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| 3GPP TR 28.846 V19.1.0 (2025-06) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Services and System Aspects;  Study on charging aspects of satellite access Phase 3  (Release 19) | |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document studies on charging aspects of satellite access Phase 3 based on the TS 22.261 [2] and TR 23.700-29 [3]:

This study item is to investigate the following aspects of the satellite access:

- Possible business scenarios;

- Possible charging scenarios and potential charging requirements based on business scenarios;

- Identify the potential charging solutions.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.261: "Service requirements for the 5G system; Stage 1".

[3] 3GPP TR 23.700‑29: "Study on integration of satellite components in the 5G architecture; Phase 3".

[4] 3GPP TR 28.844: "Study on charging aspects of satellite in the 5G System".

[5] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access".

[6] 3GPP TR 22.822: "Study on using Satellite Access in 5G ".

[7] 3GPP TS 32.251: " Packet Switched (PS) domain charging".

[8] 3GPP TS 32.255: "Telecommunication management; Charging management; 5G data connectivity domain charging; Stage 2".

[9] 3GPP TS 23.502: "Procedures for the 5G System (5GS)".

[10] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

[11] 3GPP TS 23.228: " IP Multimedia Subsystem (IMS); Stage 2".

[12] 3GPP TS 32.253: "Control Plane (CP) data transfer domain charging".

[13] 3GPP TS 32.299: "Diameter charging applications".

[14] 3GPP TS 32.298: "Charging Data Record (CDR) parameter description".

[15] 3GPP TS 23.203: "Policy and charging control architecture".

[16] 3GPP TS 32.240: "Charging architecture and principles".

[17] 3GPP TS 32.257: "Edge computing domain charging".

[18] 3GPP TS 32.260: "IP Multimedia Subsystem (IMS) charging".

[19] 3GPP TS 24.229: "IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP)".

[20] 3GPP TS 32.275: "MultiMedia Telephony (MMTel) charging".

[21] 3GPP TS 23.503:"Policy and Charging Control Framework for the 5G System; Stage 2".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

## 3.2 Symbols

Void.

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

S&F Store and Forward

# 4 Background

## 4.1 General

For Rel-19, SA1 has specified the following requirements on charging aspects for satellite access Phase 3 in the TS 22.261 [2]:

- A 5G system with satellite access supporting Store and Forward (S&F) Satellite operation may be able to collect charging information per UE or per application (e.g., number of UEs, data volume, duration, involved satellites).

- A 5G system with satellite access may be able to collect charging information for a UE registered to a HPLMN or a VPLMN, for UE-Satellite-UE communication.

- In a 5G system with satellite access, charging data records associated with satellite access(es) may include the location of the associated UE(s) with satellite access.

## 4.2 Regenerative-based satellite access

As introduced in the clause 4.5 of TR 28.844 [4], the regenerative-based satellite access architecture involves deploying some 5GC network functions on the satellites. The following from figure 6.2.1-1 of TR 23.700-29 [3] shows the high-level 5G network architecture for the regenerative-based satellite access.



Figure 4.2-1: Regenerative-based satellite access

## 4.3 Store and Forward Satellite operation

As specified in the TS 22.261 [2], the new capability that S&F operation is an operation mode of a 5G system with satellite-access, allows the satellite to store and forward data when satellite connectivity is intermittently/temporarily unavailable(e.g. when the satellite is not connected via a feeder link or via ISL to the ground network). The following from Figure J-1 of TS 22.261 [2] shows the high-level network architecture for S&F operation.



Figure 4.3-1: Illustration of "S&F Satellite operation" modes in a 5G system with satellite access

The conclusions in TR 23.700-29 [3], have two informative architectures for the support S&F operation:

- Split MME architecture, where the eNB and part of MME functions on the satellite, and other network functions are deployed on the ground, including part of MME functions and HSS.

- full CN onboard the satellite architecture, where the eNB and whole CN including MME, SGW, PGW, HSS, E-SMLC, SMSC etc are on board each satellite. Proxies are deployed on the satellite and the ground for application traffic, including support of MT traffic, MO traffic, SMS, etc. The implementation of the proxies and the interface between them is out of 3GPP scope.

## 4.4 UEs- SAT- UEs communications on satellite

As specified in the TS 22.261 [2], a 5G system with satellite access may support UE-Satellite-UE communication regardless of whether the feeder link is available or not. The UE-satellite-UE communication scenario is that UEs can communicate using satellite access without the user plane traffic going to the ground network. The following from Figure 6.28.1-1 of TR 23.700-29 [3] shows the high-level network architecture for UE-satellite-UE communication.



Figure 4.4-1: UEs- SAT- UEs communications on satellite in same cell with ISL

Editor's note: SA5 will align with the architecture and procedure for supporting UEs- SAT- UEs communications specified by SA2.

As specified in the TS 23.501 [10], only IMS voice/video services between two UEs belonging to same PLMN and in non-roaming scenario are considered by UE-satellite-UE communication in this release.

As specified in the TS 23.228 [11], to support IMS satellite media plane optimization, the IMS-AGW may be deployed on the satellite(s) that host the gNB and UPF (UL CL/BP and L-PSA) of the 5GC. It is assumed that the satellite(s) can always connect to the ground with IP transport networks. The P-CSCF is responsible for determining whether to activate UE-satellite-UE communication. The following figure shows the reference architecture of IMS satellite media plane optimization.



Figure 4.4-2: Reference architecture of IMS satellite media plane optimization

As specified in the TS 23.228 [11], the architecture deployment assumes that ISL(s) can be set-up within the same satellite constellation or across different constellations depending on satellite operator's deployments (SLA). The set of ISL(s) builds up an IP network which is out of 3GPP scope. In addition, the routing between Onboard AGWs across satellite via ISL is assumed to be based on IP routing and the Onboard AGWs in satellite need to have non-conflicting IP address during resource allocation. It is up to the deployment to manage IP routing across ISL links and is out of 3GPP scope.

## 4.5 Roaming aspects of Satellite access

As per the TS 22.261 [2], clause 6.46.4, the roaming aspects for a 5G system with satellite access, the following requirements apply:

- A 5G system with satellite access that support roaming of UE for both satellite access and terrestrial access between 5G satellite networks and 5G terrestrial networks.

- UEs supporting satellite access that support optimized network selection and reselection to PLMNs with satellite access, based on home operator policy.

The Figure 4.5-1 shows the high-level network architecture for Roaming aspects of transparent satellite access.



Figure 4.5-1: Roaming aspects of transparent satellite access

# 5 Business roles and business scenarios

## 5.1 Business roles

The business roles for satellite charging in 5G can be split accordingly:

- Mobile Network Operator (MNO): an operator who can provide satellite communication services for SCC.

- Satellite Service Provider (SSP): a provider of satellite network services for MNO, e.g. satellite companies.

- Satellite Communication Customer (SCC): a consumer who uses satellite communication services from an MNO, e.g. UE.

- Mobile Virtual Network Operator (MVNO): an operator that does not have its own radio access or satellite network, but resells communication services, typically under their own brand name, using the network of a host MNO.

Depending on the scenarios an enterprise can play one or several roles simultaneously, e.g. MNO and SSP can be provided by the same enterprise, and apply business rules based on corresponding business agreements and relationships, e.g.:

- MNO has agreements with SCC for using satellite communication services.

- SSP has agreements with MNO for using satellite network services.

- MNO has agreements with other MNOs for inbound and outbound roamers.

- MVNO has agreements with MNO for use of terrestrial network service or satellite network services.

## 5.2 Business scenarios

### 5.2.1 S&F operation

Business scenario#1a: S&F operation

A UE with the store and forward capability attaches to the satellite in the store and forward mode, the data could be stored on the satellite when the feeder link is not available. When the feeder link is available, the UE data could be forwarded to the ground DN. Several satellites may be involved to finish the attach procedure or data transmission procedure.

An MNO rents satellites to deploy a full EPC or part of (e.g. eNB and part of MME functions)from an SSP, to be able to provide service to its customer. This means that there would be a wholesale agreement between MNO and SSP, where the MNO is the charged party and the SSP is the charging party. The MNO could be charged by SSP based on the usage of involved satellites.

An end user has a subscription with the MNO which allows it to use its services including the satellite store and forward service. The subscriber is charged party and the MNO is the charging party.

### 5.2.2 Roaming between MNOs with and without satellite networks

Business scenario#2a: Roaming between MNOs with and without satellite networks.

