile communications/Enhanced data rates for global system for mobile communications evolution Radio Access Network
GSO	Geostationary Satellite Orbit
ID	Identifier
IMT-2020	International Mobile Telecommunications-2020
LEO	Low Earth Orbit
NACF	Network Access Control Function
NGSO	Non-Geostationary Satellite Orbit
NSSF	Network Slice Selection Function
PCF	Policy Control Function
PDU	Packet Data Unit
PLMN	Public Land Mobile Network
RAN	Radio Access Network
RAT	Radio Access Type
RRC	Radio Resource Control
RRM	Radio Resource Management
RSRP	Reference Signal Received Power
SMF	Session Management Function
S-NACF	Satellite-Network Access Control Function
SRI	Satellite Radio Interface
TA	Tracking Area
TDD	Time Division Duplex
T-NACF	Terrestrial-Network Access Control Function
UE	User Equipment

UPF User Plane Function

USM Unified Subscription Management

UTRAN Universal Terrestrial Radio Access Network

5 Conventions

In this Recommendation:

The phrase "is required" indicates a requirement that must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

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

The phrase "can optionally" indicates an optional requirement that is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the network operator or service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Overview

The IMT-2020 network aims to provide a wide range of telecommunication services, but in some places, such as the desert or sea, it is quite difficult to provide coverage via terrestrial networks. In addition, the terrestrial networks are too vulnerable to extreme environmental conditions, e.g., natural disasters. In contrast, satellite access networks (ANs) can have broad coverage and provide stable and reliable communication.

There are two types of satellite: geostationary satellite orbit (GSO); and non-geostationary satellite orbit (NGSO). The rotation rate of a GSO satellite is the same as that of the Earth, meaning a GSO satellite stands still with respect to the Earth. To ground observers, the rotational period of an object in GSO orbit is equal to that of the Earth and thus appears motionless at a fixed position in the sky. On the other hand, an NGSO satellite does not stand still with respect to the Earth. Therefore, it is necessary to have a constellation of several NGSO satellites associated with handover mechanisms to ensure service continuity.

Figure 6-1 shows the reference architecture for direct access with a satellite-enabled AN. The IMT-2020 network can use the reference architecture in Figure 6-1 to enable FMSC.

The satellite-enabled user equipment (UE) can be Internet of things devices, fixed or mobile terminals in this architecture. The satellite equips an entire AN. The transport layer connections between an AN and the core network (CN) are over a satellite radio interface (SRI) between the on-ground CN and the onboard AN.

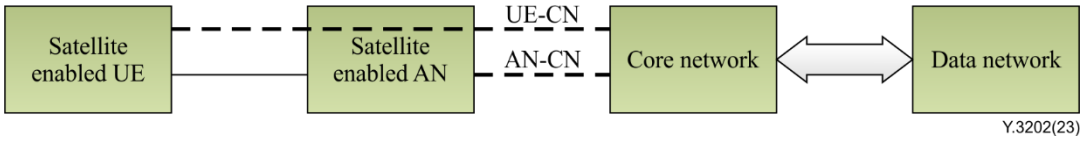

Figure 6-1 – IMT-2020 network with satellite-enabled AN

Figure 6-2 illustrates the scenario where mobile broadband services can be provided via a fixed AN, a terrestrial mobile AN or a satellite AN.

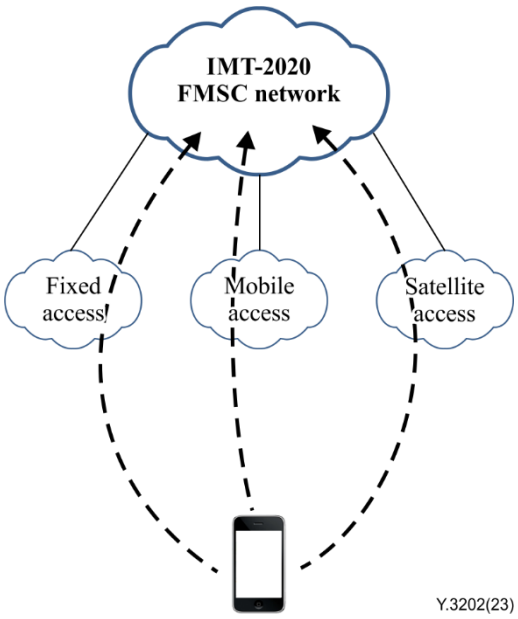

Figure 6-2 – **Scenario for fixed, mobile and satellite convergence in an IMT-2020 network**

The terrestrial network may have poor coverage in some areas, so the IMT-2020 network may provide satellite access to ensure service availability. Therefore, for UE with poor terrestrial network coverage, it shall be possible to simultaneously establish connectivity via satellite and terrestrial access to obtain network services.

The NGSO satellite keeps moving around the Earth at high speed. The beam coverage area moves with the satellite, and the movement of the beam coverage area is much faster than the movement of UE. Furthermore, the size of the satellite spot is larger than that of the terrestrial cell. As a result, the mapping relationship between the satellite spot and the tracking area (TA) of the UE does not match, and the satellite access nodes in the TA list area change dynamically. Therefore, the mobility management mechanism of the NGSO satellite needs to fully consider the movement of the NGSO satellite.

The handover for the FMSC system can be of the intra- or inter-satellite, feeder link switchover, between NGSO and GSO satellites, and between terrestrial and satellite access nodes type.

1) Intra-satellite handover

   In the low earth orbit (LEO) satellite system, UE resides on a cell for several seconds due to the fast movement of the satellite. Within the coverage area of the same satellite, intra-satellite inter-cell handover frequently occurs when UE crosses the coverage (cell) boundary of two adjacent beams of the same satellite. The handover may be an inter-beam handover within or between base stations.

Figure 6-3 shows the scenario of intra-satellite handover. In this scenario, the handover procedure frequently initiated due to the cell change for UE will introduce latency in data transmission, reducing the user experience.

