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Edinburgh, GB, December 11-15, 2023
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Type: Discussion

RP-233426

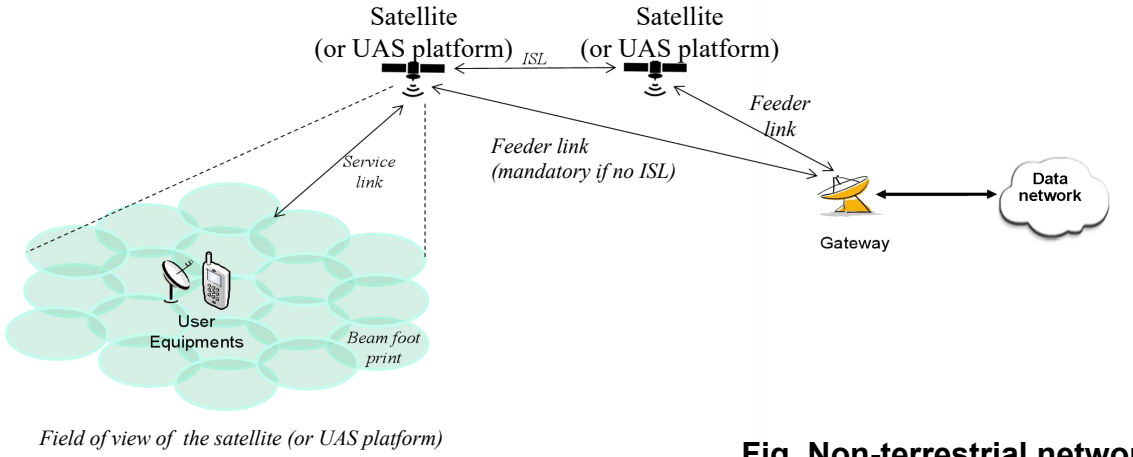
NR NTN evolution in R19

December 2023

Regenerative payload with ISL

Motivations

- In R17&R18, only transparent payload is considered. However, regenerative architecture can bring the following benefits:
  - ✓ propagation delay reduction in Uu
  - ✓ data communication could use **ISL(inter-satellite link)**, which is even applied to less NTN Gateway scenarios
  - ✓ regenerative architecture networking is more flexible and easier forward compatibility, e.g. supporting of more sparse locations of feeder links.



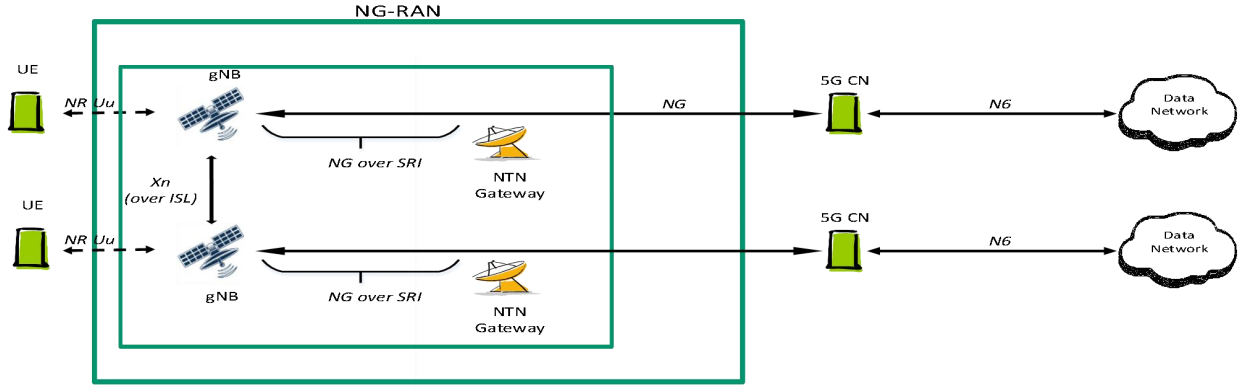


Fig. Non-terrestrial network typical scenario and network architecture with regenerative payload

Potential Objectives

- **Support regenerative payload to reduce propagation delay (RAN3)**
  - ✓ study Full gNB on board (first priority) and DU only on board (second priority)
    - support full gNB on board in TS 38.300 firstly, and study further enhancements if needed(e.g. NG enhancements)
    - F1 enhancement, DU-DU new interface (second priority)
  - ✓ QoS split during the involved links

NTN Mobility enhancement for PCI unchanged

Motivations

Issues

Signaling Storm/Frequent UP Interruption

- Excessive handover signaling i.e., UE moves next satellites: **~6s**
- Frequent UP Interruption: **~23ms**

Tx Power Limitation, etc.