Subscriber of an MNO without satellite network roams into an MNO network with satellite network. The MNO without satellite network has a wholesale agreement with the MNO with satellite network where the MNO without satellite network would be the charged party and the MNO with satellite network would be the charging party for this scenario. The SCC can have subscription with the MNO that allows roaming into the MNO with satellite network. The SCC subscriber would be charged by the MNO, while the MNO with satellite network would do interconnect charging towards the MNO without satellite network. Likewise, an SCC can have a subscription with an MNO with satellite network allowing it to roam into an MNO without satellite network, where the MNO without satellite network would do interconnect charging towards the MNO with satellite network and the MNO with satellite network would charge the SCC.

### 5.2.3 5G satellite backhaul without UPF on-board

Business scenario#3a: 5G Satellite Backhaul.

SSP can lease satellites to MNO that can be used as part of the backhaul between (R)AN and 5GC. An MNO use satellites from SSP to achieve satellite backhaul. MNO could be charged by SSP based on the total data volume transferred via the satellite. In this scenario, UPF is not deployed on the satellite.

### 5.2.4 5G satellite backhaul with UPF on-board

Business scenario#3b: Edge Computing.

SSP can lease satellites to MNO that can be used to deploy, UPF on satellite. An MNO can use satellites from SSP to achieve edge computing via UPF deployed on the satellite. MNO could be charged by SSP based on usage of satellite per EAS related to EAS deployment (EAS deployment, EAS modification, EAS termination) and infrastructure resource (virtual CPU usage, virtual memory usage, virtual disk usage, data volumes).

### 5.2.5 MVNO which provide satellite communication services

Business scenario#4a: MVNO providing satellite communication services

MVNO rents satellite network resource from MNOs and then provide satellite communication services to its subscribers, i.e. it allows the subscribers usage of 5G data connectivity while in the host MNO.

The host MNO will collect charging information related to 5G data connectivity usage for charging the MVNO, and may collect charging information related to the 5G data connectivity usage for MVNO subscribes (per UE) and convey this to the MVNO. MVNO could be charged by host MNO based on the total data volume or other types of resource usage.

### 5.2.6 Business scenarios for UE-satellite-UE communication

Business scenario#5a: UE-satellite-UE communication

An end user has a subscription with the MNO which allows it to use its services including the UE-satellite-UE communication. The subscriber is charged party and the MNO is the charging party. An MNO rents satellites from an SSP, to be able to provide service to its customer. This means that there would be a wholesale agreement between MNO and SSP, where the MNO is the charged party and the SSP is the charging party. The MNO could be charged by SSP based on the traffic and the usage of involved satellites.

# 6 Charging scenarios and key issues

## 6.1 Topic 1: Charging scenarios for store and forward satellite operation

### 6.1.1 Use cases

#### 6.1.1.1 Use Case #1.1: MNO charges SCC

This use case focuses on SCC and MNO business scenario.

An SCC has a subscription with an MNO which rents the satellite from an SSP, to allow MNO to provide S&F operation to its subscribers.

The charging party and charged party can be:

- Charged party: the SCC identified by the UE.

- Charging party: MNO.

The MNO charges the subscribers based on the usage of satellites to provide the S&F operation service.

Potential charging requirements: REQ-CH\_ SAT\_PH3-01, REQ-CH\_ SAT\_PH3-02 and REQ-CH\_ SAT\_PH3-03.

#### 6.1.1.2 Use Case #1.2: MNO charged by SSP

This use case focuses on MNO and SSP business scenario.

An MNO has a wholesale agreement to use the satellite from an SSP for the deployment of eNB and NFs.

The charging party and charged party can be:

- Charged party: MNO.

- Charging party: SSP

The SSP charges MNO based on the usage of satellites to deploy the eNB and NFs.

Potential charging requirements: REQ-CH\_ SAT\_PH3-01, REQ-CH\_ SAT\_PH3-02 and REQ-CH\_ SAT\_PH3-03.

### 6.1.2 Potential charging requirements

The following are potential high-level charging requirements for satellite in 5GS, derived from the requirements in TS 23.401 [5].

**REQ-** **CH\_ SAT\_PH3-01**: The 5GS should support collecting charging information for S&F operation with SMS service.

**REQ-** **CH\_ SAT\_PH3-02**: The 5GS should support collecting charging information for S&F operation with CP CIoT service.

**REQ-** **CH\_ SAT\_PH3-03**: The 5GS should support collecting charging information for S&F operation with UP CIoT service.

### 6.1.3 Key issues

#### 6.1.3.1 Key issue #1.1: Charging events and charging information required

This key issue is for investigating how to support the S&F operation service charging considering REQ- CH\_ SAT\_PH3-01. This investigation covers the following:

- identification of the triggers for charging events for S&F operation;

- identification and classification of the charging information for S&F operation;

#### 6.1.3.2 Key issue #1.2: NF/Service suitable to provide charging information

This key issue is for investigating how to support the S&F operation charging considering REQ- CH\_ SAT\_PH3-01. This investigation covers the following:

- determination of which NF in the 4G system are suitable to provide the charging information to support the S&F operation.

### 6.1.4 Possible solutions

#### 6.1.4.1 Solution #1.1: MME Charging Trigger Function (CTF) based solution for S&F operation charging of SMS service

This solution which relying on EPC offline Charging System for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As described in the TR 23.700-29 [3], S&F Satellite operation is especially suited for the delivery of delay-tolerant/non-real-time satellite services (i.e. CIoT/MTC, SMS) that have been supported in the Rel-19. As described in the TS 23.401 [5], the UE registers in S&F mode to access S&F-based services from E-UTRAN satellite access running in S&F mode. The attach procedure for S&F-based services may use one or more satellites, depending on the deployment and implementation options. On-board MME determines a list of satellites (i.e. S&F Monitoring list) from the same (UE selected) PLMN with which UE can attempt to use to finish the attach procedure.

For the MME split architecture, the CTF may be deployed on the ground. The MME-ground together with the set of MME-onboard instances deployed in the set of satellites behaves jointly as a single MME entity and the UE context is synchronized between them. Each MME-onboard instance is associated with a different Satellite ID identifier. The high level of the MME split architecture is shown below:



Figure 6.1.4.1-1: MME split charging architecture

The MME-ground reports charging information to OFCS about satellite access running in S&F mode with the following trigger events:

- Short Message sent by a UE via the MME on-board (MO direction) to the SMSC;

- Short Message received by a UE via the MME on-board (MT direction) from the SMSC.

For the whole EPC on-board architecture, the CTF may be deployed on the satellite. SA2 has pointed out that this architecture does not support roaming. The high level of the whole EPC on-board architecture is shown below:



Figure 6.1.4.1-2: Whole EPC on-board charging architecture

The MME on-board reports charging information to OFCS about satellite access running in S&F mode with the following trigger events:

- Short Message sent by a UE via the MME on-board (MO direction) to the SMSC;

- Short Message received by a UE via the MME on-board (MT direction) from the SMSC.

The "SMS over MME Charging" information assignment for Service Information has the following charging information enhancements compared with the Table 6.3.1.1a.1 in TS 32.251 [7]:

- RAT type extends to include "WB-E-UTRAN(LEO)", "WB-E-UTRAN(MEO)", " WB-E-UTRAN(GEO)", " WB-E-UTRAN(OTHERSAT)", "NB-IoT(LEO)", "NB-IoT(MEO)", "NB-IoT(GEO)", "NB-IoT(OTHERSAT)", "LTE-M(LEO)", "LTE-M(MEO)", "LTE-M(GEO)" and "LTE-M(OTHERSAT)"

- Store and Forward indicator

- Satellite information

- Satellite Access Indicator

- S&F Monitoring list (i.e. Satellite IDs)

- Store duration

- Store data volume

The SMS-MO data in SGSN/MME (S-SMO-CDR) / SMS-MT data in SGSN/MME (S-SMT-CDR) may be produced for each short message via the MME on-board. The following enhancements are needed compared with the Tables 6.1.5.1/6.1.6.1 in TS 32.251 [7]:

Table 6.1.4.1: Extend to S-SMO-CDR/ S-SMT-CDR for S&F   
(3GPP TS 32.251 [7] – Tables 6.1.5.1/6.1.6.1)

|  |  |  |
| --- | --- | --- |
| Field | Category | Description |
| Satellite Access Indicator | OC | This field holds the use of 4G Satellite Access. |
| Satellite information | OC | This field holds all the satellite information that support to finish the Store and Forward Satellite operation. |
| Store and Forward indicator | OC | This field holds the use of Store and Forward Satellite operation. |
| S&F Monitoring list (1..max) | OC | This field holds the satellite IDs that used for the Store and Forward Satellite operation. |
| Store duration | OC | This field holds the storage duration of data on the satellite. |
| Store data volume | OC | This field stores the amount of data stored on the satellite. |

For IP data, this solution and MME-CDR would be specified in the TS 32.251 [7].