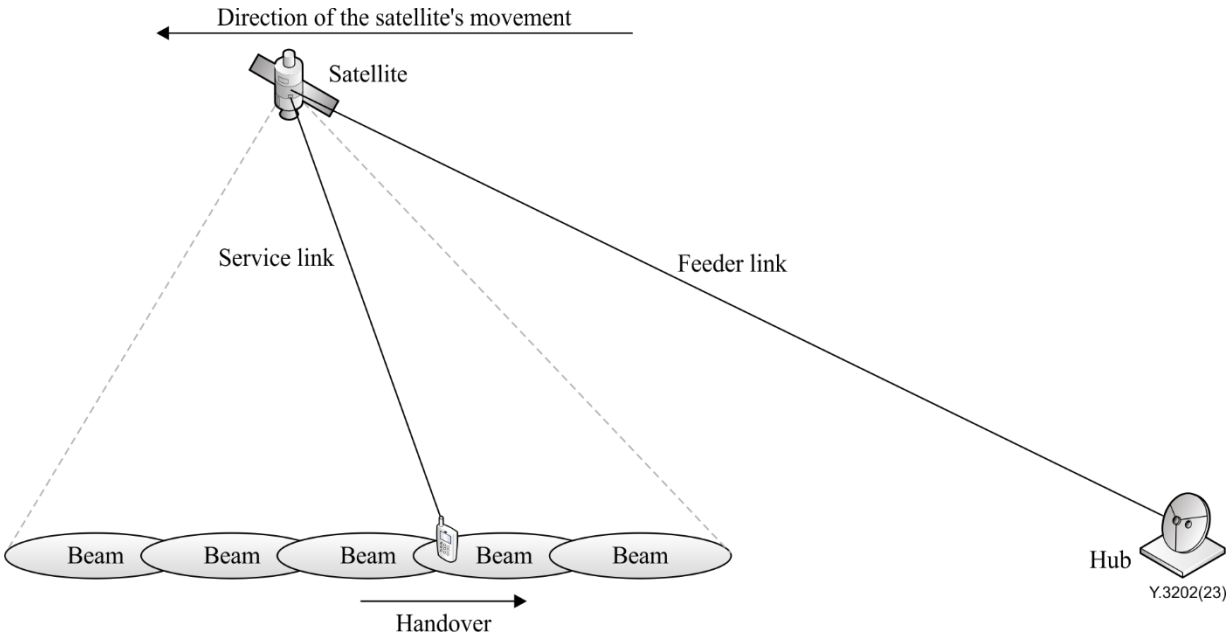

Figure 6-3 – Scenario for intra-satellite handover

A satellite-enabled AN predicts the orbit of a satellite and decides on handover based on satellite ephemeris, radio resource control (RRC) measurement and UE location information.

2) Inter-satellite handover

The inter-satellite handover procedure is initiated when the service link is switched from the current to the adjacent satellite due to UE entering the coverage area of the adjacent satellite. Figure 6-4 shows the inter-satellite handover scenario where two satellites can belong to the same or different Earth stations.

As a significant number of UEs are served by one satellite, the inter-satellite handover procedure causes many UEs to simultaneously hand over from one satellite to another, leading to a group handover of the mobility management anchor.

The inter-satellite handover needs to consider the UE beam tracking and switch capability.

NOTE – The UEs of a parabolic antenna spend more time switching between beams.

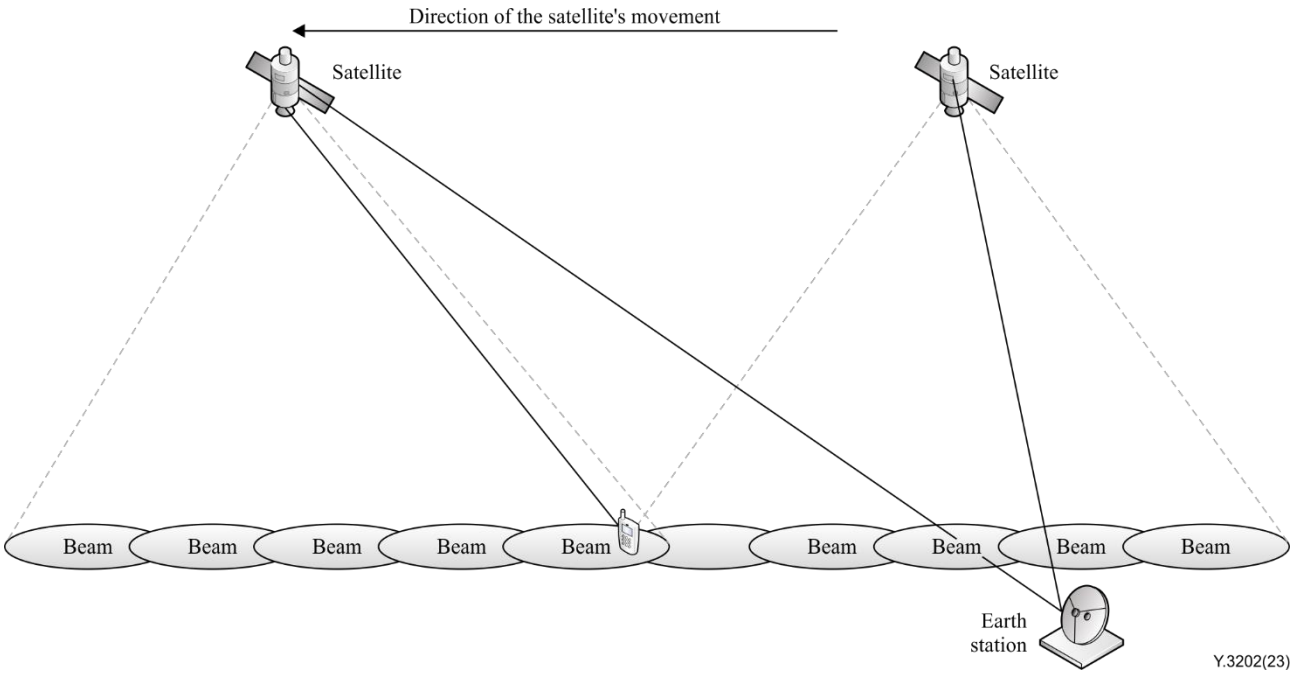

Figure 6-4 – Scenario for inter-satellite handover

3) Feeder link switchover

As the satellite moves, the gateway to which it is connected may no longer be able to serve and another gateway takes over. As shown in Figure 6-5, the feeder link of satellite 3 switches from the source to the target gateway at a certain time. During the handover process, all UEs operating under the satellite need to switch to the target gateway station.

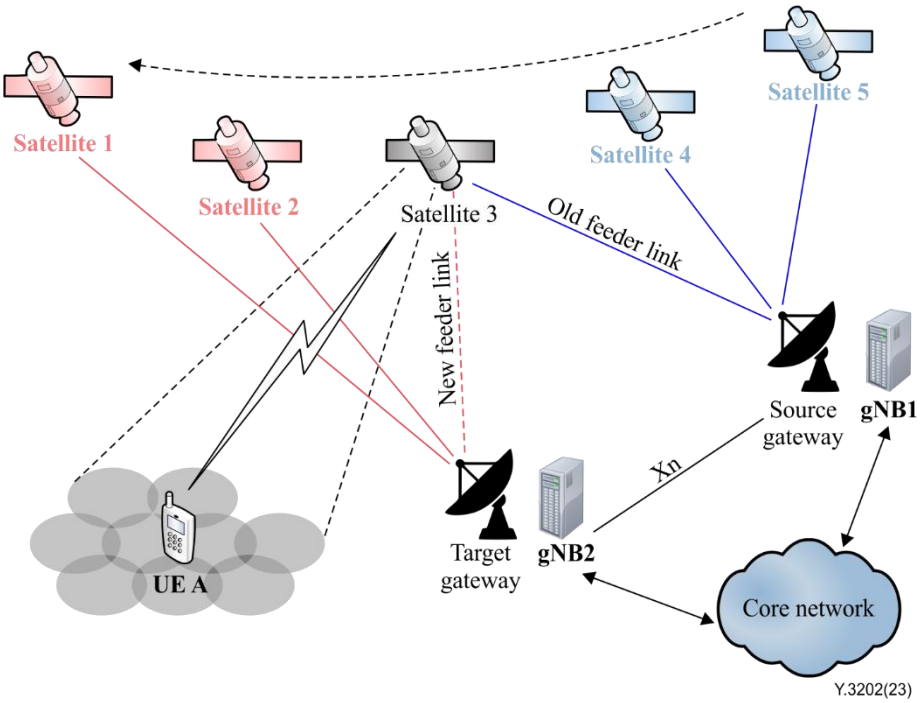

Figure 6-5 – Feeder link switchover

The satellite ephemeris data contains information about the orbital trajectories of artificial satellites, which are used to describe the location and orbital behaviour of stars and other astronomical bodies. In addition, it may predict feeder link switchover occurrences and mobility management events (idle and connected mode).

