**3GPP TSG-SA5 Meeting #155 *S5-242779***

Jeju, South Korea, 27 - 31 May 2024

**Source: Ericsson**

**Title: pCR 28.874 Add potential solutions for Management of connections and associations between satellite and ground systems**

**Document for: Approval**

**Agenda Item: 6.19.15**

# 1 Decision/action requested

***In this box give a very clear / short /concise statement of what is wanted.***

# 2 References

[1] 3GPP TR 28.874-010 Study on management aspects of NTN – Phase 2

# 3 Rationale

A potential solution is proposed for the two use cases #1 and #2.

# 4 Detailed proposal

# 5 Use cases, potential requirements and solutions

## 5.1 Management of connections and associations between satellite and ground systems (gNB/eNB/CN/management system)

### 5.1.1 Use case #1: Connections between RAN node on-board satellite and CN (regenerative mode)

#### 5.1.1.1 Description

When non-geo synchronized objects like LEO and MEO satellites are used for the NTN system, the satellites will not always be at the same position relative the earth’s surface, and the coverage area on the earth surface for one satellite varies over time.

One consequence of non-geosynchronous satellites is that the associations between the entities on ground segment and entities in space segment are changing frequently, typically with a period of one to several minutes.



Figure 5.1.1.1-1 Non-geosynchronous satellites in NTN with regenerative gNB processed satellite payload

Fig. 5.1.1.1-1 illustrates this association change in an NTN system with regenerative gNB satellite payload. In this case, the ground segment Core Network (CN) will serve the same spotbeams all the time, while the space segment gNB on different satellites (satellite 1, 2 and 3) will serve the spotbeam in different time period as the satellites are approaching and leaving the coverage of the spotbeam over time. From management point of view, it will e.g. impact the association between GNBCUCPFunction and AMFFunction.

Another issue is the topology between space segment Managed Element (MnS producer) and the ground based Management System (MnS consumer): With long distances in between, disturbances (e.g. bad weather conditions), and partial reachability issues (when satellites fly over oceans with no gateway coverage), the latency, availability and reliability of the interface between them (feeder link + Inter-satellite link) are impacted.

Summary:

For the deployment scenario of RAN nodes on-board satellites, this would result in the following scenario: a LEO or MEO satellite with an onboard RAN node leaves the coverage area of a CN and then returns to the coverage area of that CN after cycling around the Earth.

From the operator’s perspective, it’s necessary to investigate how to efficiently manage the connections between RAN nodes and CN to avoid errors in CN due to stale connections, e.g. AMF/MME sending paging requests or AMF configuration updates to an unavailable RAN node. For example, 3GPP management system configures AMF/MME and/or gNB/eNB to add necessary information to support their awareness of when connectivity between a RAN node and a CN NF is available or unavailable.

#### 5.1.1.2 Potential requirements

**REQ-NTN-REGCON-1：**3GPP MnS producer should have the capability to configure the connections between RAN nodes on-board satellite and 5GC on an unreliable management interface.

#### 5.1.1.3 Potential solutions

##### 5.1.1.3.1 Potential solution #<1>: Batch pre-configuration of the eNB/MME gNB/AMF associations

For NTN with regenerative eNB/gNB processed satellite payload, it is assumed that the sector equipment and eNB/gNB are located at the satellites, while MME/AMF and ProvMnS consumer are located on ground according to figure below.



**Figure 5.1.1.3.1-1 Location of NTN functions for regenerative eNB/gNB processed satellite payload.**

As mentioned in the Use case #1 description, the interface between functions in the ground segment and space segment is unreliable, and the relationship between the eNB/gNB and MME/AMF is changing all the time, therefore there is a need to pre-configure the relation (association) between eNB/gNB and MME/AMF end points as a batch in advance.

For LTE/EPC, in order to realize batch configuration of the association, one possible solution is to modify the EP\_RP\_EPS (on eNB side) and EP\_RP\_EPS (on MME side) instances.

Attribute farEndNeIpAddr, which consists of an IP address of the remote MME/eNB, is replaced by attribute farEndNeIpAddrList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and IP address(es) of the remote MME/eNB. Further, the FarEndEntity attribute (inherited from EP\_RP) also needs to be replaced by a list where each list element consists of a FarEndEntity and a timeWindow.

For NR/5GC, in order to realize batch configuration of the association, one possible solution is to modify the EP\_NgC (on gNB side) and EP\_N2 (on AMF side) instances.

Attribute remoteAddress, which consists of an IP address of the remote AMF/gNB, is replaced by attribute remoteAddressList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and IP address of the remote AMF/gNB. Further, the FarEndEntity attribute (inherited from EP\_RP) also needs to be replaced by a list where each list element consists of a FarEndEntity and a timeWindow.