For non-IP data, this solution and MME-CDR would be specified in the TS 32.253 [12].

The corresponding AVPs for S&F operation would be specified in the TS 32.299 [13].

The MME-CDR ASN.1 would be specified in the TS 32.298 [14].

#### 6.1.4.2 Solution #1.2: MME Charging Trigger Function (CTF) based solution for S&F operation charging with Control Plane CIoT

This solution which relying on EPC offline Charging System for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in the clause 5.3.4B of TS 23.401 [5], when the UE accesses the network with Control Plane CIoT EPS Optimisation, the data is stored in the MME-onboard. The UE registers in S&F mode to access S&F-based services from E-UTRAN satellite access running in S&F mode. The attach and service request procedure for S&F-based services may use one or more satellites, depending on the deployment and implementation options. On-board MME determines a list of satellites (i.e. S&F Monitoring list) from the same (UE selected) PLMN with which UE can attempt to use to finish the attach and service request procedure.

For the MME split architecture, the CTF may be deployed on the ground. The MME-ground together with the set of MME-onboard instances deployed in the set of satellites behaves jointly as a single MME entity and the UE context is synchronized between them. Each MME-onboard instance is associated with a different Satellite ID identifier. The high level of the MME split architecture is shown below:



Figure 6.1.4.2-1: MME split charging architecture

The MME-ground reports charging information to OFCS about satellite access running in S&F mode with the following trigger events:

- Attach Complete via the MME onboard for the CIoT CP Optimizations;

- Service Request via the MME onboard for the CIoT CP Optimizations.

For the whole EPC on-board architecture, the CTF may be deployed on the satellite. SA2 has pointed out that this architecture does not support roaming. The high level of the whole EPC on-board architecture is shown below:



Figure 6.1.4.2-2: Whole EPC on-board charging architecture

The MME on-board reports charging information to OFCS about satellite access running in S&F mode with the following trigger events:

- Attach Complete via the MME onboard for the CIoT CP Optimizations.

- Service Request via the MME onboard for the CIoT CP Optimizations.

When the MME obtains the attach request or service request including S&F support indication from the UE and determines to support the S&F-based services, the MME (CTF) sends the Charging Data Request to OFCS for S&F operation charging, which has the following enhancement charging information:

- RAT type extends to include "WB-E-UTRAN(LEO)", "WB-E-UTRAN(MEO)", " WB-E-UTRAN(GEO)", " WB-E-UTRAN(OTHERSAT)", "NB-IoT(LEO)", "NB-IoT(MEO)", "NB-IoT(GEO)", "NB-IoT(OTHERSAT)", "LTE-M(LEO)", "LTE-M(MEO)", "LTE-M(GEO)" and "LTE-M(OTHERSAT)"

- Satellite Access Indicator

- Satellite information

- Store and Forward indicator

- S&F Monitoring list (i.e. Satellite IDs)

- Store duration

- Store data volume

Figure 6.1.4.2-1 describes the high level charging procedure for MME (CTF) charging for S&F operation charging of MME split architecture.



Figure 6.1.4.2-1: Attach procedure message flow for S&F operation charging with Control Plane CIoT

1. If the PLMN broadcast that it is in S&F mode, the UE sends the attach request including S&F support indication.

2. If the UE indicates that it supports S&F satellite operation, the on-board MME may consider whether to accept the request.

3-16. Attach procedure as described in clause 5.3.2.1 of TS 23.401 [5].

17. After successful attach, the MME may provide the estimated UL delivery time, a S&F wait timer and S&F monitoring list to UE in the Attach Accept message as described in clause 5.3.2.1 of TS 23.401 [5].

17ch-a. The MME sends Charging Data Request [Event] including Satellite Access Indicator, Store and Forward indicator and S&F Monitoring list to OFCS for the UE's successful attach for the S&F-based services.

17ch-b. The CDF creates the CDR.

17ch-c. The CDF acknowledges by sending Charging Data Response [Event] to the MME.

The high level charging procedure for whole EPC on-board architecture is similar to above. The only difference is that all the NFs are on the satellite.

The MME-CDR may be produced for S&F operation charging with Control Plane CIoT via the MME on-board and would be:

Table 6.1.4.2: MME-CDR

|  |  |  |
| --- | --- | --- |
| Field | Category | Description |
| Satellite Access Indicator | OC | This field holds the use of 4G Satellite Access. |
| Satellite information | OC | This field holds all the satellite information that support to finish the Store and Forward Satellite operation. |
| Store and Forward indicator | OC | This field holds the use of Store and Forward Satellite operation. |
| S&F Monitoring list (1..max) | OC | This field holds the satellite IDs that used for the Store and Forward Satellite operation. |
| Store duration | OC | This field holds the storage duration of data on the satellite. |
| Store data volume | OC | This field stores the amount of data stored on the satellite. |

For IP data, this solution and MME-CDR would be specified in the TS 32.251 [7].

For non-IP data, this solution and MME-CDR would be specified in the TS 32.253 [12].

The corresponding AVPs for S&F operation would be specified in the TS 32.299 [13].

The MME-CDR ASN.1 would be specified in the TS 32.298 [14].

#### 6.1.4.3 Solution #1.3: MME CDF/CGF based solution for S&F operation charging with User Plane CIoT

This solution which relying on EPC CDF/CGF for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in the TS 23.401 [5], only the whole EPC on-board architecture support using the User Plane CIoT EPS optimisation to transfer data.

UE using satellite access with S&F operation indication in the initial attach or the service request procedure can only be known by MME, CDR generation in MME can be used to charge the S&F operation of the User Plane CIoT service. For the whole EPC on-board architecture, the CDF/CGF may be deployed on the satellite. The high level of the whole EPC on-board architecture is the same as the Figure 6.1.4.1-2 of the solution#1.2.

The MME on-board reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following trigger events:

- Attach Complete via the MME onboard for the CIoT UP Optimizations;

- Service Request via the MME onboard for the CIoT UP Optimizations.

The charging solution is similar with the solution#1.2 except for all the devices are on the satellite.

Since the MME cannot obtain the store duration and store data volume, the charging information would be:

- RAT type extends to include "WB-E-UTRAN(LEO)", "WB-E-UTRAN(MEO)", " WB-E-UTRAN(GEO)", " WB-E-UTRAN(OTHERSAT)", "NB-IoT(LEO)", "NB-IoT(MEO)", "NB-IoT(GEO)", "NB-IoT(OTHERSAT)", "LTE-M(LEO)", "LTE-M(MEO)", "LTE-M(GEO)" and "LTE-M(OTHERSAT)"

- Satellite information

- Store and Forward indicator

- S&F Monitoring list (i.e. Satellite IDs)

- Satellite Access Indicator

#### 6.1.4.4 Solution #1.4: MME CDF/CGF based solution for S&F operation of SMS service

This solution which relying on EPC CDF/CGF for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As described in the TR 23.700-29 [3], S&F Satellite operation is especially suited for the delivery of delay-tolerant/non-real-time satellite services (i.e. CIoT/MTC, SMS) that have been supported in the Rel-19. As described in the TS 23.401 [5], the UE registers in S&F mode to access S&F-based services from E-UTRAN satellite access running in S&F mode. The attach procedure for S&F-based services may use one or more satellites, depending on the deployment and implementation options. On-board MME determines a list of satellites (i.e. S&F Monitoring list) from the same (UE selected) PLMN with which UE can attempt to use to finish the attach procedure.

For the MME split architecture, the CDF/CGF may be deployed on the ground. The MME ground together with the MME onboard behaves jointly as a single MME entity and the UE context is synchronized between them. Each MME-onboard is associated with a different Satellite ID identifier. The high level of the MME split architecture is shown below:



Figure 6.1.4.4-1: MME split charging architecture

The MME-ground reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following trigger events:

- Short Message sent by a UE via the MME onboard (MO direction) to the SMSC.

- Short Message received by a UE via the MME onboard (MT direction) from the SMSC.

For the whole EPC onboard architecture, the CDF/CGF may be deployed on the satellite. The high level of the whole EPC on-board architecture is shown below:



Figure 6.1.4.4-2: Whole EPC on-board charging architecture

The MME onboard reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following trigger events:

- Short Message sent by a UE via the MME onboard (MO direction) to the SMSC.

- Short Message received by a UE via the MME onboard (MT direction) from the SMSC.