4) Handover between NGSO and GSO satellites

When the GSO satellite network signal is not good, or the NGSO satellite is not covered for the UE, handover between GSO and NGSO satellites is performed. In this case, the UE is simultaneously connected to one kind of satellite and the handover is completed via the CN.

5) Handover between the terrestrial and satellite access nodes

When UE enters into discontinuous coverage of a satellite AN, it has two options: to remain in no service; or to look for an alternate radio access type (RAT) or public land mobile network (PLMN) to receive normal services. If the UE detects that it is about to move outside of network coverage in the current satellite access node based on the ephemeris information and the UE detects another available terrestrial AN, then the satellite access node is handed over to its terrestrial counterpart based on operator policy.

When the handover happens, the satellite beams are moving, and there is a potential disconnect between geographical coverage, cell and TA, and registration area. Therefore, mobility management mechanisms need enhancement based on the features of the FMSC network, such as network selection, the determination of the TA for the fixed, mobile, and satellite convergence network and UE reachability management. The related mobility management functions of the IMT-2020 network, such as the location management function, handover control function and coordination management function, need to be enhanced to complete service continuity for FMSC.

The mobility management of FMSC has the following characteristics based on the analysis of the above scenarios:

– the impact on handover performance caused by large delay;
– the impact on handover triggered by satellite ephemeris and terminal location information (network-based, terminal-based, or both);
– the impact on handover caused by frequent handover.

7 Requirements of mobility management for fixed, mobile and satellite convergence

The IMT-2020 network is required to support mobility management when the UE occurs in the following cases:

- crossing multi-ANs;
- changing the type of AN;
- crossing the coverage boundary (cell boundary) of two adjacent beams of the same NGSO satellite;
- entering the coverage area of the adjacent NGSO satellite.

Mobility management is required to support service continuity of UE when the feeder link is switched over.

Mobility management is required to provide a set of signalling and control operations for mobility management. Those signalling and control operations are performed among various mobility management-related functional entities. To support FMSC in the IMT-2020 network, an operator may implement those mobility management-related functions in the CN and different ANs.

Mobility management is required to provide service continuity for FMSC in the IMT-2020 network. When UE moves between the fixed, mobile and satellite ANs, support for service continuity is required in the IMT-2020 network. For session continuity between different types of ANs for FMSC in the IMT-2020 network, mobility management is also required to support coordination management.

Mobility management is required to provide UE and satellite access control functions in FMSC networks.

Mobility management is required to provide the functions of UE registration management and satellite registration management in FMSC networks.

Mobility management is required to provide UE location management and satellite location management functions in FMSC networks.

Mobility management is required to provide UE and satellite handover management functions in FMSC networks. Satellite ephemeris can accurately calculate, predict, describe, and track satellite time, position, and speed.

IMT-2020 network can predict the mobility event based on the satellite ephemeris and UE location information and prepare for handover in advance.

Mobility management is required to provide a mechanism taking account of the large delay, satellite ephemeris, and UE location information, etc.

Mobility management is required to provide mobility restriction functionality in FMSC networks. Mobility restrictions restrict mobility handling or service access of a UE. The UE, the AN and the CN provide the mobility restriction functionality.

8 The architecture of mobility management for fixed, mobile and satellite convergence

8.1 The framework of mobility management with geostationary earth orbit positioning satellite

The framework of mobility management for FMSC in the IMT-2020 network with a geostationary earth orbit (GEO) positioning satellite is depicted in Figure 8-1. Multi-access UE has fixed, mobile and satellite access. Apart from the fixed and mobile ANs, the NGSO satellite AN, including the NGSO satellite gateway, is introduced. The converged CN has connections to all the ANs, including those for fixed, mobiles and NGSO satellites; it also connects to the data network. The control plane functions (including network access control function (NACF), session management function (SMF), policy control function (PCF), capability exposure function (CEF), network function registry (NFR) function, unified subscription management (USM) function, network slice selection function (NSSF), authentication server function (ASF), an application function (AF), user plane functions (UPFs, including those for access via mobiles, fixed or NGSO satellites), service plane functions, and management plane functions are included in the converged CN. The NACF mainly provides mobility management functionalities in the converged CN. The NACF is enhanced to support fixed, mobile, NGSO satellite access and fixed, mobile, and satellite convergence. The multi-access UE and converged CN have connections to the GEO positioning satellite.

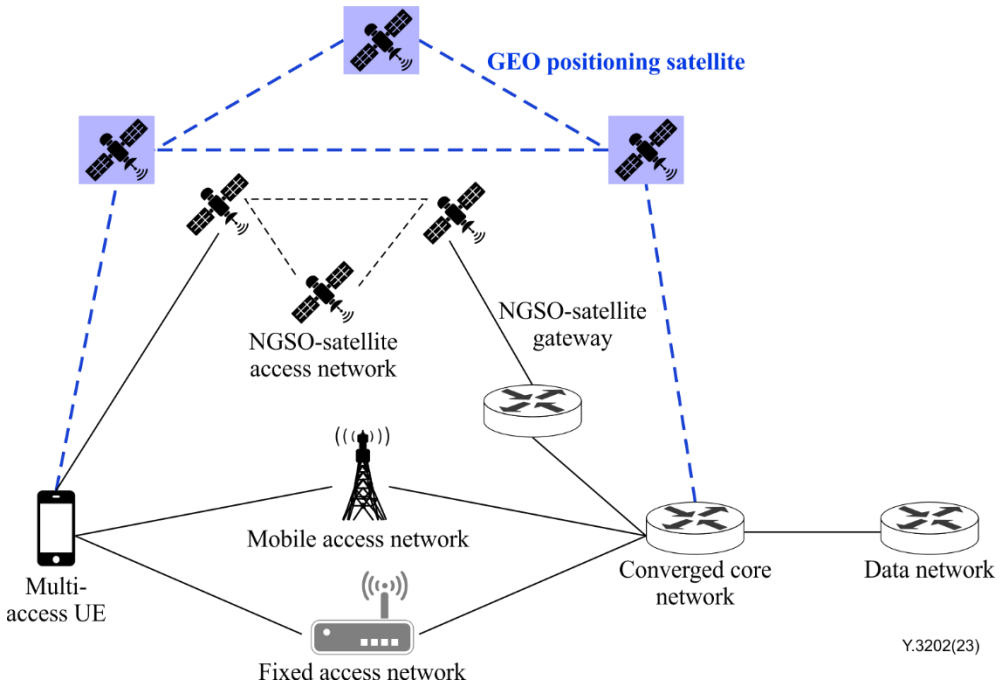

Figure 8-1 – Framework of mobility management for fixed, mobile and satellite convergence in IMT-2020 network with GEO positioning satellite

It is recommended that multi-access UE and converged CNs have connections to the GEO positioning satellite. The accurate real-time location acquired from the GEO positioning satellite is useful in the service procedures of mobility management, including initial registration, location update, and NGSO satellite handover. The rationale for introducing the GEO positioning satellite is that the size of the NGSO satellite beam is typically larger than the size of the cell of mobile communications; therefore, to map the location of UE into cell and TA, and to provide the services requiring accurate location, an assisting positioning method has to be introduced in FMSC networks. Considering the wide use of GEO positioning satellite and related technologies, it is reasonable to introduce the GEO positioning satellite to provide the assisting positioning method to multi-access UE and converged CNs in the mobility management framework.