Editor’s Note: An alternative potential solution may also be considered, based on the approach that all different time windows for one type of association are handled by means of one instance of e.g. EP\_NgC for each time window. This option may avoid a potential backward compatibility issue with the above solution, but has the drawback of managing a huge number of instances for all the connections (hundreds or even thousands) with the high system load to create and update them frequently, and risk of delays in the creation/updates due to loss of feeder link between the management system and satellites. It also introduces a new risk of inconsistent associations in case the feeder link is lost during the ongoing execution of updates of all the associations for one or more gNB/eNB onboard satellites.

Editor’s Note: This solution needs further consideration and evaluation, especially concerning the complexity and backward compatibility.

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration for NR/5GC, is shown below.

 

**Figure 5.1.1.3.1-2 Sequence diagram: Configuration of gNB/AMF endpoint as a batch (for NR/5GC)**

1. For each gNB in space, the ProvMnS consumer creates a number of EP\_NgC instances for the CUCPFunction through ProvMnS. The number of EP\_NgC instances shall be equal to the max number of simultaneous AMFs that the gNB will connect to during its movement in the satellite orbit.

For each AMF on ground, the ProvMnS consumer creates a number of EP\_N2 instances for the AMFFunction through ProvMnS. The number of EP\_N2 instances shall be equal to the max number of simultaneous gNBs that the AMF will connect to.
2. The ProvMnS consumer receives, from an external entity, a list of the associations between all the gNBs in space and the AMFs on ground over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. position of the ground gateways, and possibility for the AMFs to connected to these ground gateways, the expected orbit position of the space gNBs over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite gNB, ground gateways, ground AMF, transport over the time period, etc. Observe that the MnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.
3. The ProvMnS consumer sends, to each gNB in space, a batch of its associations to all AMFs during the time period by the ProvMnS service ModifyMOIAttributes() with the remoteAddressList for all the EP\_NgC instances in the gNB. FarEndEntity attribute (inherited from EP\_RP) also needs to be replaced by a list where each list element consists of a FarEndEntity and a timeWindow.
4. The ProvMnS consumer sends, to each AMF on ground, a batch of its associations to all gNBs during the time period by the ProvMnS service ModifyMOIAttributes() with the remoteAddressList for all the EP\_N2 in the AMFs. FarEndEntity attribute (inherited from EP\_RP) also needs to be replaced by a list where each list element consists of a FarEndEntity and a timeWindow.
5. The actual changes of all EP\_NgC associations to AMFs for all gNBs over the time period are continuously and timely executed by the gNBs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notificationservice.
6. The actual changes of all EP\_N2 associations to gNB for all AMF over the time period are continuously and timely executed by the AMFs according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notificationservice.

#### 5.1.1.4 Evaluation of potential solutions

### 5.1.2 Use case #2: Associations between SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground (transparent mode)

#### 5.1.2.1 Description

When non-geo synchronized objects like LEO and MEO satellites are used for the NTN system, the satellites will not always be at the same position relative the earth’s surface, and the coverage area on the earth surface for one satellite varies over time.

One consequence of non-geosynchronous satellites is that the associations between the entities on ground segment and entities in space segment are changing frequently, typically with a period of one to several minutes.



Figure 5.1.2.1-1 Non-geosynchronous satellites in NTN system with transparent satellite payload

Fig. 5.1.2.1-1 illustrates this association change in an NTN system with transparent satellite payload. In this case, the ground segment gNB will serve the same spotbeams all the time, while different satellites (satellite 1, 2 and 3) in the space segment will serve the same spotbeam in different time periods as the satellites are approaching and leaving the coverage to the spotbeam over time. From management point of view, it will e.g. impact the association between NRSectorCarrier in the gNB and SectorEquipmentFunction in the satellite.

Another issue is the topology between space segment Managed Element (MnS producer) and the ground based Management System (MnS consumer): With long distances in between, disturbances (e.g. bad weather conditions), and partial reachability issues (when satellites fly over oceans with no gateway coverage), the latency, availability and reliability of the interface between them (feeder link + Inter-satellite link) are impacted.

Summary:

For the deployment scenario of SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground, this would result in the following scenario: a LEO or MEO satellite with an onboard SectorEquipmentFunction leaves the coverage area of a RAN node (gNB/eNB) on ground and then returns to the coverage area of that RAN node (gNB/eNB) after cycling around the Earth.

From the operator’s perspective, it’s necessary to investigate how to efficiently manage the connections between SectorEquipmentFunction on-board satellite and the RAN nodes (gNB/eNB) on ground due to stale connections. For example, 3GPP management system configures association between NRSectorCarrier in the gNB and SectorEquipmentFunction in the satellite, adding necessary information to support their awareness of when connectivity between the satellite and the RAN nodes (gNB/eNB) on ground is available or unavailable.

#### 5.1.2.2 Potential requirements

**REQ-NTN-TRANSCON-1：**3GPP MnS producer should have the capability to configure the associations between SectorEquipmentFunction on-board satellite and NRSectorCarrier in the RAN nodes (gNB/eNB) on ground on an unreliable management interface.

