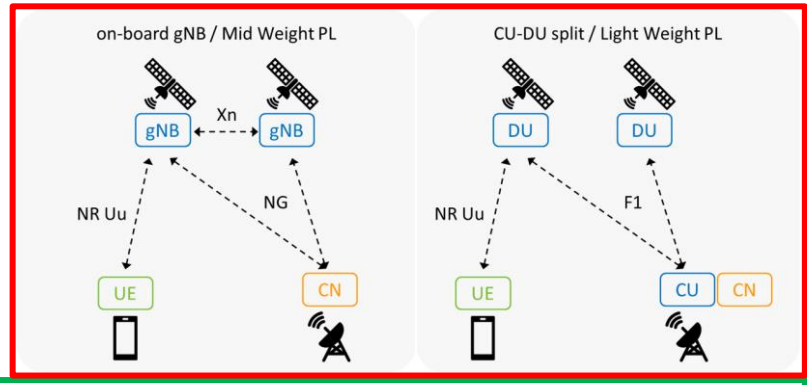
3GPP TSG RAN #101
Bangalore, India, September 11 - 15, 2023
RP-232078
Agenda Item: 8A.2.7
Document for: Discussion

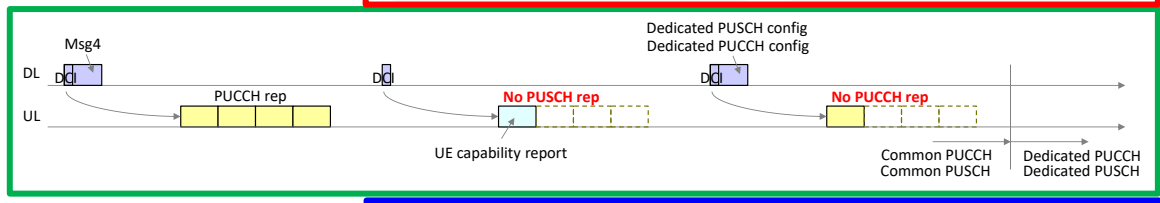
Further enhancements on NR NTN

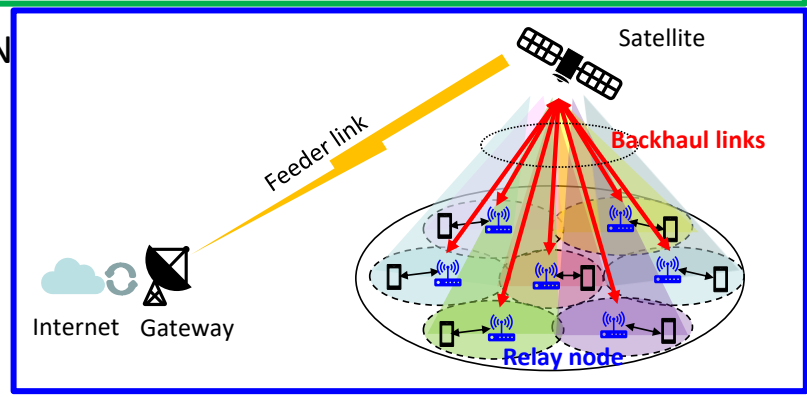
NTT DOCOMO, INC.

Overview

- Rel-17 NR NTN
  - Initial spec for NR NTN
    - » E.g., NTN-specific synchronization, timing-related enhancements in lower/higher layers, HARQ-related enhancements, NTN-specific mobility support
    - » Transparent payload
- Rel-18 NR NTN
  - Enhancements for three aspects
    - » 1. Coverage of handheld UEs
    - » 2. UE location verification by NW side
    - » 3. Better mobility/service continuity
- Rel-19 NR NTN
  - The following three topics should be included
    - » A. **Regenerative payload support**: more flexible NW, shorter RTT, towards meshed NTN
    - » B. **Coverage enhancement**: DL coverage and UL coverage leftovers for handheld UE
    - » C. **UL data rate enhancement**: support 1 Mbps or more for handheld UEs
    - » Note: in addition, HAPS-specific RAN4 discussion as mentioned in RP-232087 is also an important topic for R19