It is recommended that the ephemeris of the NGSO satellite be stored and periodically updated in multi-access UE and converged CNs. The ephemeris of the NGSO satellite include the accurate location, trajectory and connection capabilities (including signal quality, communications data rate, communications delay and communications reliability) of the NGSO satellite. With the ephemeris of the NGSO satellite, multi-access UE can choose the best-suited NGSO satellite according to the connection capabilities of NGSO satellites in the ephemeris and accurate real-time location of UE acquired from the GEO positioning satellite. With the ephemeris of the NGSO satellite, multi-access UE can initiate the location update and NGSO satellite handover, according to the accurate location and trajectory of the NGSO satellites in the ephemeris. With the ephemeris of the NGSO satellite, the converged CN could determine the current NGSO satellite and its current beam for multi-access UE according to the accurate location and trajectory of NGSO satellites in the ephemeris and UE's accurate real-time location inserted in the registration request message.

NOTE – The current NGSO satellite and its current beam for multi-access UE can also be inserted in the registration request message by the NGSO satellite, which currently serves multi-access UE.

8.2 Enhancements for the framework of mobility management

For NGSO satellites, satellite orbits are accurately determined and anticipated. Satellite beams generate a fixed pattern based on the tracking scheme and generate fixed radio coverage towards the UE. For NGSO satellites, as time goes on, the mapping between the access node and satellite beams

will change. Figure 8-2 shows the relationship between the cell and TA. The cell is the coverage of the NGSO satellite, and the TA is the pre-configuration by the operator based on the geographic area. The area of the cell includes several TAs.

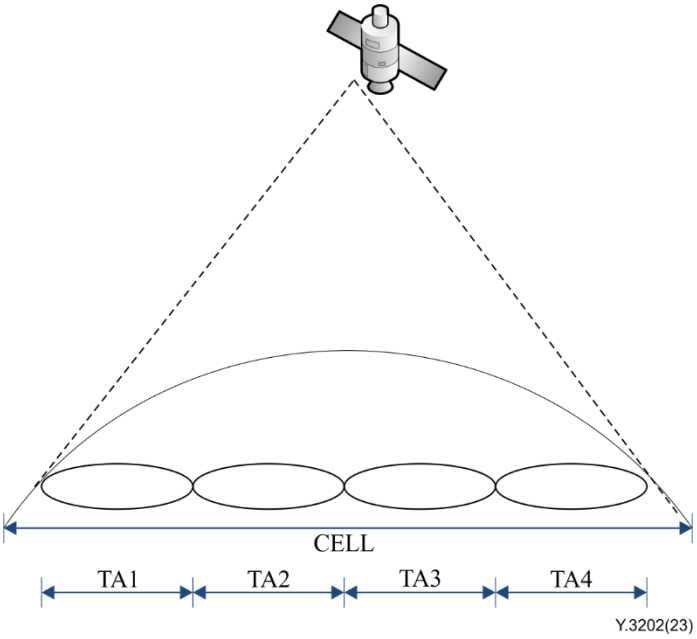

Figure 8-2 – The relationship between the cell and TA in the NGSO satellite

The design consideration of mobility management for FMSC is not based on the coverage of the NGSO satellite AN because the PLMN for FMSC is larger than the PLMN for fixed, mobile convergence. For the NGSO satellite, the beam coverage provided by the AN node moves with the corresponding AN node. The relationship between the satellite spot, the TA, and the registration area assigned to UE are not static. When the IMT-2020 network triggers the paging process, the NACF sends a paging request to the AN nodes in the TA list. However, for NGSO satellites, the satellite AN nodes in the TA list change dynamically.

It is recommended that the IMT-2020 network create, store and update the NGSO satellite coverage information.

The NGSO satellite coverage information includes the mapping relationship between the TA and the coverage area of the NGSO satellite AN node. The NGSO satellite coverage information is required to be dynamically maintained based on the satellite ephemeris information and the TA planning information.

When the IMT-2020 network creates mapping information, the satellite access node is required to report its ephemeris information and antenna parameters to the network. The ephemeris information and antenna parameters are mainly used to calculate the irradiation range of the satellite beam.

When the coverage of the satellite access node is changed, the IMT-2020 network is required to update the appropriate parameters.

The IMT-2020 network creates a relationship between satellite coverage and registration area tracking based on the satellite coverage and registration area tracking planning so that the NACF can find the satellite information covering the area based on the list of registration area tracking information.

The mobility management functional architecture in the IMT-2020 network architecture for NGSO satellite access is shown in Figure 8-3.

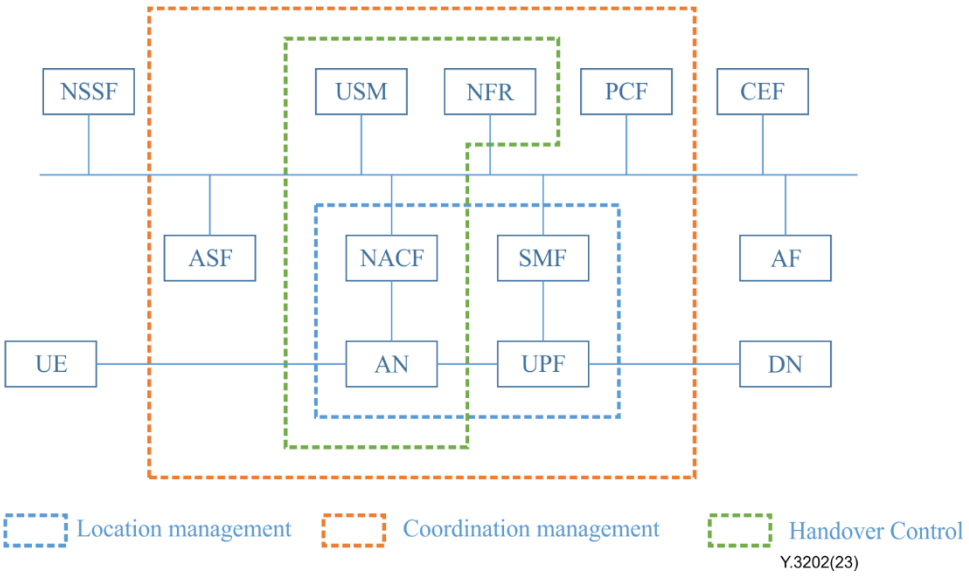

Figure8-3 – Mobility management related functions in IMT-2020 network architecture for NGSO satellite access

The NFR determines the NGSO satellite access node current coverage area based on the received ephemeris information and antenna parameters of the NGSO satellite access node. Furthermore, the NFR derives the TA of the satellite access node based on the determined current coverage area and the preconfigured TA. The NFR stores the mapping relationship between the TA and the NGSO satellite AN node coverage area. When the NACF needs to page the UE, the NACF first queries the satellite coverage information from the NFR, and determines the satellite access node identification that can currently cover the registration area tracking according to the list of registration area tracking contained in the UE registration area. The NACF gets the track area from the registration area in the UE context and sends the track area identity to the NFR. The NFR determines the related NGSO satellite access node based on the mapping information between the TA and the NGSO satellite AN node coverage area.