Table 6.1.4.4-1 shows the enhancements needed for S-SMO-CDR and S-SMT-CDR compared with the Tables 6.1.5.1/6.1.6.1 in TS 32.251 [7].

Table 6.1.4.4-1 Extension to S-SMO-CDR/ S-SMT-CDR for S&F  
 (3GPP TS 32.251 [7] – Tables 6.1.5.1/6.1.6.1)

|  |  |  |
| --- | --- | --- |
| Field | Category | **Description** |
| RAT Type | OC | This field indicates the Radio Access Technology (RAT) type currently used by the UE, extended with RAT types for satellite. |
| Satellite information | OC | This field holds all the satellite information that support to finish the store and forward satellite operation. |
| Satellite Access Indicator | OC | This field indicates the use of satellite access. |
| S&F Indicator | OC | This field indicates the use of store and forward satellite operation. |
| S&F Monitoring List | OC | This field holds the satellite IDs that used for the store and forward satellite operation. |
| S&F Duration | OC | This field holds the storage duration of data on the satellite. |
| S&F Data volume | OC | This field holds the data volume stored on the satellite. |

#### 6.1.4.5 Solution #1.5: MME CDF/CGF based solution for S&F operation with CP data transfer

This solution which relying on EPC CDF/CGF for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in the clause 5.3.4B of TS 23.401 [5], when the UE accesses the network with Control Plane CIoT EPS Optimisation, the data is stored in the MME onboard. The UE registers in S&F mode to access S&F-based services from E-UTRAN satellite access running in S&F mode. The attach and service request procedure for S&F-based services may use one or more satellites, depending on the deployment and implementation options. On-board MME determines a list of satellites (i.e. S&F Monitoring list) from the same (UE selected) PLMN with which UE can attempt to use to finish the attach and service request procedure.

For the MME split architecture, the CDF/CGF may be deployed on the ground. The MME ground together with the MME onboard behaves jointly as a single MME entity and the UE context is synchronized between them. Each MME-onboard is associated with a different Satellite ID identifier. The high level of the MME split architecture is shown below:



Figure 6.1.4.5-1: MME split charging architecture

The MME ground reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following chargeable events:

- PDN connection creation/release. via the MME onboard for the Control Plane (CP) data transfer.

For the whole EPC onboard architecture, the CDF/CGF may be deployed on the satellite. The high level of the whole EPC onboard architecture is shown below:



Figure 6.1.4.5-2: Whole EPC on-board charging architecture

The MME onboard reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following trigger events:

- PDN connection creation/release. via the MME onboard for the CIoT CP Optimizations.

Table 6.1.4.5-1 shows the enhancements needed for CPDT-SNN-CDR compared with the Table 6.1.3.3.1 in TS 32.253 [12].

Table 6.1.4.5-1 Extension to CPDT-SNN-CDR for S&F (3GPP TS 32.253 [12] – Table 6.1.3.3.1)

|  |  |  |
| --- | --- | --- |
| Field | Category | Description |
| RAT Type | OC | This field indicates the Radio Access Technology (RAT) type currently used by the UE, extended with RAT types for satellite. |
| Satellite information | OC | This field holds all the satellite information that support to finish the store and forward satellite operation. |
| Satellite Access Indicator | OC | This field indicates the use of satellite access. |
| S&F Indicator | OC | This field indicates the use of store and forward satellite operation. |
| S&F Monitoring List | OC | This field holds the satellite IDs that used for the store and forward satellite operation. |
| S&F Duration | OC | This field holds the storage duration of data on the satellite. |
| S&F Data volume | OC | This field holds the data volume stored on the satellite. |

#### 6.1.4.6 Solution #1.6: SCEF CDF/CGF based solution for S&F with CP data transfer

This solution which relying on EPC CDF/CGF for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in the clause 5.3.4B of TS 23.401 [5], when the UE accesses the network with Control Plane CIoT EPS Optimisation, the data is stored in the MME onboard. The UE registers in S&F mode to access S&F-based services from E-UTRAN satellite access running in S&F mode. The attach and service request procedure for S&F-based services may use one or more satellites, depending on the deployment and implementation options. On-board MME determines a list of satellites (i.e. S&F Monitoring list) from the same (UE selected) PLMN with which UE can attempt to use to finish the attach and service request procedure.

For the MME split architecture, the CDF/CGF may be deployed on the ground. The MME ground together with the MME onboard behaves jointly as a single MME entity and the UE context is synchronized between them. Each MME-onboard is associated with a different Satellite ID identifier. The high level of the MME split architecture is shown below:



Figure 6.1.4.6-1: MME split charging architecture

The SCEF reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following trigger events:

- PDN connection creation/release via the SCEF for the Control Plane (CP) data transfer.

For the whole EPC onboard architecture, the CDF/CGF may be deployed on the satellite. The high level of the whole EPC onboard architecture is shown below:



Figure 6.1.4.6-2: Whole EPC charging architecture

The SCEF reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following trigger events:

- PDN connection creation/release via the SCEF for the Control Plane (CP) data transfer.

There is no enhancement required for the SCEF CDRs needed.

#### 6.1.4.7 Solution #1.7: TDF Charging Trigger Function (CTF) based solution for S&F operation charging with User Plane CIoT

This solution which relying on EPC offline Charging System for store and forward satellite operation charging, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in the TS 23.401 [5], only the whole EPC on-board architecture support using the User Plane CIoT EPS optimisation to transfer data. The EPS may expose whether a UE is in S&F Mode and provide to the SCS/AS related timing information to guide the SCS/AS decision when to try to contact the UE. The TS 23.401 [5], TS 23.203 [15] and TS 32.251 [7] would need to be enhanced to enable the S&F information to be transferred from the AS to TDF via PCRF.

For the whole EPC onboard architecture, the CDF/CGF may be deployed on the satellite. The high level of the whole EPC on-board architecture is shown below:



Figure 6.1.4.7-1: Whole EPC on-board charging architecture

The TDF onboard reports charging information to CGF or Billing Domain about satellite access running in S&F mode with the following chargeable events:

- PDN connection creation/release via the AS onboard for the User Plane data transfer.

Table 6.1.4.7-1 shows the enhancements needed for TDF-CDR compared with the Table 6.1.14.1 in TS 32.251 [7].

Table 6.1.4.7-1 Extension to TDF-CDR for S&F (3GPP TS 32.251 [7] – Table 6.1.14.1)

|  |  |  |
| --- | --- | --- |
| **Field** | **Category** | **Description** |
| RAT Type | OC | This field indicates the Radio Access Technology (RAT) type currently used by the UE, extended with RAT types for satellite. |
| Satellite information | OC | This field holds all the satellite information that support to finish the store and forward satellite operation. |
| Satellite Access Indicator | OC | This field indicates the use of satellite access. |
| S&F Indicator | OC | This field indicates the use of store and forward satellite operation. |
| S&F Monitoring List | OC | This field holds the satellite IDs that used for the store and forward satellite operation. |
| S&F Duration | OC | This field holds the storage duration of data on the satellite. |
| S&F Data volume | OC | This field holds the data volume stored on the satellite. |

### 6.1.5 Evaluation

#### 6.1.5.1 Solutions evaluation for Key issue #1.1

Solutions #1.1 addresses Key issue #1.1 and potential requirement REQ-CH\_ SAT\_PH3-01, for the SMS service using the satellite access running in the S&F mode, with the enhancement of the new trigger events and charging information. The new trigger events are Short Message sent by a UE via the MME on-board (MO direction) to the SMSC and Short Message received by a UE via the MME on-board (MT direction) from the SMSC. The enhancement of the charging information includes RAT type, Satellite Access Indicator, Store and Forward indicator, S&F Monitoring list, Store duration and Store data volume.

Solutions #1.2 addresses Key issue #1.1 and potential requirement REQ-CH\_ SAT\_PH3-02, for the Control Plane CIoT using the satellite access running in the S&F mode, with the new trigger events and charging information. The new trigger events are Attach Complete via the MME onboard for the CIoT CP Optimizations and Service Request via the MME onboard for the CIoT CP Optimizations. The charging information including RAT type, Satellite Access Indicator, Store and Forward indicator, S&F Monitoring list, Store duration and Store data volume.

Solutions #1.3 addresses Key issue #1.1 and potential requirement REQ-CH\_ SAT\_PH3-03, for the User Plane CIoT using the satellite access running in the S&F mode, with the new trigger events and charging information. The new trigger events are Attach to the MME onboard for the CIoT UP Optimizations and Service Request. The charging information including RAT type, Satellite Access Indicator, Store and Forward indicator and S&F Monitoring lists.