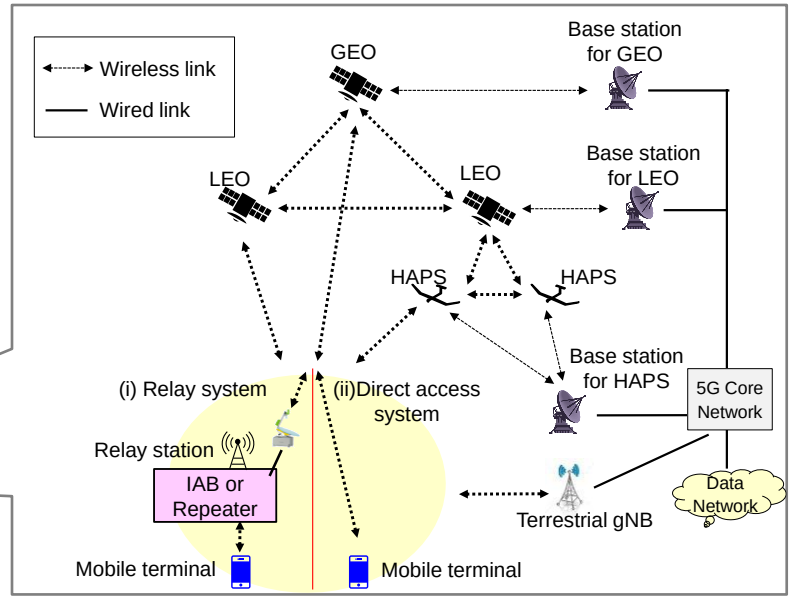




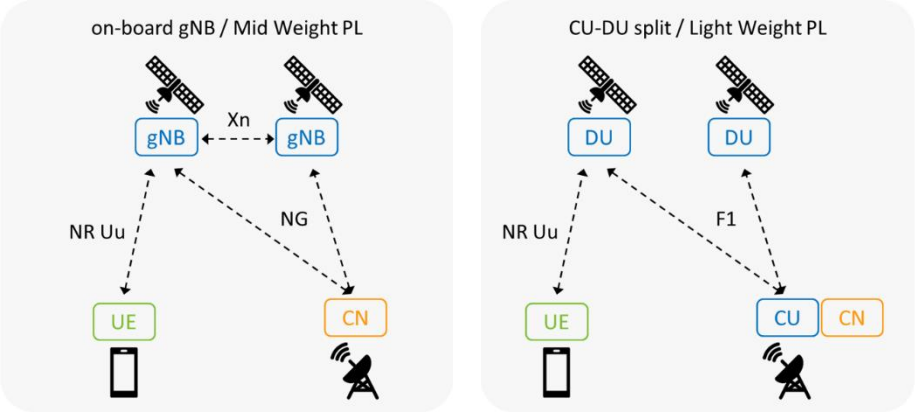
Regenerative payload support (1/2)

High Priority

- Background (Justification)
  - Study on introduction of NTN was conducted in Release 16. Both transparent and regenerative payload were in scope at that time, but in later releases (Rel-17/18) only transparent payload was taken in consideration.
  - Support of regenerative payload enables more flexible NTN as well as shorter round-trip time for L1/MAC interaction.
    - » Steady step to realize meshed NTN (i.e., NTN with inter-satellite/HAPS links) in future releases.
  - Scope of item: including LEO/GEO/HAPS scenarios, both on-board gNB on-board (with ISL) and CU-DU split (without ISL) implementations.
    - » gNB on-board: No specific enhancement is needed on top of Rel-17/18 framework. Specifying support in TS 38.300 will be enough unless showstopper issue in Xn/NG interface is found.
    - » CU-DU split: We see potential issues on F1 interface.



Future (later releases) realization of meshed-NTN



Scope of regenerative payload implementations in Rel-16 study

Regenerative payload support (2/2)

High Priority

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- Proposal (Objective)