#### 5.1.2.3 Potential solutions

##### 5.1.2.3.1 Potential solution #<1>: Batch pre-configuration of the NRSectorCarrier/ sectorEquipmentFunction associations

For NTN with transparent satellite payload, it is assumed that the sector equipment is located at the satellites, while eNB/gNB, MME/AMF (not shown in the figure) and the ProvMnS consumer are located on ground according to figure below.



**Figure 5.1.2.3.1-1 Location of NTN functions for transparent satellite payload according to 3GPP architecture**

As mentioned in the Use case #2 description, the interface between functions in the ground segment and space segment is unreliable, and the relationships between the eNB/gNB and SectorEquipment are changing all the time, therefore there is a need to pre-configure the relation (association)between eNB/gNB and SectorEquipment end points as a batch in advance.

In order to realize batch configuration of the association, one possible solution is to modify EUtranGenericCell/NRSectorCarrier (on eNB/gNB side) and SectorEquipmentFunction (on sector Equipment side) instances.

For EUtranGenericCell on eNB side, attribute relatedSector, which consists of Distinguished Name (DN) of the remote Sector Equipment, is replaced by attribute relatedSectorList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and DN of the remote Sector Equipment.

For NRSectorCarrier on gNB side, attribute sectorEquipmentFunctionRef, which consists of Distinguished Name (DN) of the remote Sector Equipment, is replaced by attribute sectorEquipmentFunctionRefList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and DN of the remote Sector Equipment.

For SectorEquipmentFunction on Sector Equipment side, in case of LTE, attribute theCellList, which consists of Distinguished Name (DN) of a list of remote eNB E-UTRAN cell, is replaced by attribute theCellListList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and a list of DN of remote eNB E-UTRAN cell.

For SectorEquipmentFunction on Sector Equipment side, in case of NR, attribute theNRSectorCarrierList, which consists of Distinguished Name (DN) of a list of remote gNB sector carrier, is replaced by attribute theNRSectorCarrierListList, which is a list, where each list element consists of a timeWindow (start and end time when this association is valid), and a list of DN of remote gNB sector carrier.

Editor’s Note: An alternative potential solution may also be considered, based on the approach that all different time windows for one type of association are handled by means of one instance of e.g. theNRSectorCarrierList for each time window. This option may avoid a potential backward compatibility issue with the above solution, but has the drawback of managing a huge number of instances for all the connections (hundreds or even thousands) with the high system load to create and update them frequently, and risk of delays in the creation/updates due to loss of feeder link between the management system and satellites. It also introduces a new risk of inconsistent associations in case the feeder link is lost during the ongoing execution of updates of all the associations for one or more SectorEquipmentFunction onboard satellites.

Editor’s Note: It is not clearly stated that how SectorEquipmentFunction / NRSectorCarrier / Beam / NRCellDU are related to each other, and which of them are located on ground and/or in space. This needs further studies, and the suggestion mentioned in this clause can be seen as one alternative.

The sequence diagram for setup of the batch configuration in advance, and the results of the batch configuration for NR is shown below.

 

**Figure 5.1.2.3.1-2 Sequence diagram: Configuration of Sector Carrier / Sector Equipment function associations as a batch (for NR)**

1. For each Sector Equipment in space, the ProvMnS consumer creates SectorEquipmentFunction instances through the ProvMnS.

For each gNB on ground, the ProvMnS consumer creates a number of NRSectorCarrier instances for the GNBDUFunction through the ProvMnS. The number of NRSectorCarrier instances shall be equal to the max number of sector Carriers that the gNB will handle.
2. The ProvMnS consumer receives, from an external entity, a list of the associations between all the sector equipments in space and the gNBs on ground over a time period (and related time windows indicating when each association is valid). These associations and time windows are calculated based on e.g. position of the ground gateways, and possibility for the gNBs to connected to these ground gateways, the expected orbit position of the space sector equipment over the time period, availability of the feeder link between the ground gateways and satellites over the time period (e.g. expected unavailability due to weather condition), the operation condition of the satellite sector equipment, ground gateways, ground gNB, transport over the time period, etc. Observe that the MnS consumer can receive new associations from the external entity before the previous time period ends due to unexpected changes in the NTN system.
3. The ProvMnS consumer sends, to each sector equipment in space, a batch of its associations to all sector carriers in one or several specific gNBs during the time period through the ProvMnS ModifyMOIAttributes() with the theNRSectorCarrierListList for all the sectorEquipmentFunctions.
4. The ProvMnS consumer sends, to each gNB on ground, a batch of its associations to all sector equipment in space for all sector carriers in all gNBs during the time period through the ProvMnS service ModifyMOIAttributes() with the sectorEquipmentFunctionRefList for all the NRSectorCarrier in the gNBs.
5. The actual changes of the associations to all sector carriers in different gNBs over the time period are continuously and timely executed by the sector equipment according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notificationservice.
6. The actual changes of the associations to all sector equipment for all sector carriers in all gNBs over the time period are continuously and timely executed by the gNB according to the pre-defined time windows, and also logged and transferred back to the ProvMnS consumer through file data report service and/or notificationservice.

#### 5.1.2.4 Evaluation of potential solutions