Solutions #1.4 addresses Key issue #1.1 and potential requirement REQ-CH\_ SAT\_PH3-01, for the SMS service using the satellite access running in the S&F mode, with the enhancement of the new charging information. The CDF/CGF may be deployed on the satellite. The enhancement of the charging information includes RAT type, Satellite Access Indicator, Store and Forward indicator, S&F Monitoring List, S&F Duration and S&F Data volume.

Solutions #1.5 addresses Key issue #1.1 and potential requirement REQ-CH\_ SAT\_PH3-02, for the Control Plane CIoT using the satellite access running in the S&F mode, with the new charging information. The CDF/CGF may be deployed on the satellite. The extension to CPDT-SNN-CDR for S&F charging include RAT type, Satellite Access Indicator, Store and Forward indicator, S&F Monitoring list, Store duration and Store data volume.

Solutions #1.6 addresses Key issue #1.1 and potential requirement REQ-CH\_ SAT\_PH3-02, for the Control Plane CIoT using the satellite access running in the S&F mode, with the new charging information. The CDF/CGF may be deployed on the satellite. There is no enhancement required for the SCEF CDRs needed.

Solutions #1.7 addresses Key issue #1.1, for the User Plane CIoT using the satellite access running in the S&F mode, with the new trigger events and charging information. The new trigger events are PDN connection creation/release via the AS onboard for the User Plane data transfer. The enhancement of the charging information includes RAT type, Satellite Access Indicator, Store and Forward indicator, S&F Monitoring List, S&F Duration and S&F Data volume.

All solutions propose to extend the triggers for MME CDRs and the information in the MME CDRs, except solution #1.4 which proposes to reuse the trigger events for MME and #1.6 which proposes to reuse the SCEF CDR. The solutions #1.1 and #1.2 also have some indication of extending Diameter.

#### 6.1.5.2 Solutions evaluation for Key issue #1.2

All address Key issue #1.2 and all solutions propose to have CDR generation in MME and except solution #1.6 which proposes SCEF. Solution #1.1 enhances the MME over SMS charging that MME provides the charging information. Solution #1.2, Solution#1.3, Solution#1.4 and Solution#1.5 directly uses the MME provides the charging information and provides the message flow. Solution #1.6 uses SCEF to report charging information to CGF or Billing Domain about satellite access running in S&F mode. Solution #1.7 uses TDF to report charging information to CGF or Billing Domain about satellite access running in S&F mode.

### 6.1.6 Conclusion

It is concluded that the solution #1.4 is the feasible solution for the SMS service using the satellite access running in the S&F mode. New parameters in MME CDRs need to be added for the S&F operation charging in the TS 32.251 [7]. The enhancement of charging principles for this case need to be enhanced in the TS 32.240 [16].

It is concluded that the solution #1.6 is the feasible solution for the CP CIoT service using the satellite access running in the S&F mode. No enhancement for the CDRs is needed. The enhancement of charging principles for this case need to be enhanced in the TS 32.240 [16].

It is concluded that the solution #1.3 is the feasible solution for the UP CIoT service using the satellite access running in the S&F mode. New trigger events and new parameters in MME CDRs need to be added for the S&F operation charging in the TS 32.251 [7]. The enhancement of charging principles for this case need to be enhanced in the TS 32.240 [16].

## 6.2 Topic 2: Roaming charging of satellite access

### 6.2.1 Use cases

#### 6.2.1.1 Use Case #2.1: MNO's subscriber roams to MNO with satellite network

This use case focuses on roaming between MNOs with and without satellite networks business scenario.

An SSC subscriber (identified by the UE) has a subscription with an MNO (i.e. HPLMN), the MNO has a roaming agreement with the MNO without satellite network.

When the UE has roamed to the coverage of the satellite network belonging to the other MNO, it will as an inbound roamer, access the satellite network provided by the MNO. The MNO provides the service access and connectivity for the UE.

When the UE moves back to the coverage of the terrestrial network, the MNO provides the terrestrial communication service access and connectivity for the UE based on the network selection policy, which is described in the TR 22.822 [6].

For the retail part the charging party and charged party can be:

- Charged party: SSC

- Charging party: MNO

For the wholesale part the charging party and charged party can be:

- Charged party: MNO

- Charging party: MNO with satellite network

The potential charging requirements for this Use Case is: REQ-CH\_ SAT\_RO-01.

#### 6.2.1.2 Use Case #2.2: MNO's SSC subscriber roams to MNO

This use case focuses on roaming between MNOs with and without satellite networks business scenario.

An SCC has a subscription with the MNO with satellite network, the MNO (with the SSC subscription) has a roaming agreement with the MNO.

When the SCC (identified by the UE) has moved to where it has coverage of both MNOs, it may based be on the network selection policy access the MNO, as the inbound roamer. The MNO provides service access and connectivity for the SCC.

For the retail part the charging party and charged party can be:

- Charged party: SCC

- Charging party: MNO

For the wholesale part the charging party and charged party can be:

- Charged party: MNO (with the SSC subscription)

- Charging party: MNO

The potential charging requirements for this Use Case is: REQ-CH\_ SAT\_ RO-01.

### 6.2.2 Potential charging requirements

The following are potential high-level charging requirements for satellite roaming:

**REQ-** **CH\_ SAT\_RO-01**: The 5GS should support collecting charging information for inbound Roaming UEs and out bound roaming UEs.

### 6.2.3 Key issues

#### 6.2.3.1 Key issue #2.1: Charging procedure for satellite roaming

This key issue is for investigating how to support the satellite roaming considering REQ- CH\_ SAT\_RO-01 and REQ- REQ- CH\_ SAT\_RO-02. This investigation covers the following:

- identification of the charging architecture for the satellite roaming;

- identification of triggers and potential roaming charging profile mechanism for satellite roaming;

- identification of charging information required to support the satellite roaming.

### 6.2.4 Possible solutions

#### 6.2.4.1 Solution #2.1: Roaming architecture for satellite roaming case

##### 6.2.4.1.1 General description

This solution #2.1 which relying on CHF/5G Converged Charging System for both satellite access charging and satellite backhaul charging in roaming cases, including the Home Routed and Local breakout roaming scenarios, addresses the Key Issue #2.1.

##### 6.2.4.1.2 Architecture description

The 5G System high level charging architecture for SMF charging in roaming cases as described in TS 32.255 [8] clause 4.2 can be used to support the satellite backhaul roaming, including three roaming architectures in Figure 6.2.4.1.2-1, Figure 6.2.4.1.2-2, Figure 6.2.4.1.2-3.

In this solution, the satellite access architecture refers to the Transparent Payload Satellite architecture where the 5GC NFs are deployed on the ground, as described in TR 28.844 [4] Figure 4.2-1. For instance, when VPLMN provide the satellite communication service for the inbound roamer, the V-SMF is deployed on the ground, but can report the satellite access or backhaul information to CHF. Both V-CHF (owned by the MNO that can provide satellite communication service) and H-CHF (owned by the MNO that only provide terrestrial communication service) are deployed on the ground.



Figure 6.2.4.1.2-1: The Home Routed roaming architecture



Figure 6.2.4.1.2-2: The Local breakout with N47 roaming architecture



Figure 6.2.4.1.2-3: The Local breakout with N107 roaming architecture

##### 6.2.4.1.3 Procedures description

For satellite backhaul charging:

- According to the figure 4.3.2.2.2 in TS 23.502 [9], for Home-routed Roaming case, the Nsmf\_PDUSession\_Create Request or Nsmf\_PDUSession\_Update Request is transferred from V-SMF to H-SMF in step6, including the Satellite backhaul category. The satellite backhaul category is reported to V-CHF and H-CHF, in the HR roaming scenario.

- According to the figure 4.3.2.2.1 in TS 23.502 [9], for Local breakout Roaming, the Nsmf\_PDUSession\_CreateSMContext Request and Nsmf\_PDUSession\_UpdateSMContext Request is transferred from AMF to SMF in step3, including the Satellite backhaul category, GEO Satellite ID. The satellite backhaul category and GEO Satellite ID is reported to V-CHF and H-CHF, in the LBO roaming scenario.

For satellite access charging:

- The satellite access type is reported to V-CHF and H-CHF, in both HR and LBO roaming scenarios.

### 6.2.5 Evaluation

#### 6.2.5.1 Solutions evaluation for Key issue #2.1

The solution #2.1 addresses Key issue #2.1, using V-SMF/H-SMF to provide the charging information for satellite backhaul charging and satellite access charging in roaming cases, with the required charging information (e.g. Satellite backhaul category, GEO Satellite ID) specified in the TS 32.255 [8]. No extension to the existing charging mechanism.