For intra- and inter-satellite handover, the radio resource management (RRM) measurement of the NGSO satellite access node ensures the target cell is available beforehand. When the reference signal received power (RSRP) of the target cell is higher than the threshold, the access node performs the measurement report and updates the UE location to the NACF. The NACF decides whether to hand over based on UE location and ephemeris.

For feeder link handover, the satellite is only connected to one access node at any time. If the feeder link is handed over, the connection with the source access node should be cut off and connected to the target access node. After the handover is prepared, the access node can perform the path switch procedure to ensure the data is lossless during handover. After receiving the path switch request from the source access node or the handover notification message from the target access node, the CN stops sending data to the source access node and starts sending data to the target access node. After the path switch, the target access node catches the data and transfers it to UE.

The IMT-2020 network determines the mobility restrictions for the given UE based on UE subscription information, location or local policy. The mobility restriction may change due, for example, to UE subscription, location change and local policy. Optionally, the service area restrictions or the non-allowed area may be fine-tuned by the PCF, e.g., based on UE location and network policies. The USM is required to provide to the NACF the information about subscriber access restriction set by the operator determined:

– LEO satellite access is not allowed as primary access;

– medium Earth orbit satellite access is not allowed as primary access;

– GEO satellite access is not allowed as primary access;

– OTHERSAT (i.e., other than GEO, LEO or MEO) satellite access is not allowed as primary access.

9 Service procedures of mobility management for fixed, mobile and satellite convergence

9.1 Service procedures of mobility management with GEO positioning satellite and ephemeris of NGSO satellite

With the GEO positioning satellite and the ephemeris of the NGSO satellite introduced in the mobility management framework, the mobility management service procedures for fixed mobile and NGSO satellite convergence in the IMT-2020 network are as follows. Figure 9-1 depicts the service procedures of mobility management with GEO positioning satellite and ephemeris of NGSO satellite, which includes initial registration, location update and NGSO satellite handover.

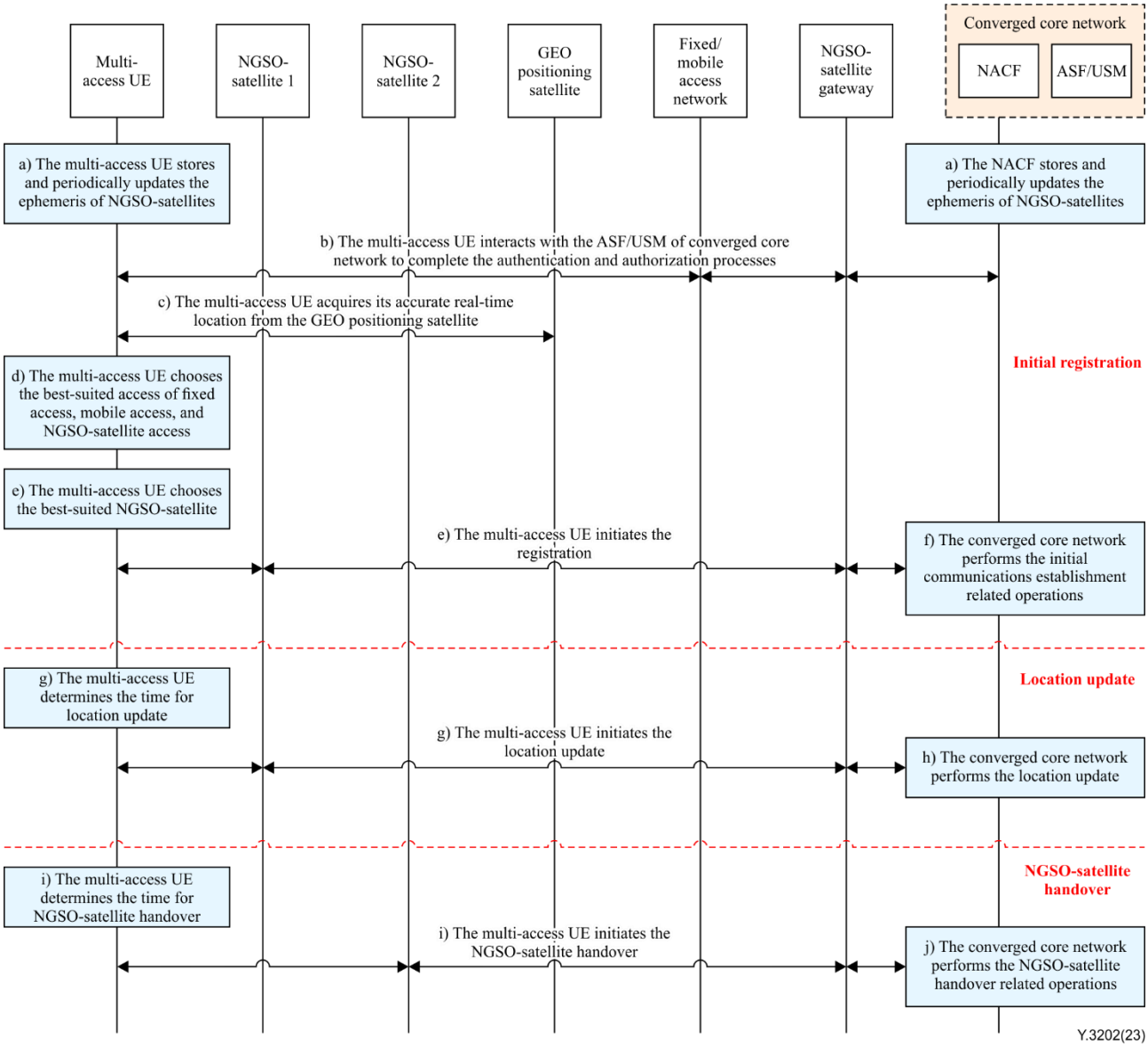

Figure 9-1 – Service procedures of mobility management with GEO positioning satellite and ephemeris of NGSO satellite

- Initial registration

a) The multi-access UE and the converged CN store and periodically update the ephemeris of NGSO satellites, which includes the accurate location, trajectory and connection capabilities (including signal quality, communications data rate, communications delay and communications reliability) of NGSO satellites.

b) The multi-access UE interacts with the ASF/USM of the converged CN to complete the authentication and authorization processes. The converged CN recognizes the multi-access UE as a trustable UE for a period after completing the authentication and authorization processes.

c) The multi-access UE acquires its accurate real-time location from the GEO positioning satellite.

d) The multi-access UE looks up the ephemeris of the NGSO satellites and executes the access performance evaluation based on signal quality, communications data rate, communications delay, communications reliability and user preference to choose the best-suited access of fixed access, mobile access and NGSO satellite access.

e) When NGSO satellite access is chosen, multi-access UE executes the access performance evaluation based on signal quality, communications data rate, communications delay, communications reliability and user preference to select the best-suited NGSO satellite, initiates the registration and uses voice service, message service, data service, etc. on demand. In the registration request message, multi-access UE inserts its accurate real-time location acquired from the GEO positioning satellite.

f) The converged CN uses the accurate real-time location of multi-access UE inserted in the registration request message to map into cell and TA and determines the current NGSO satellite and its current beam for multi-access UE according to the accurate location and trajectory of NGSO satellites in the ephemeris and accurate real-time location of a UE inserted in the registration request message. Then the converged CN performs initial registration-related operations.