- Each satellites resource is limitation, i.e., Power, coverage

PCI unchanged Scheme in R18

Hard Switch

- Satellites switch PCI unchanged, which can reduce the HO signaling and

Soft Switch

- UE implementation to measure/connect to serving or target satellites among overlapping area, i.e., soft switch
- *At least to ensure **non-colliding SSB** with same PCI at UE side*

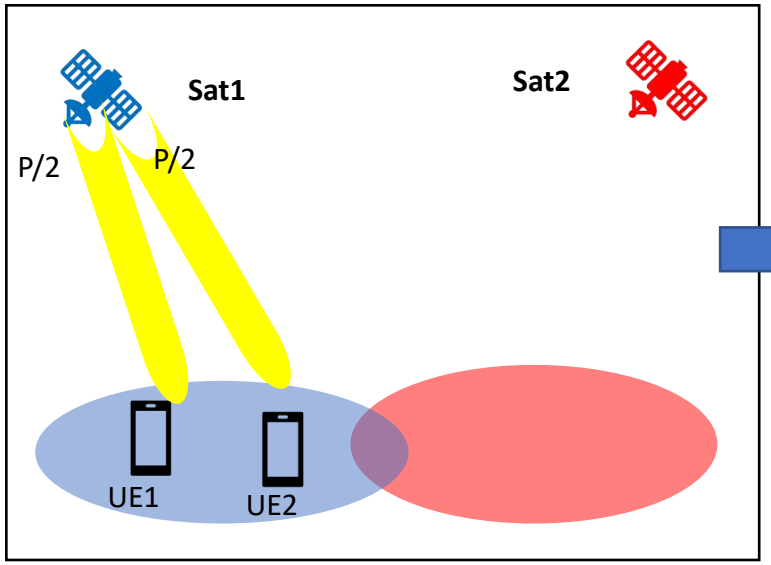
Rel-19 Improvement for PCI unchanged

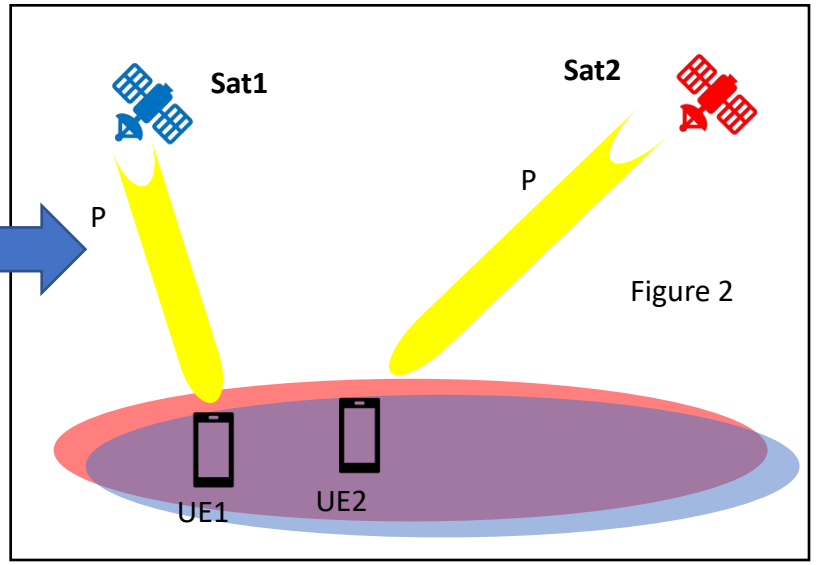
Resource pool among multiple satellites

- Multiple satellites within one PCI area can aggregate DL Tx Power in resources, share the resources and jointly schedule the resources (i.e., Beam, RB). The Tx Power/radio resources are no longer limited by one satellite, but shared by multiple satellites

Multiple satellite measurements

- UE can measure multiple satellites with overlapping area





One example of sharing resources, in which the Tx power can be set twice than without resource sharing in low load.