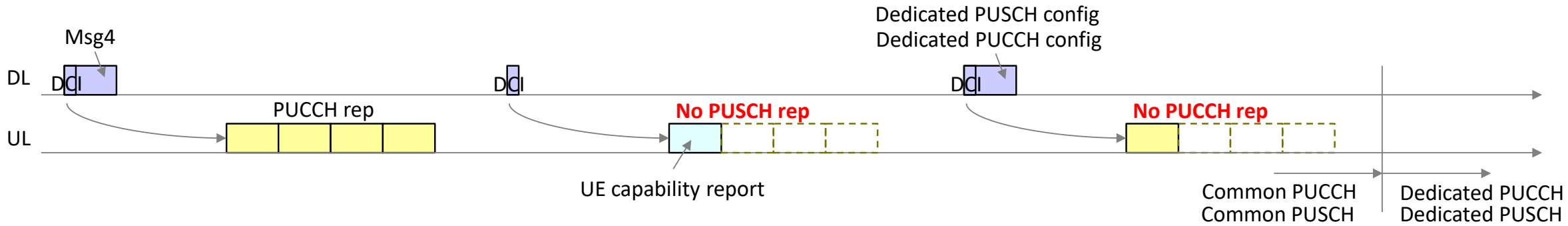
This topic aims to specify the enhancements identified for regenerative payload architecture of NR NTN (non-terrestrial networks) especially CU-DU split and on-board gNB architecture regarding the following aspects:

- Specify support of regenerative payload with on-board gNB architecture in Stage-2 spec (RAN2)
- Specify an enhancements for the F1 interface (RAN3)
  - » Signaling enhancements for UP packet buffering considering RTT.
- Analyze impacts on F1/Xn/NG interfaces, if necessary (RAN3)
  - » Suspending F1 interface in case of feeder link switch over in CU-DU split architecture (described in clause 8.7.2.3, TR 38.821).
  - » Suspending NG interface in case of feeder link switch over in on-board gNB architecture (described in clause 8.7.2.2, TR 38.821).
  - » Signaling enhancements for frequent Xn setups in case of feeder link switch over in on-board gNB architecture, or in case of SRI (satellite radio interface) switch over in on-board gNB architecture with ISLs (inter satellite links) (described in clause 8.4.3.4, TR 38.821).

Coverage enhancement (1/2)

High Priority

- UL coverage enhancement
  - Background (Justification)
    - » In R18 NR NTN, repetition for Msg4 HARQ-ACK and NTN-specific DMRS bundling for PUSCH are to be specified. Besides, PRACH repetition is to be specified in R18 CovEnh WI
    - » However, two UL transmissions are still insfficient for handheld UE in NTN due to non-support of repetition. The reason seems to be that simply the problem was missed in study/work. Although PUCCH aspect is to be discussed for R18 NR NTN in this meeting, but may not be specified
      - – PUCCH transmission after Msg4 HARQ-ACK but before reception of dedicated PUCCH configuration
      - – PUSCH scheduled by DCI format 0_0 with CRC scrambled by C-RNTI, including “Msg5 PUSCH” (i.e., PUSCH transmission after Msg3 PUSCH but before reception of dedicated PUSCH configuration)
  - **<u>Proposal (Objective) – UL coverage enh</u>**
    - » (If not supported in R18,) specify repetition for PUCCH after Msg4 HARQ-ACK and before reception of dedicated PUCCH config
    - » Specify repetition for PUSCH scheduled by DCI format 0_0 with CRC scrambled by C-RNTI
      - – Note: This PUSCH repetition may be handled in TN coverage enhancement WI as mentioned in RP-232084



Coverage enhancement (2/2)