- Location update

g) Multi-access UE uses the accurate real-time location acquired from the GEO positioning satellite and the ephemeris (including the accurate location and trajectory) of the NGSO satellite to determine the time for a location update and initiates the location update with the accurate real-time location inserted in the location update request message.

h) The converged CN uses the accurate real-time location of a multi-access UE inserted in the location update request message to map into the cell and TA and determines the current NGSO satellite and its current beam for the multi-access UE according to the accurate location and trajectory of NGSO satellites in the ephemeris and accurate real-time location of a UE inserted in the location update request message. Then the converged CN performs location update-related operations.

- NGSO satellite handover

i) Multi-access UE uses the accurate real-time location acquired from the GEO positioning satellite and the ephemeris (including accurate location and trajectory) of the NGSO satellite to determine the time for NGSO satellite handover, and initiates the NGSO satellite handover with the accurate real-time location inserted in the NGSO satellite handover request message.

j) The converged CN uses the accurate real-time location of multi-access UE inserted in the NGSO satellite handover request message to map into cell and TA and determines the current NGSO satellite and its current beam for the multi-access UE according to the accurate location and trajectory of NGSO satellites in the ephemeris and accurate

real-time location of UE inserted in the NGSO satellite handover request message. Then the converged CN performs NGSO satellite handover-related operations.

9.2 Service procedures of the mobility management for the NGSO satellite

The mobility management procedures for NGSO satellites include UE reachability management, intra-satellite handover, inter-satellite, feeder link handover, and handover procedures between the terrestrial and satellite ANs. Detailed information flows of these procedures are described in clauses 9.2.1 to 9.2.4.

9.2.1 UE reachability management procedure

The UE reachability management request procedure is illustrated in Figure 9-2.

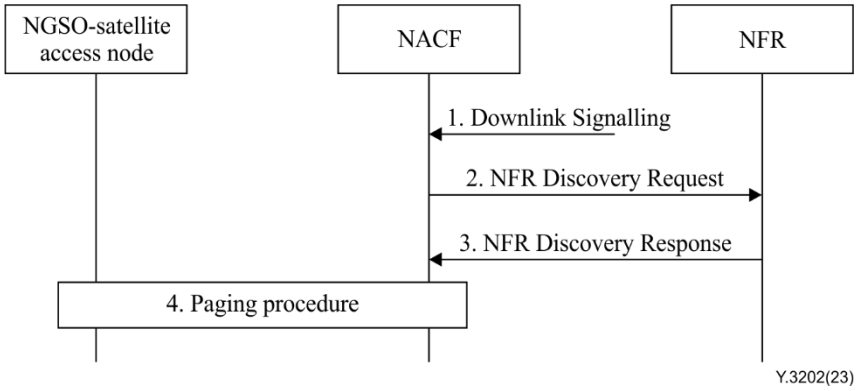

Figure 9-2 – UE reachability management procedure

1. After the NACF receives the downlink signalling for the UE in the IDLE state, the NACF determines the registration area of UE, including the TA information from the UE context.

2. The NACF sends the NFR discovery request message to the NFR that includes the TA identification of the UE.

3. The NFR checks the stored mapping relationship between the registration area tracking and coverage area of the NGSO satellite access node and finds the corresponding access node. Then, the NFR sends the NFR discovery response message to the NACF, which includes the related access node information.

4. The NACF receives the relevant access node information and initiates the paging procedure to make the UE enter the connective state.

9.2.2 Inter-satellite handover procedure

The inter-satellite handover procedure is shown in Figure 9-3. When the RSRP of the target access node is higher than the preconfigured threshold, the access node produces the measurement report and updates the UE location to the NACF. The NACF decides whether to hand over based on UE location and ephemeris.