Figure 1

PCI unchanged without Resource pooling

Figure 2

PCI unchanged with Resource pooling

NTN Mobility enhancement for PCI unchanged

Further consideration for supporting soft switching without PCI changed

- SSB collisions and measurements were observed during the discussion. Limited standard efforts can solve the issue and reduce the complexity of implementation.
  - For SSB collisions, "*Interference avoidance/mitigation between two satellites may potentially be done by gNB implementation at least to ensure non-colliding SSB with same PCI at UE side.*", This can be achieved, e.g., by assigning different SSB index for different satellites. Then legacy UEs can be operated for PCI unchanged. However, further investigations on the feasibility is expected, including performance and potential specification impact.
  - For measurement,
    - The following behaviors are assumed from RAN1 considerations
      - *#1: UE is provided with the information on new common TA, K_mac, ephemeris and cell-specific K-offset are applied during resynchronization to new satellite.*
      - *#2: UE may be provided with the information if needed to detect the SSB of the new satellite for soft satellite switching.*
    - Assumption #1 is compatible for legacy UEs for PCI unchanged deployment.
    - Assumption #2 is not compatible for legacy UEs. Since legacy UE does not have these new information. Such that legacy UEs cannot detect the new satellite for soft satellite switching. New UEs should be OK to operate so.
    - In addition, considering the HO case of TN to NTN which is less discussed in R17/R18, mobility enhancements for this case are expected to be further considered.

Potential Objectives

- **Mobility enhancements [RAN2, RAN4, RAN1]**
  - For soft satellite switching without PCI change in quasi-earth fixed cell case,
    - Specify necessary enhancements of UE measurements that allows more detections of the satellites within the PCI unchanged area. [RAN2, RAN4]
  - Study and specify mobility enhancements for some new cases, e.g., TN-NTN mobility with QoS adaptation(e.g. PDB relax due to long RTT). [RAN2, RAN1]

Beam Managment

Motivations

- The satellite (or UAS platform) typically generates several beams over a given service area：
  - ✓ Considering a small difference in signal strength between two beams in a region of overlap, a new triggering for beam switching can be studied， e.g. location/time-based triggering for conditional beam switching
  - ✓ Considering the large cell size of NTN, many devices may be served within a single beam. Depending on constellation assumptions (e.g. propagation delay and satellite speed) and UE density, many UEs may need to perform beam switching at a given time, a possible group beam switching command can be studied to reduce signalling overhead

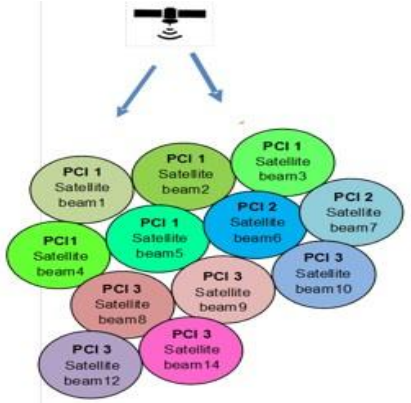


Fig. same PCI for several satellite beams

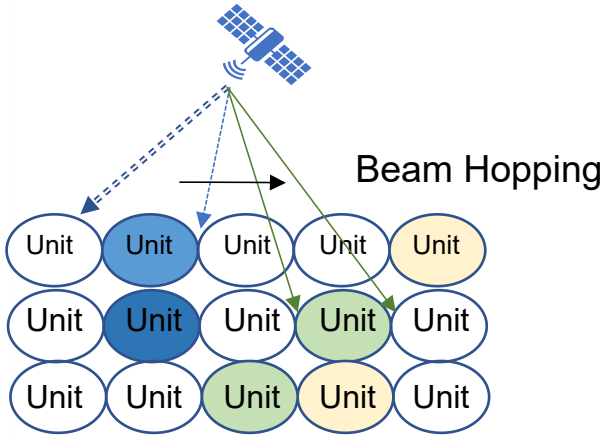
Potential Objectives

- **Support multiple beam operation in NTN (RAN2,RAN1)**
  - ✓ Beam management and reporting over the multiple beams from the satellite
    - ✓ e.g. location/time-based triggering conditional beam switching
    - ✓ group beam switching

DL Coverage Enhancement-
Satellite Beamhopping

Motivations

- Considerging the coverage area of NTN is much larger than that of TN, the beam number within one satellite is large but also limited.
  - Only limited area can be covered by the beam due to limited transmission capabilty of satellite. And a large portion of the service area is not covered at the same time, e.g. suppose total beam units of one satellite is more than 1000, while there are only 128 beams for signalling/data transmission simultaneously, it is essential to study how to achieve full coverage as soon as possible .