High Priority

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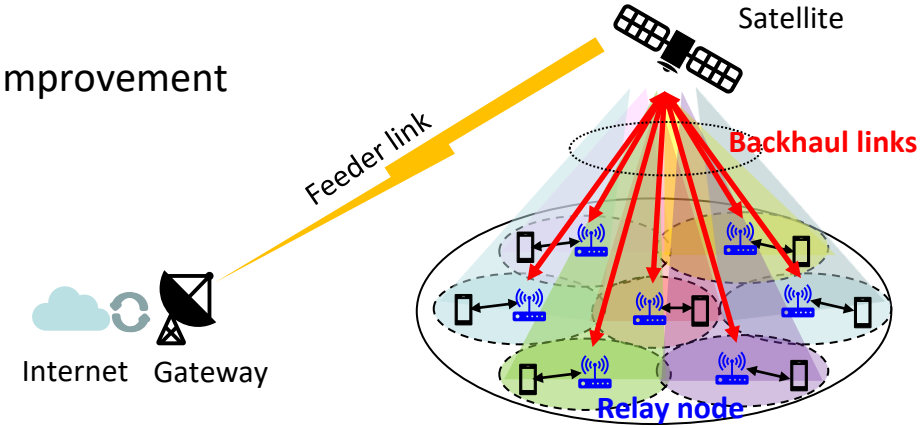
- DL coverage enhancement
  - Background (Justification)
    - » It is argued by satellite companies that in actual satellite deployment, max total transmit power is not extremely high to be shared among a lot of beams and thus there is a trade-off between the max power per satellite beam and the number N of simultanesouly used satellite beam. The number N should be increased as much as possible; otherwise, communication time per satellite beam is quite small. For efficient NTN for handheld UE, DL coverage enhancement is desriable.
    - » For NTN commercialization, supporting critical message e.g., ETWS is an important aspect. Even though UE is located in an area that NW intends, UE may fail to receive the critical message in some situations. This probability should be reduced as much as possible. From this perspective as well, DL coverage enhancement is desirable.
    - » Meanwhile, SSB enhancement is not preferred in consideration of NBC issue. SSB should be kept as it is, and thus performance of other channels should be improved to the same required SNR level.
  - Observation
    - » The 2nd point above has been discussed as a separate topic, i.e., Notification/alart. However, unless SSB is enhanced, what we aim to resolve in study/work phase is common to the 1st point above. Separate objective between these topics seems unnecessary.
    - » WID should not include/prioritize any technique for improvement; it should be discussed in WG.
    - » Current SSB performance and/or performance margin compared to required SNR are unclear in this stage. They should be clarified in study phase, rather than deciding in RAN plenary discussion.
  - **<u>Proposal (Objective) – DL coverage enh</u>**
    - » Idenfify target performance level based on SSB channel
    - » Identify which channels/signals need to be enhanced and identify the gap from the target performance
    - » (If necessary) Study/specifiy enhancements of the identified channels/signals

UL data rate improvement via relay node

- Background (Justification)
  - In Release 18, coverage enhancement is studied/specified for handheld UE in NTN with extremely low data rate requirement of **several kbps**
    - » For support of such a low data rate, a number of UL repetitions are essential for any handheld UE, which is inefficient and impractical
  - Much larger data rate as **1 Mbps** or more would be required for market expansion of NTN
    - » Similar user experience as in TN is desirable
  - Satellite access through relay nodes on the ground is beneficial for the data rate improvement
    - » For relay nodes, IAB/NCR are the candidates
    - » Such an architecture is included in SA spec on satellite access (TR 22.865)



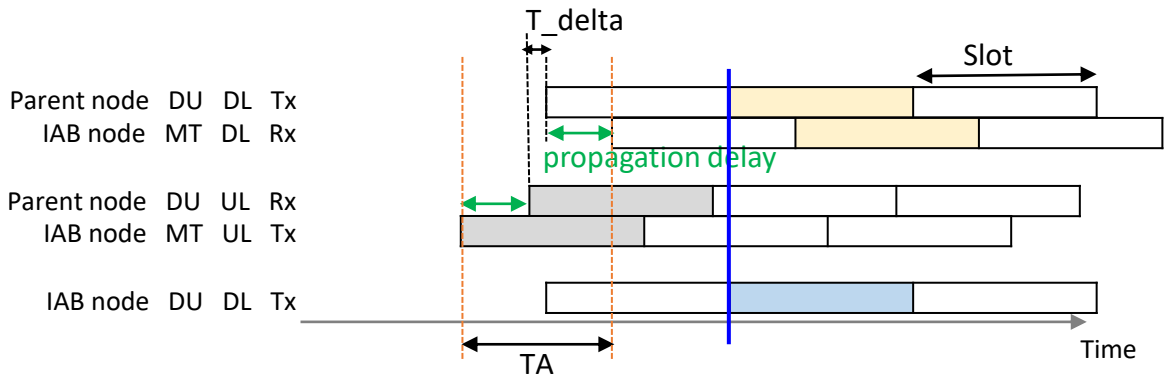
- **Proposal (Objective) – UL data rate improvement**
  - Study and (if feasible/necessary) specify NR NTN via relay node on the ground
    - » Study NR NTN via IAB on the ground
      - – Timing aspects of IAB node, e.g., “case1” timing, “case7” timing, misalignment between MT/DU, F1 interface enhancement to deal with higher RTT (similar to regenerative payload)
    - » Study NR NTN via NCR on the ground
      - – Timing aspects of NCR-related indication
      - – Usage of NTN+NCR, e.g., when UE can access NTN via relay node, how UE differentiates R17/18 NTN (direct access) and NTN via relay node, etc.