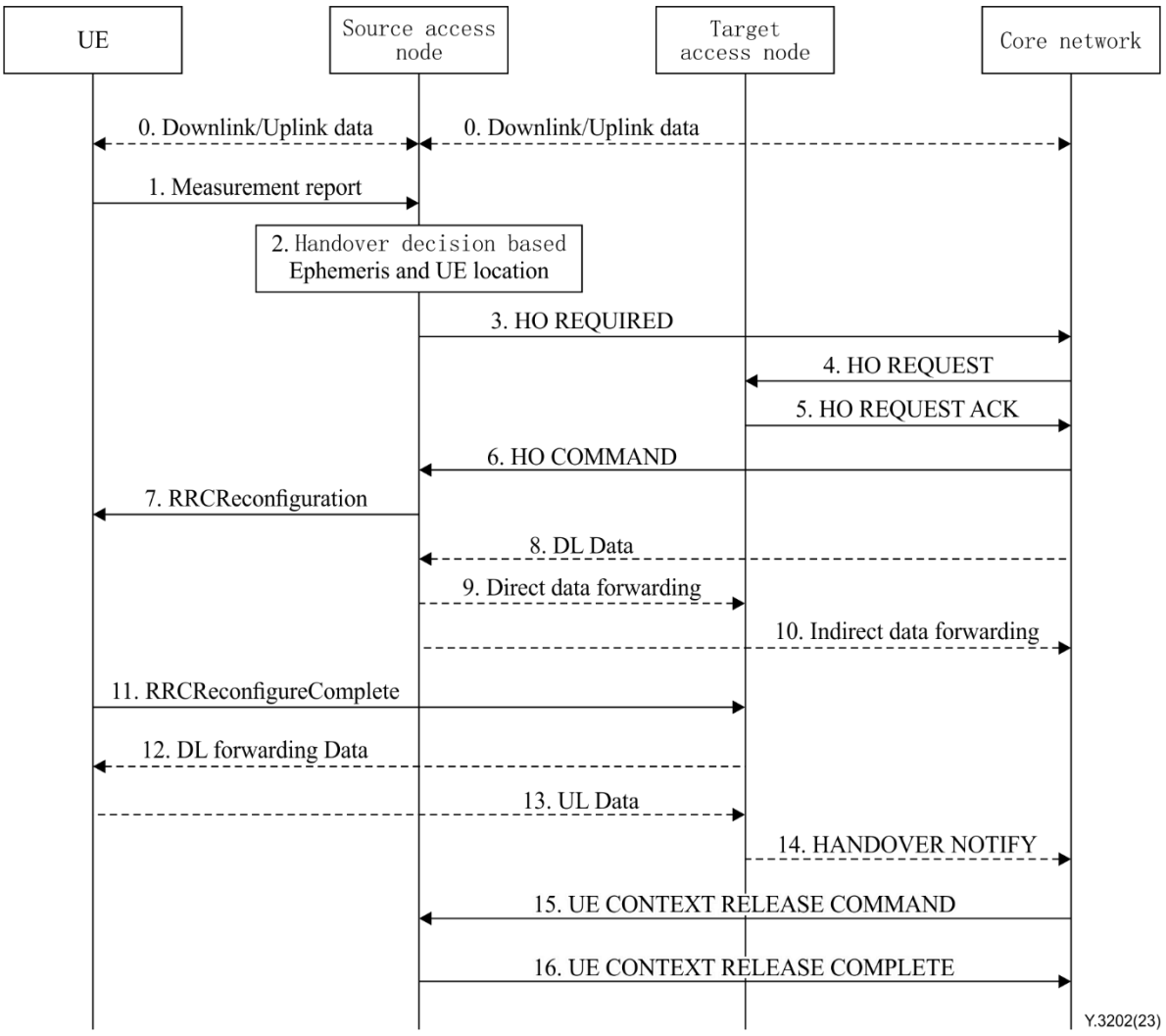

Figure 9-3 – Inter-satellite handover procedures

1. The UE measures RRM and reports the result and location information to the access node.

2. The source access node makes the handover decision based on the ephemeris, the RRM of UE and location information.

3–6. After receiving the handover request from the source access node, the CN initiates the handover request procedure to the target access node. The target access node allocates corresponding resources for the UE and responds with a handover request acknowledgement (ACK) message to the CN.

7–11. UE completes the RRC reconfiguration procedure. The source access node performs the data forwarding to the target access node.

12–13. The UE and the target access node perform uplink and downlink data transmission.

14. The target access node notifies the CN that UE successfully accesses the target access node.

15–16. The CN notifies the source access node to release the context, and the source access node sends the confirmation message to the CN.

9.2.3 Feeder link handover procedure

The feeder link handover procedure is illustrated in Figure 9-4. If the feeder link handover happens, the source access node's connection should be cut off and connected to the target access node.

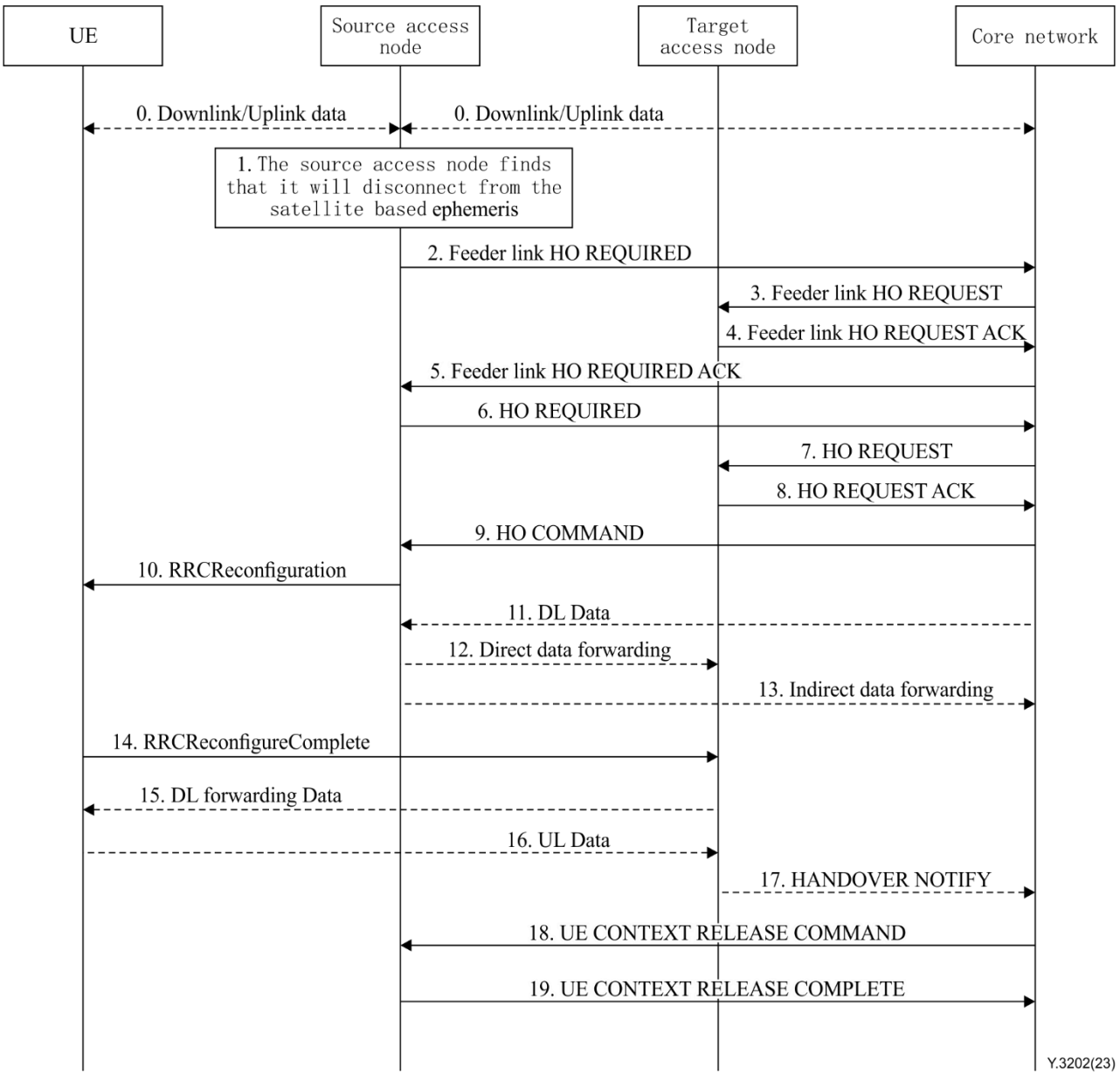

Figure 9-4 – Feeder link handover procedure

1. The source access nodes find that it will disconnect the satellite, and the satellite will connect the target access node based on the ephemeris information.

2–3. The source access node sends the feeder link handover request message to the target access node, which includes the satellite identifier (ID) and beam list.

4–5. The target access node confirms the feeder link handover request based on the ephemeris information and sends the feeder link handover request ACK to the source access node.

6. The source access node initiates a handover preparation process to the target access node for all connected UEs under the satellite.

7–8. After receiving the source access node's handover request, the CN initiates a handover request process to the target access node. The target access node allocates corresponding resources for the UE and responds with a handover request confirmation message.

9. The CN sends the handover command to the source access node.

10–14. UE completes the RRC reconfiguration procedure. Then, the source access node forwards the data to the target access node.

15–16.The UE and the target access node perform uplink and downlink data transmission.