NOTE: The roaming charging for the Regenerative payload satellite architecture depends on the SA2 system and architecture enhancement, which is outside the scope of the present document.

### 6.2.6 Conclusion

The solution #2.1 is the only solution and therefore recommended into the normative work with the clarification in the TS 32.255 [8].

## 6.3 Topic 3: Charging for satellite resource usage between SSP and MNO

### 6.3.1 Use cases

#### 6.3.1.1 Use Case #1.1: SSP charging MNO for satellite used for backhaul

MNO has an agreement for rental of the satellite from SSP to be used for backhaul.

The charging party and charged party can be:

- Charged party: MNO.

- Charging party: SSP.

This charging could be based on the total data volume transferred via the satellite.

#### 6.3.1.2 Use Case #1.2: SSP charging MNO for edge computing via UPF deployed on the satellite

SSP provides the satellite infrastructure resources to terrestrial network operator to enable the EAS to be running on the satellite. The charging party and charged party can be:

- Charged party: MNO.

- Charging party: SSP.

This charging could be based on usage of satellite per EAS related to EAS deployment (EAS deployment, EAS modification, EAS termination) and infrastructure resource (virtual CPU usage, virtual memory usage, virtual disk usage, data volumes).

### 6.3.2 Potential charging requirements

**REQ-CH\_ SAT\_PH3\_BH-01**: The 5GS should support collecting and converging charging information per UE related to satellite backhaul service or edge computing for charging of an SSP.

### 6.3.3 Key issues

#### 6.3.3.1 Key issue #3.1: Charging information required

This key issue is for investigating how to support the charging for satellite resource usage between SSP and MNO considering REQ-CH\_ SAT\_PH3\_BH-01. This investigation covers the following:

- identification of charging information required to support the satellite resource usage charging.

#### 6.3.3.2 Key issue #3.2: Charging architecture and procedure

This key issue is for investigating how to support the charging for satellite resource usage between SSP and MNO considering REQ-CH\_ SAT\_PH3\_BH-01. This investigation covers the following:

- identification of the charging architecture for the satellite resource usage between SSP and MNO;

### 6.3.4 Possible solutions

#### 6.3.4.1 Solution #3.1: CDR in MNO for SSP to perform wholesale to MNO

##### 6.3.4.1.1 General description

A possible solution for key issue #3.1 and #3.2 covering requirements REQ-CH\_ SAT\_PH3\_BH-01.

##### 6.3.4.1.2 Architecture description



Figure 6.3.4.1.2-1: Satellite resource usage charging architecture

The SMF and CEF interact with CHF using Nchf interface. The CHF produces CDRs which may be send for wholesale charging which then can be used to aggregate and calculate the amount of charging data per UE for an SSP. The wholesale part is only included for completeness and is currently outside the scope of 3GPP SA5.

SMF collect charging data related to satellite backhaul (satellite backhaul category, data volumes) for each subscriber according to TS 32.255 [8].

CEF collect charging data related to EAS deployment (EAS deployment, EAS modification, EAS termination) and infrastructure resource (virtual CPU usage, virtual memory usage, virtual disk usage, data volumes) according to TS 32.257 [17].

##### 6.3.4.1.3 Procedures description

The message flows for satellite backhaul for each subscriber would be the same as in clause 5.2.2 of TS 32.255 [8]. The CHF produces CDRs which may be send for wholesale charging which then can be used to aggregate and calculate the amount of charging data per UE for an SSP.

The message flows for infrastructure resource usage would be the same as in clause 5.2.2 of TS 32.257 [17]. The CHF produces CDRs which may be send for wholesale charging which then can be used to aggregate and calculate the amount of charging data per UE for an SSP.

The message flows for EAS deployment would be the same as in clause 5.2.3 of TS 32.257 [17]. The CHF produces CDRs which may be send for wholesale charging which then can be used to aggregate and calculate the amount of charging data per UE for an SSP.

### 6.3.5 Evaluation

The solution #3.1 addresses Key issue #3.1. SMF collects charging data related to satellite backhaul, the required charging information (satellite backhaul category, data volumes) is specified in TS 32.255 [8]. CEF collects charging data related to edge computing via UPF deployed on the satellite, the required charging information for EAS deployment (EAS deployment, EAS modification, EAS termination) and infrastructure resource (virtual CPU usage, virtual memory usage, virtual disk usage, data volumes) is specified in TS 32.257 [17]. No extension to the existing charging information.

### 6.3.6 Conclusion

It is concluded that the solution #3.1 is a feasible solution and therefore recommended into the normative work with the clarification in TS 32.255 [8] and TS 32.257 [17].

## 6.4 Topic 4: Charging scenarios for UE-satellite-UE communication

### 6.4.1 Use cases

#### 6.4.1.1 Use Case #4.1: MNO charges SCC

This use case focuses on SCC and MNO business scenario.

An SCC has a subscription with an MNO which rents the satellite from an SSP, to allow MNO to provide UE-sat-UE to its subscribers.

The charging party and charged party can be:

- Charged party: the SCC identified by the UE.

- Charging party: MNO.

The MNO charges the subscribers based on the usage of satellites to provide the UE-sat-UE communication service.

Potential charging requirements: REQ- CH\_ SAT\_PH3-01.

#### 6.4.1.2 Use Case #4.2: MNO charged by SSP

This use case focuses on MNO and SSP business scenario.

An MNO has a wholesale agreement to use the satellite from an SSP.

The charging party and charged party can be:

- Charged party: MNO.

- Charging party: SSP

The SSP charges MNO based on the usage of satellites.

Potential charging requirements: REQ- CH\_ SAT\_PH3-01.

### 6.4.2 Potential charging requirements

The following are potential high-level charging requirements for satellite in 5GS, derived from the requirements in TS 23.501 [10] and TS 23.228 [11].

**REQ-** **CH\_ SAT\_PH3-01**: The 5GS should support collecting charging information for UE-sat-UE communication service.

### 6.4.3 Key issues

#### 6.4.3.1 Key issue #4.1: Charging events and charging information required

This key issue is for investigating how to support the UE-sat-UE communication service charging considering REQ- CH\_ SAT\_IMS-01. This investigation covers the following:

- identification of the triggers for charging events for UE-sat-UE communication;

- identification and classification of the charging information for UE-sat-UE communication;

- determination of which NF in the IMS are suitable to provide the charging information to support the UE-sat-UE communication.

### 6.4.4 Possible solutions

#### 6.4.4.1 Solution #4.1: IMS-GWF Charging Trigger Function (CTF) based solution for UE-SAT-UE communication

This solution which relying on IMS converged Charging System for UE-SAT-UE communication, addresses the Key Issue#1.1 and Key Issue#1.2.

As specified in the TS 23.228 [11], if UE-Satellite-UE communication in IMS is supported, the P-CSCF receives from the PCF the identifier of the satellite serving the UE and receives from the P-CSCF serving the remote UE the identifier of the satellite serving the remote UE via the IMS AGW on ground. The P-CSCF uses this information to determine whether or not activate optimized media routing. If the P-CSCF determines the activation of optimized media routing is possible, the P-CSCF releases the IMS AGW on ground when needed and select instead an IMS AGW on satellite.

For the session procedure, the Figure 6.4.4.1-1 describes the high level charging procedure for IMS-GWF (CTF) charging for UE-SAT-UE communication.



Figure 6.4.4.1-1: Charging message flow for UE-SAT-UE session establishment procedure

1. UE A sends a SIP INVITE request, containing an initial SDP offer, to P CSCF A. The access information in the SIP INVITE request indicates that the UE is accessing from NR satellites access

2. After receiving the SIP INVITE request indicating NR satellite access, if UE A is in the non-roaming scenario and the P-CSCF A supports UE-Satellite-UE communication, it may perform following actions to determine whether UE-satellite-UE communication is possible:

- P-CSCF A retrieves Access Network Information from PCF based on the mechanism defined in TS 23.503 [21] and determines whether the UE A is using regenerative satellite access or not based on whether a serving satellite identification is obtained as part of the Access Network Information or not.

3. The P-CSCF A allocates an IMS-AGW A (e.g. on the ground). P-CSCF A interacts with IMS-AGW A to allocate transport resources. The P-CSCF A sends the support of UE-Satellite-UE communication to the whole IMS functions including S-CSCF and IMS-GWF.

4. The IMS-GWF A sends a Charging Data Request[Initial] to the CHF A to record start of a user session. And start of a media component in the CHF CDR including AGW on the ground indication, AGW IP address information, AGW on the ground start time stamp for UE-SAT-UE communication.