Summary on views for NR NTN including other topics

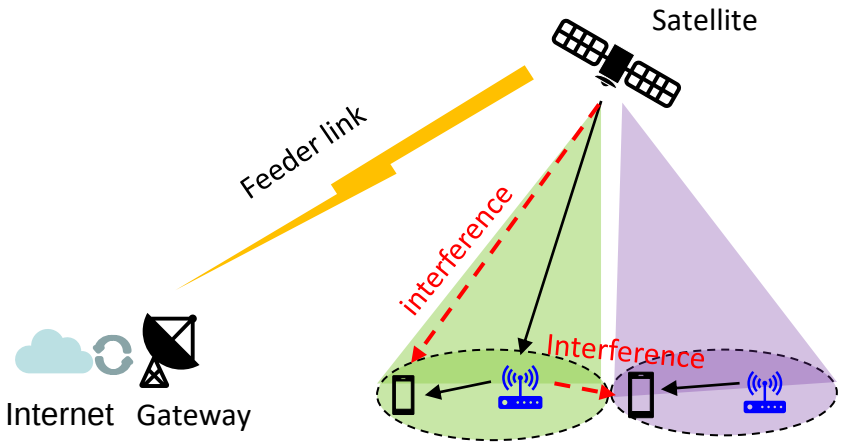
- DL Coverage enhancements
  - View: Support
- Support of Regenerative payloads for NR
  - View: Support
- Enhanced GNSS Operation
  - View: Not support. It is unclear whether the issue is critical in real deployment and what is potential solution from RAN perspective
- Support of MBS « Multicast and Broadcast Services » in NTN
  - View: Not support. It is unclear why enhancenment beyond the existing NTN + MBS is required
- Dedicated Notification/Alert
  - View: Should be discussed together with ‘DL coverage enhancements’
- Uplink Capacity/Throughput Enhancement for NR NTN
  - View: Support
- Discontinuous coverage for NR
  - View: Not support. Use case is not promising in NR-NTN
- Support of RedCAP - Reduced Capabilities
  - View: Neutral. Although RedCap in NTN is a promising topic, urgency is unclear for us
- NTN/TN Mobility enhancement in connected mode for NR
  - View: Support

Appendix – details on UL data rate improvement

- NR NTN via IAB on the ground
  - Example 1: “case-1” timing alignment
    - » In TN, DL timing is aligned across gNBs/IAB nodes, so that interference between DL signals from gNBs/IAB nodes can be alleviated.
    - » In Rel-16/17 IAB, an IAB node sets its DL Tx timing same as DL Tx timing of its parent node using TA and T_delta, where T_delta accounts for the gap between DL Tx and UL Rx timing at parent node.
    - » In NTN via IAB on the ground, DL timing needs to be aligned across IAB nodes on the ground. Interference alleviation at UE side between DL signals from gNB and DL signals from IAB-DU needs to be considered as well. How to determine DL timing of IAB-DU for IAB nodes connecting to NTN needs to be studied.