17. The target access node notifies the CN that UE successfully accesses the target access node.

18–19. The CN notifies the source access node to release the context, and the source access node sends the confirmation message to the CN.

9.2.4 Handover procedure between the terrestrial access network and satellite access network

When UE detects it is about to leave network coverage of the satellite access node and the terrestrial access node is available to access, it reports the radio condition measurements in which the UE wants to access it and includes them in the source access node. This detection can be based on the UE current location and ephemeris information.

Both the source AN and the target AN have different RATs and belong to the same or different operators. The inter AN node radio access network (RAN)-NACF interface-based handover for the UE may cause serving PLMN change in this solution. Figure 9-5 shows the handover procedure.

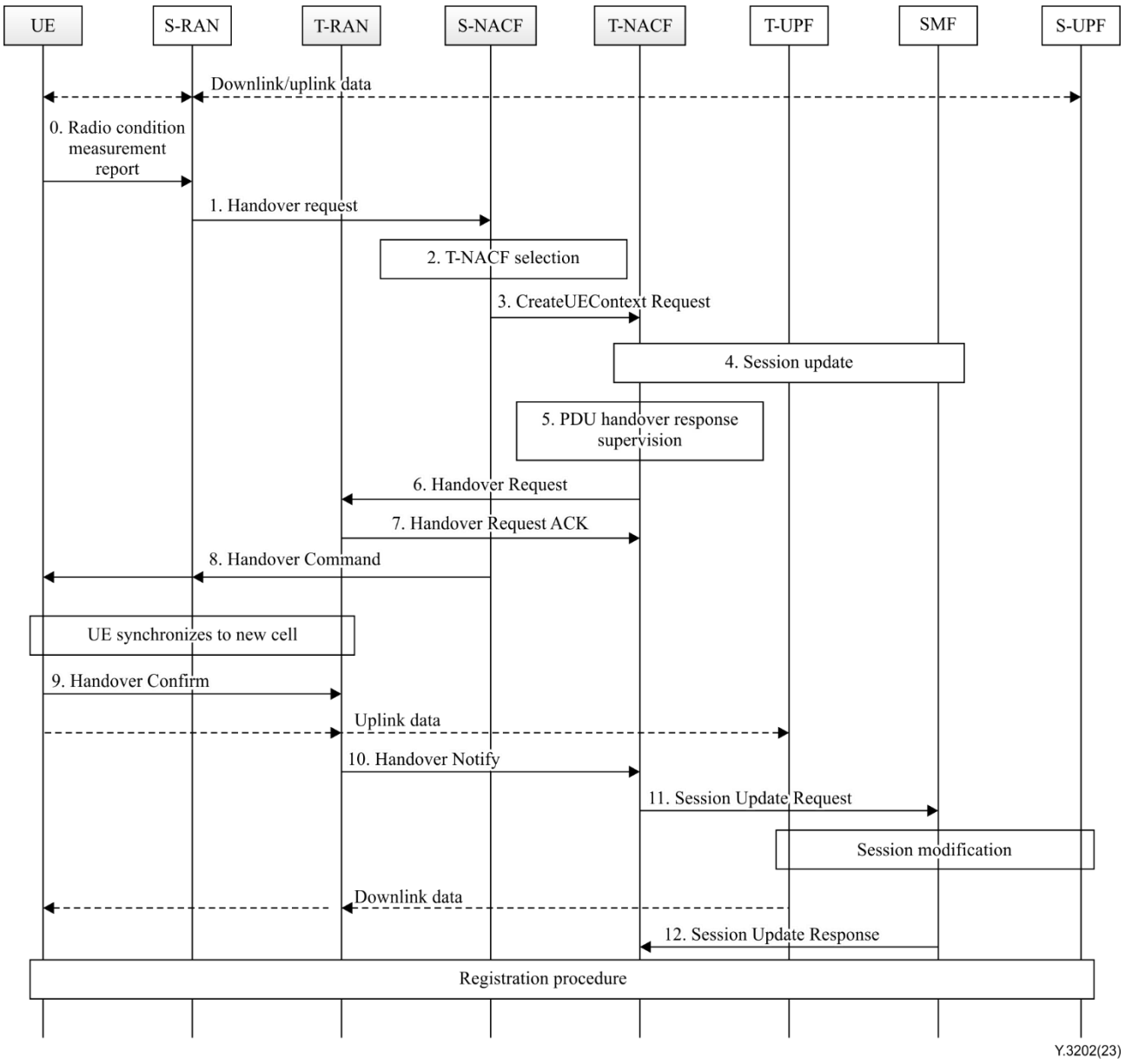

Figure 9-5 – Handover procedure between the terrestrial and satellite access networks

0. When UE detects that it is about to leave network coverage of the satellite AN and the terrestrial AN is available, it reports to the source access node the radio condition measurements in which the UE wants terrestrial access. This detection can be based on UE current location and ephemeris information of the satellite.

1. Triggered by the radio condition measurements report, the source access node determines whether to hand over based on the available AN. The source access node sends a handover request message to the source NACF and provides the access node information created by the source access node. The handover required message shall include all the packet data unit (PDU) sessions handled by the source access node, indicating which PDU session(s) are requested by the source access to handover.

2. When the S-NACF can no longer serve the UE, the S-NACF selects the T-NACF.

3. The S-NACF sends the create UE context request message to the target NACF to initiate the handover resource allocation procedure.

4. The T-NACF sends a PDU session update request to the associated SMF for each PDU session indicated by the source access node.

5. T-NACF supervises the PDU session update response messages from the SMFs involved.

6. T-NACF sends the handover request to the target access node.

7. The target access node sends the handover request ACK to T-NACF.

8. S-NACF sends a handover command to the source access node including the target access node information. The target access node information is provided to the UE by the source access node using a handover command.

9. After the UE has successfully synchronized to the target cell, it sends a handover confirm message to the T-RAN. Handover is considered successful by the UE with this message.

10. T-RAN sends a handover notify message to T-NACF. Handover is considered successful in T-RAN with this message.

11. T-NACF sends a session update request to the SMF indicating handover complete for a PDU session. A handover complete is sent for each PDU session to the corresponding SMF to indicate the success of the handover. T-NACF also uses UE registration to register itself as the serving NACF with the USM.

12. SMF sends a session update response with PDU session ID to T-NACF to confirm receipt of handover complete.

10 Security considerations

The FMSC in the IMT-2020 network is required to be aligned with the security requirements contained in [ITU-T Q.1762] and the requirements of security and personal data protection contained in [ITU-T Y.3101], with the following additions.

- The FMSC in the IMT-2020 network is required to provide mechanisms to support data confidentiality and integrity for fixed, mobile and satellite ANs.
- The FMSC in the IMT-2020 network is required to provide secure storage, handling and enforcement of policies.
- The FMSC in the IMT-2020 network is required to provide a security coordination function [ITU-T Y.3130] to coordinate security policies of each AN.
- The FMSC in the IMT-2020 network is required to meet the specific requirements based on each country's policy.

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[b-ITU-T Q.1741.7] Recommendation ITU-T Q.1741.7 (2011), *IMT-2000 references to release 9 of GSM-evolved UMTS core network.*

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

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