5. The CHF A acknowledges the reception of the data and opens a CDR. P-CSCF sends a SIP MESSAGE to IMS AS to request it to send SIP re-INVITE to the terminating network and then towards the UE in the originating network after receiving the SDP answer from the terminating network. This SIP message contains the IP address allocated in IMS AGW on the target satellite to be used by the terminating network as the destination of media traffic. This SIP message also contains the satellite ID of the target satellite. IMS AS sends SIP re-INVITE to the terminating network. This SIP re-INVITE contains an SDP offer that has the IP address allocated in IMS AGW on the target satellite to be used by the terminating network as the destination of media traffic. This SIP re-INVITE also contains a SIP header for conveying the satellite ID of the target satellite.

6. Same procedure as the steps 5-10 in Figure AE.5.1-1 of TS 23.228 [11]. The P-CSCF A sends the satellite ID to the whole IMS functions including S-CSCF and IMS-GWF.

7. The IMS-GWF B sends a Charging Data Request[Initial] to the CHF B to record start of a user session for UE B. And start of a media component in the CHF CDR including AGW on the ground indication, AGW IP address information, AGW on the ground start time stamp for UE-SAT-UE communication.

8. The CHF B acknowledges the reception of the data and opens a CDR.

9. More SIP signalling as the steps 11-15 in the TS 23.228 [11]. P-CSCF A determines to perform UE-satellite-UE communication and determines to change IMS-AGW from A (e.g. on the ground) to A' (e.g. on the satellite).

10. P-CSCF A interacts with IMS-AGW A' on satellite to allocate transport resources for both IMS access and core network sides. P-CSCF A also releases the IMS-AGW A on ground.

11. The IMS-GWF A sends a Charging Data Request[Update] to the CHF A to record update of a user session. And update of a media component in the CHF CDR including AGW on the ground indication, AGW IP address information, AGW on the ground end time stamp. The IMS-GWF A' sends a Charging Data Request[Update] to the CHF A to record update of a user session. And update of a media component in the CHF CDR including Satellite ID, AGW on the satellite indication, AGW IP address information, AGW on the satellite start time stamp for UE-SAT-UE communication.

12. The CHF A acknowledges the reception of the data and opens a CDR.

13-14. P-CSCF A forwards the Response Confirmation to P-CSCF B. The Response Confirmation includes SDP offer modified/generated by P-CSCF A. Upon receiving the SDP offer, P-CSCF B updates the allocated IMS-AGW on the satellite for UE B with the transport address in the SDP offer.

15. The IMS-GWF B sends a Charging Data Request[Update] to the CHF B to record update of a user session. And update of a media component in the CHF CDR including AGW on the ground indication, AGW IP address information, AGW on the ground end time stamp. The IMS-GWF B' sends a Charging Data Request[Update] to the CHF B to record update of a user session. And update of a media component in the CHF CDR including Satellite ID, AGW on the satellite indication, AGW IP address information, AGW on the satellite start time stamp for UE-SAT-UE communication.

16. The CHF B acknowledges the reception of the data and opens a CDR.

17. Procedure continues

18. P-CSCF releases IMS AGW on the source satellite sometime after receiving SIP 200 OK.

19. The IMS-GWF sends a Charging Data Request[Termination] to the CHF to record end of a user session. And end of a media component in the CHF CDR including Satellite ID, AGW on the satellite indication, AGW IP address information, AGW on the satellite end time stamp for UE-SAT-UE communication.

20. The CHF A acknowledges the reception of the data and opens a CDR.

As specified in the TS 23.228 [11], if the originating network cannot continue, P-CSCF determines IMS AGW relocation and media routing path change due to change of satellites. Moreover, if P-CSCF determines that optimized media routing cannot continue if there is no target satellite ID included, or the two satellites identified by the satellite ID for the originating network and the satellite ID stored for the terminating network has no ISLs. The P-CSCF determines to activate ground fallback routing.

For above cases, the main change is based on the SIP RE-INVITE message triggering the change of IMS GWF. So the default trigger conditions in IMS node in the Table 5.4.3.1 of TS 32.260 [18] need to have the following enhancements:

- SIP RE-INVITE or UPDATE due to IMS AGW IP address changes

The IMS charging information in the clause 6.4.2.2.1 of TS 32.260 [18] need to have the following enhancements:

- Satellite ID

Note: The satellite ID is planned to be specified in the SIP header of the TS 24.229 [19].

#### 6.4.4.2 Solution #4.2: IMS based charging for UE-Sat-UE communication

This solution which relying on IMS for UE-satellite-UE charging, addresses the Key Issue#4.1.

UE-satellite-UE communication for IMS voice implies that the IMS architecture will be used and therefore should be able to reuse the IMS charging in TS 32.260 [18] and TS 32.275 [20].

### 6.4.5 Evaluation

#### 6.4.5.1 Solutions evaluation for Key issue #4.1

Solution #4.1 addresses Key Issue #1.1 using the enhancement of the new charging information. It uses IMS-GWF to report charging information to CHF about the state of UE-SAT-UE communication. The enhancement of the IMS charging information includes Satellite ID.

Solution #4.2 addresses Key Issue #1.1 by reusing the IMS charging in TS 32.260 [18] and TS 32.275 [20].

Note: The satellite ID is planned to be specified in the SIP header of the TS 24.229 [19]. If the satellite ID is not specified by CT1 finally, no enhancement is needed for the IMS charging information.

### 6.4.6 Conclusion

It is concluded that the solution #4.1 is the feasible solution for UE-SAT-UE communication. New parameters need to be added for the UE-SAT-UE communication.

Note: The satellite ID is planned to be specified in the SIP header of the TS 24.229 [19]. If the satellite ID is not specified by CT1 finally, no enhancement is needed for the IMS charging information.

## 6.5 Topic 5: Charging scenarios for MVNO which provide satellite communication services

### 6.5.1 Use cases

#### 6.5.1.1 Use Case #5.1: MVNO charges SCC

This use case focuses on SCC and MVNO business scenario.

An SCC has a subscription with an MVNO which rents network resource from MNOs and then provide satellite communication services to its subscribers.

The charging party and charged party can be:

- Charged party: the SCC identified by the UE.

- Charging party: MVNO.

The MVNO charges the subscribers based on data connectivity usage.

#### 6.5.1.2 Use Case #5.2: MVNO charged by MNO

This use case focuses on MVNO and MNO business scenario.

An MVNO has a wholesale agreement to use the network resource from MNOs and then provide satellite communication services to its subscribers.

The charging party and charged party can be:

- Charged party: MVNO.

- Charging party: MNO.

The MNO charges MVNO based on the total data volume or other types of resource usage.

### 6.5.2 Potential charging requirements

The following are potential high-level charging requirements for MVNO which provide satellite communication services:

**REQ-CH\_ SAT\_MVNO-01**: The charging mechanism should support collecting and conveying charging information related to 5G data connectivity usage for each UE.

**REQ-CH\_ SAT\_MVNO-02**: The charging mechanism should support collecting and conveying charging information related to 5G data connectivity usage for each MVNO.

### 6.5.3 Key issues

#### 6.5.3.1 Key issue #5.1: Charging information, architecture and procedure

This key issue is for investigating how to support MVNO which provide satellite communication services considering REQ-CH\_ SAT\_MVNO-01 and REQ-CH\_ SAT\_MVNO-02. This investigation covers the following:

- identification of charging information required to support MVNO which provide satellite communication services.

- identification of the charging architecture and procedure for MVNO which provide satellite communication services.

### 6.5.4 Possible solutions

#### 6.5.4.1 Solution #5.1: MNO performs wholesale charging and MVNO performs retail charging

##### 6.5.4.1.1 General description

A possible solution for key issue #5.1 covering requirements REQ-CH\_ SAT\_MVNO-01 and REQ-CH\_ SAT\_MVNO-02.

##### 6.5.4.1.2 Architecture description

The 5G System high level charging architecture for 5G data connectivity converged charging architecture in Local Breakout V-SMF to H-CHF scenario reference point representation or 5G data connectivity converged charging architecture in Local Breakout Inter-CHF scenario reference point representation as described in TS 32.255 [8] clause 4.2 can be used to support the MVNO charging which provide satellite communication services.



Figure 6.5.4.1.2-1: 5G data connectivity converged charging architecture in Local Breakout V-SMF to H-CHF scenario reference point representation

For scenarios with MVNO (owning a CHF referred to as A-CHF) non-roaming, the N40 reference point is defined for the interactions between SMF and CHF owned by MNO, the N47 reference point is used for the interactions between SMF owned by the MNO and A-CHF owned by the MVNO.