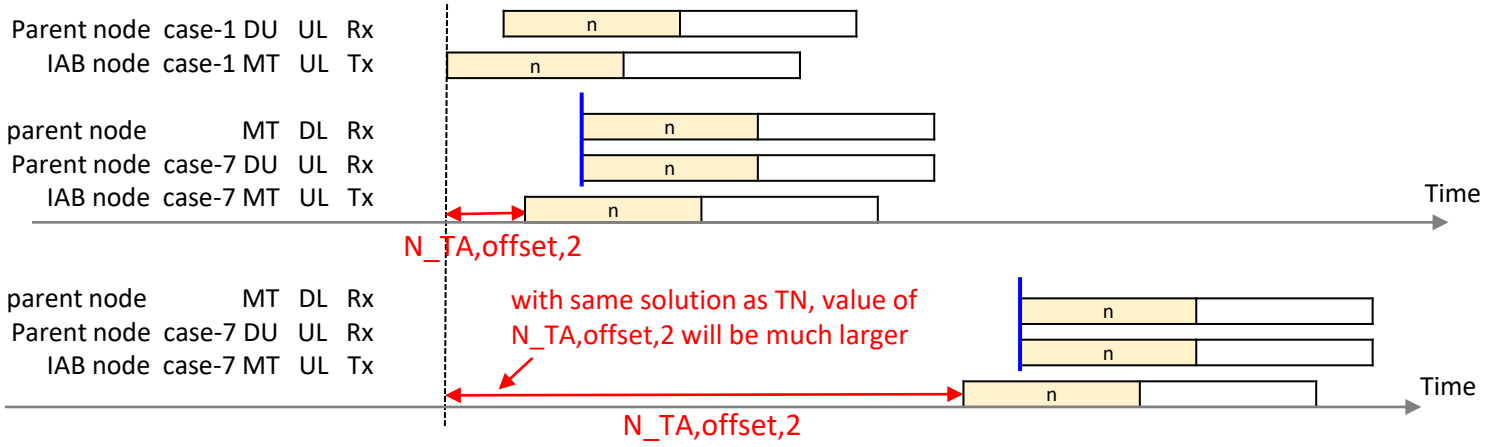
Example of case-1 timing alignment in TN



Example of interference between DL signals from gNB and DL signals from IAB nodes

Appendix – details on UL data rate improvement

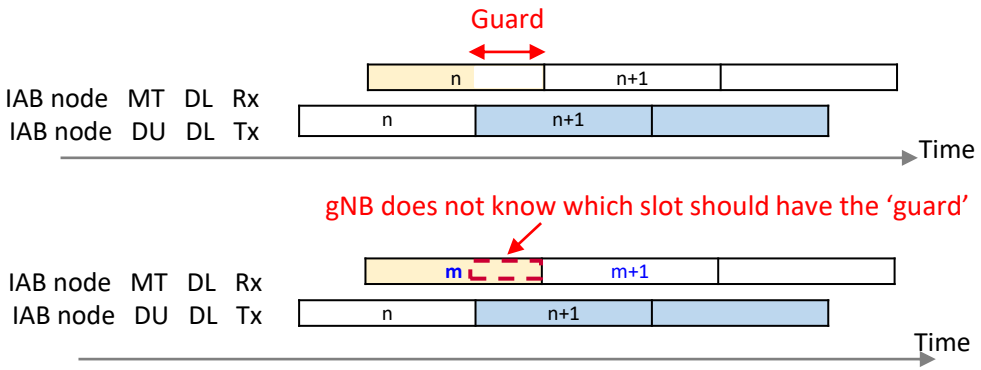
- NR NTN via IAB on the ground
  - Example 2: “case-7” timing alignment
    - » In Rel-17 IAB, IAB node determines its UL transmission timing as TA + N_TA,offset,2 ·Tc , where N_TA,offset,2 approximately accounts for the propagation delay between its parent node and grand-parent node.
    - » In NTN, the propagation delay can be much larger than TN. Case-7 timing alignment for IAB nodes connecting to NTN needs to be studied.



Example of case-7 timing alignment
(upper: TN, lower: NTN)