Potential Objectives

- **Support multiple beam operation in NTN (RAN2,RAN1)**
  - ✓ The enhancements for beam management in case of a large number of beams from the satellite
    - ✓ to support an efficient dynamic and flexible beamhopping between beams or different beam pattern/size (i.e., wide or narrow) across the satellite foot print
    - ✓ to reduce the CSI-RS feedback reporting

DL coverage enhancement-Physical channels & signals

Motivations

- Rel-18 only focus on UL channel coverage enancements for NTN scenarios to support commercial smartphones services
- Considering the NTN characteristics including large propagation delay and potential limited DL transmit power, potential issues and enhancements of DL coverage should be further studied.
- Considering a large number of beams would be used for satellites, the beam specific transmit power of DL would be reduced compared with single beam transmission

Potential issues

- During Rel-18 NTN, DL coverage performance of PDSCH (for VoIP, low data rate, Msg2, Msg4), PDCCH, SSB have been evaluated.
  - ✓ DL coverage limitations was observed during the evaluations, e.g. Msg4 PDSCH (2.2~2.8dB gap) in the LEO scenarios, PDCCH without repetition (1.9~2.6dB gap) in the NLOS scenarios for LEO.
- DL coverage will be significantly restricted if the satellite transmission power is limited.

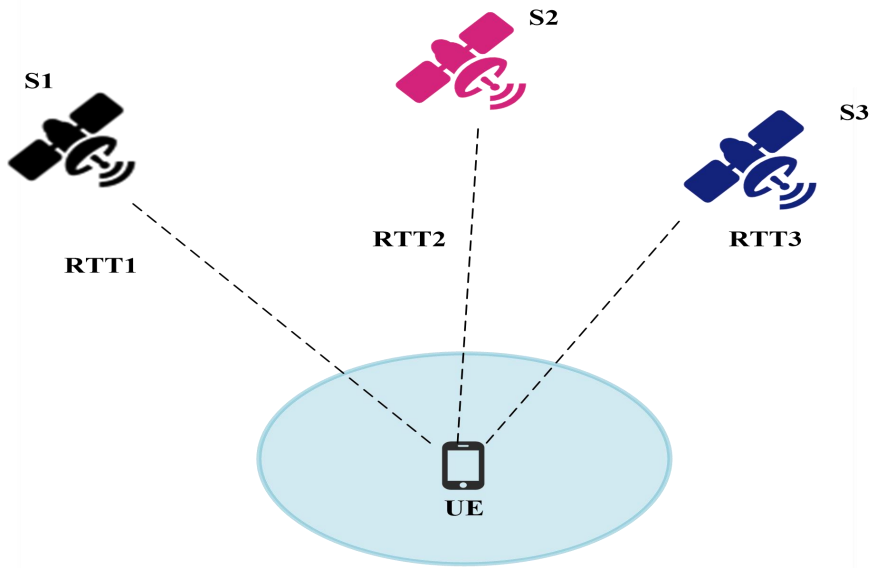
Potential Objectives

- **Study and specify NR NTN-specific DL coverage enhancements in Rel-19(RAN1,RAN4,RAN2)**
  - Coverage performance evaluation:
    - ✓ A study phase is preferred to identify the bottleneck of DL channels and the coverage gap for the enhancement.
      - ✓ Identify/prioritise which physical channels or signals need to be enhanced
  - Study and specify DL coverage enhancements
    - ✓ DL beam enhancements, repetition, etc.

Network verified UE location Enhancements

Motivations

- In R18, regarding network verified UE location, we focus on single satellite and existing LCS framework for verification.
- For R19, we could further consider multiple satellites case to purse more accurate UE positioning calculation considering the positioning inaccuracy issue due to long propagation delay in single satellite case of NTN system.



Potential Objectives

- **Support network verified UE location enhancements (RAN1, RAN2)**
  - study **MULTIPEL** satellites for network verified UE location (e.g., satellite-specific assistant information to LMF)

HPUE for NTN and IoT NTN

Motivations

- UL channel coverage enancements for NTN scenarios had been specified in Rel-18 to support commercial smartphones services.
- Besides physical layer UL channel coverage enhancements techniques, increasing UE transmit output power is another efficient way to improve UL coverage.
- Considering that PC2 is the supported highest UE power class for TN bands, it is suggested to focus on PC2 in FR1 NTN bands and IoT NTN bands in Rel-19.

Potential Objectives

- **Specify RF requirements for PC2 NTN FR1 bands (n255 and n256) and IoT NTN bands (255 and 256), including:**
  - UE maximum output power and Tx power tolerance
  - A-MPR requirements if needed
  - PC2 sensitivity degradation requirements if needed

RedCap for NR NTN

Motivations

- RedCap has already been supported in all TN bands in existing NR specifications.
- RedCap devices supported for NTN are beneficial for satellite IoT services with higher data rate than IoT NTN and reducing device complexity/cost.
- No RAN4 requirements in existing specifications for 1Rx NTN.
- RRM relaxation similar as RedCap UE can be considered for NR NTN

Potential Objectives

- **Specify the following RF and RRM requirements for NR NTN including:**
  - 1Rx
  - Power saving in RRM

THANK YOU !