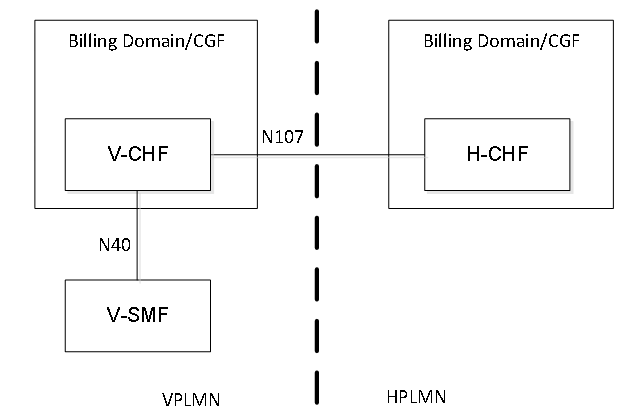


Figure 6.5.4.1.2-2: 5G data connectivity converged charging architecture in Local Breakout Inter-CHF scenario reference point representation

For scenarios with MVNO (owning a CHF referred to as A-CHF) non-roaming, the N40 reference point is defined for the interactions between SMF and CHF owned by MNO, the N107 reference point is used for the interactions between CHF owned by the MNO and A-CHF owned by the MVNO.

There are following differences on the SMF interactions with the CHF in the MNO and A-CHF in the MVNO:

- V-SMF in V-PLMN is replaced by the SMF in MNO;

- V-CHF in V-PLMN is replaced by the CHF in MNO;

- H-CHF in H-PLMN is replaced by the A-CHF in MVNO.

N47 or N107 used by A-CHF owned by an additional actor (i.e. MVNO) to perform retail charging for its own subscribers is operator specific.

The CDRs produced by CHF in MNO may be sent for wholesale charging, which then can be used to aggregate and calculate the amount of charging data per MVNO.

For satellite backhaul charging, the satellite backhaul category is reported to CHF in MNO and A-CHF.

For satellite access charging, the satellite access type is reported to CHF in MNO and A-CHF.

##### 6.5.4.1.3 Procedures description

The message flows for the PDU session establishment, PDU session Modification and PDU session Release for LBO charging specified in clause 5.2.2.18 of TS 32.255 [8] could be applicable depending on the deployment scenarios for additional actor (MVNO), with the following differences:

- V-SMF in V-PLMN is replaced by the SMF in MNO;

- V-CHF in V-PLMN is replaced by the CHF in MNO;

- H-CHF in H-PLMN is replaced by the A-CHF in MVNO.

### 6.5.5 Evaluation

Solutions #5.1 solves key issues #5.1. The satellite information is reported to CHF in MNO and A-CHF to support MVNO charging.

### 6.5.6 Conclusion

It is concluded that the solution #5.1 is the feasible solution and new parameters related to satellite information need to be added for MVNO charging.

# 7 Conclusions and Recommendations

The present technical report described the business roles and business scenarios (see clause 5) including store and forward operation with spilt MME architecture, S&F operation with full EPC on-board architecture, roaming between MNOs with and without satellite networks, 5G satellite backhaul without UPF on-board, 5G satellite backhaul with UPF on-board, MVNO which provide satellite communication services and Business scenarios for UE-satellite-UE communication. The present document also identified and documented the use cases and key issues, derived the corresponding potential requirements, and developed and evaluated the possible solutions (see clause 5) for satellite charging. The present document made conclusions on the following aspects:

- Store and forward satellite operation charging in clause 6.1.6.

- Roaming charging of satellite access in clause 6.2.6.

- Charging for satellite resource usage between SSP and MNO in clause 6.3.6.

- UE-satellite-UE communication charging in clause 6.4.6 and

- Charging for MVNO which provide satellite communication services in clause 6.5.6.

To support converged charging for satellite in normative work, the business relationships need to be updated in the TS 32.255 [8].

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2024-08 | SA5#156 | S5-244186 |  |  |  | Initial skeleton | 0.0.0 |
| 2024-08 | SA5#156 | S5-244187  S5-244188  S5-244504  S5-244505  S5-244506  S5-244507  S5-244508  S5-244509  S5-244510  S5-244528  S5-244529  S5-244530  S5-244531 |  |  |  | Add the skeleton to TR 28.846  Add scope and reference to TR 28.846  Add the background for FS\_5GSAT\_Ph3\_CH to TR 28.846  Introduce the background for satellite access charging  Add business roles for satellite charging  Introduce the use cases for the roaming charging of satellite access  Add business scenarios for roaming from terrestrial operator network to satellite operator network  Add business scenarios for satellite resource rental between satellite network operator and terrestrial network operator  Charging for satellite resource rental between satellite network operator and terrestrial network operator  Charging between satellite operator and satellite MVNO  Add business scenarios for store and forward satellite operation  Add charging scenarios and charging requirements for store and forward satellite operation  Add key issues for store and forward satellite operation charging | 0.1.0 |
| 2024-10 | SA5#157 | S5-245878  S5-245908  S5-245909  S5-245910  S5-245911  S5-245912  S5-245913  S5-245914  S5-245915 |  |  |  | Update of business roles and scenarios  Add store and forward satellite operation charging solutions for SMS  Add store and forward satellite operation charging solutions for Control Plane CIoT  Add evaluation for store and forward satellite operation charging  Update charging scenario for Satellite Roaming Charging  Introduce the solution for Satellite Roaming Charging  Clarification of topic 1 use cases  Clarification of topic 2 use cases  Clarification of topic 3 use cases | 0.2.0 |
| 2024-11 | SA5#158 | S5-246935  S5-246936  S5-246937  S5-246938  S5-246939  S5-246940  S5-246941  S5-246942  S5-246943  S5-246944  S5-246945  S5-246946  S5-246947  S5-246832  S5-246948  S5-246949  S5-246950  S5-246951 |  |  |  | Clarification on the business roles  Resolve EN in the satellite roaming charging solution  Evaluation and conclusion for satellite charging topic 2  Add Charging requirements and Key issues for satellite resource usage charging  Add Possible Solution, Evaluation and Conclusion for satellite resource usage charging  Add Use cases, Potential charging requirements and Key issues for MVNO providing satellite service  Add Possible Solution, Evaluation and Conclusion for MVNO charging  Update background for UE-satellite-UE communication  Add business scenarios for UE-satellite-UE communication  Add charging scenarios and charging requirements for UE-satellite-UE communication  Add key issues for UE-satellite-UE communication charging  Update store and forward satellite operation charging solutions to solve Ens  Add store and forward satellite operation charging solutions for User Plane CIoT  MME CDF\_CGF based solution for S\_F operation of SMS service  MME CDF\_CGF based solution for S\_F operation with CP data transfer  SCEF CDF\_CGF based solution for S\_F operation with CP data transfer  Update evaluation for store and forward satellite operation charging  Add conclusion for store and forward satellite operation charging | 0.3.0 |
| 2024-12 |  |  |  |  |  | editHelp's cleanup | 0.3.1 |
| 2024-12 | SA#106 | SP-241600 |  |  |  | Presentation to SA for Information | 1.0.0 |
| 2025-02 | SA5#159 | S5-250702  S5-250703  S5-250704  S5-250705  S5-250706  S5-250707  S5-250708  S5-250709  S5-250710  S5-250711  S5-250535  S5-250712  S5-250713  S5-250714  S5-250509 |  |  |  | Architecture updates  Business scenario updates  Add TDF based solution for S&F operation charging with User Plane CIoT  New solution for topic 1  Update evaluation for store and forward satellite operation charging  Update conclusion for store and forward satellite operation charging  Correction and conclusion update for topic 1  Add References, Evaluation and Conclusion for satellite resource usage charging  Solution update for topic 3  Add charging solutions for UE-SAT-UE communication  Solution for topic 4  Add evaluation for UE-SAT-UE communication  Add conclusion for UE-SAT-UE communication  Add conclusions and recommendations  Clean TR 28.846 based on edithelp | 1.1.0 |
| 2025-02 | SA5#159 |  |  |  |  | EditHelp cleanup | 1.1.1 |
| 2025-03 | SA#107 | SP-250144 |  |  |  | Presentation to SA for approval | 2.0.0 |
| 2025-03 | SA#107 |  |  |  |  | Upgrade to change control version | 19.0.0 |
| 2025-06 | SA#108 | SP-250518 | 0001 | 1 | D | Update reference for the TR | 19.1.0 |