Appendix – details on UL data rate improvement

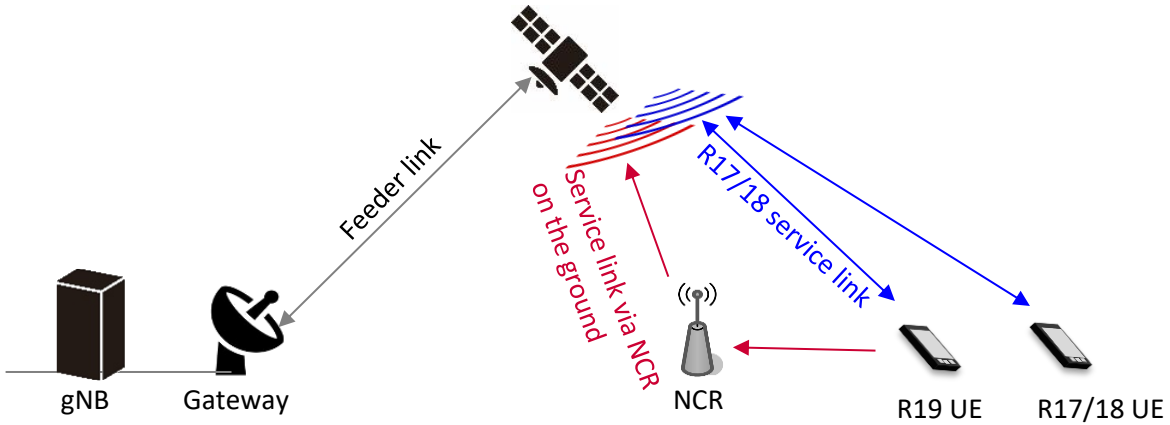
- NR NTN via IAB on the ground
  - Example 3: MT/DU timing misalignment
    - » In Rel-16/17 IAB, guard symbols can be reported so that parent node is aware of misalignment of MT Tx/Rx and DU Tx/Rx timing at IAB node.
    - » In NTN, the misalignment between MT Tx/Rx and DU Tx/Rx timing can be much larger than TN. Report of MT/DU timing misalignment for IAB nodes connecting to NTN needs to be studied.

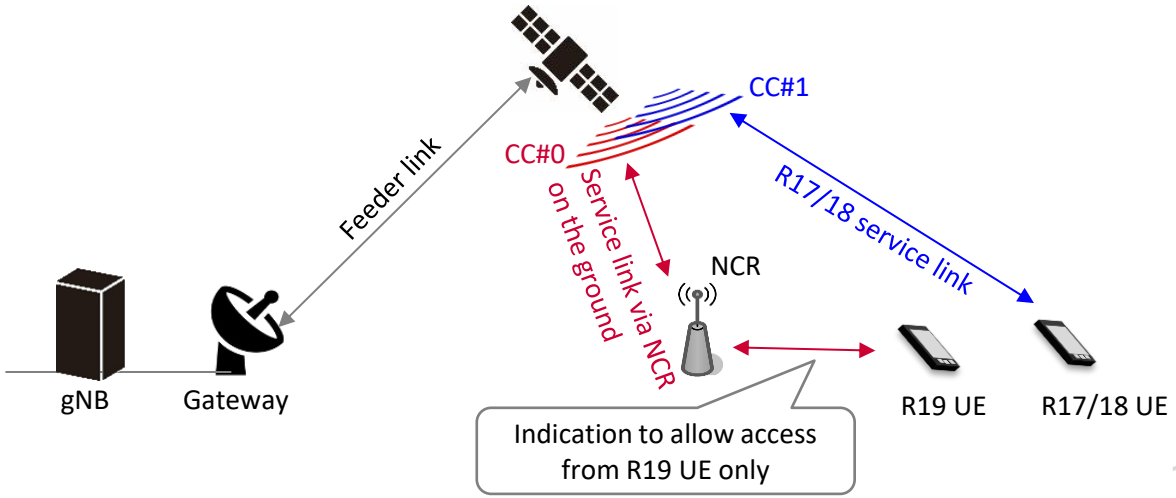


Example of MT/DU timing misalignment
(upper: TN, lower: NTN)

Appendix – details on UL data rate improvement

- NR NTN via NCR on the ground
  - Example 1: Timing aspects of NCR-related indication
    - » In R18 NCR, resource allocation / beam indication for access link via MAC-CE or DCI format 2_8 includes timing indication
    - » For NTN, additional offset by using K_offset or K_mac would be required for such a NCR-related timing indication
  - Example 2: Enhancement of UE-specific TA
    - » When NTN service link is via NCR, the existing UE-specific TA mechanism does now work well
    - » Modified determination mechanism for TA corresponding to NTN service link via NCR will be necessary
  - Example 3: Usage of NTN via NCR on the ground
    - » From UE perspective, NCR is transparent node. Meanwhile, TA calculation will be different as mentioned in Example 2, and also existence of legacy UEs shall be considered. Some rule/restriction to use NTN via NCR on the ground will be inevitable
      - – Possibility 1: UE has a connection within a cell based on R17/18 NR NTN, and NTN via NCR on the ground is used as a kind of SUL additionally
      - – Possibility 2: Band/cell for legacy UE and band/cell for R19 UE are separately configured and indication to inform UE of applying R19 sync as Example 2, without NBC issue





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