3GPP TSG RAN Meeting #102
Edinburgh, Scotland, December 11 - 15, 2023
Agenda Item: 9.1.2.3
Source: Apple

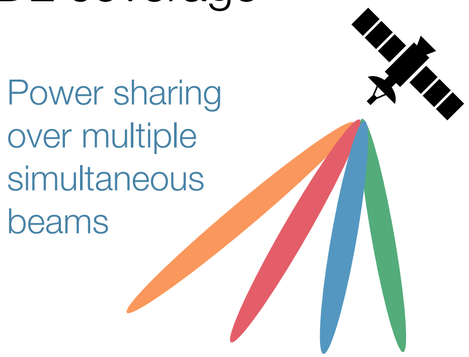
RP-233167

Views on NR NTN Evolution in R19

Apple

Rel-19 NR NTN | Topic 1: DL Coverage Enhancement

- **Justification:**
  - Coverage is the most important issue for successful NTN commercialization
  - Rel-19 NR NTN enhancement should focus on further coverage enhancement, especially DL coverage enhancement
  - NTN DL coverage issue can be due to single satellite sectorization
    - Single satellite to simultaneously support multiple beams



- **Objective:**
  - Specify schemes to enhance PDCCH coverage [RAN1, RAN2]
    - For example, PDCCH repetition, extended CORESET symbols, reduced DCI payload size, channel estimation enhancement, etc
  - Specify schemes to enhance PDSCH Msg2 and PDSCH Msg4 coverage [RAN1, RAN2]
    - For example, PDSCH repetition, channel estimation enhancement, etc.

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Rel-19 NR NTN | Topic 1: DL Coverage Enhancement

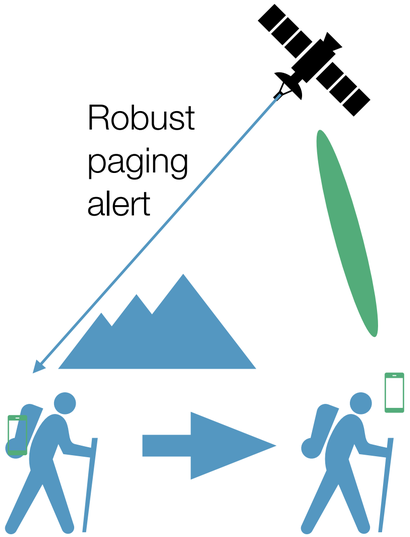
- Exemplary justification:
  - Coverage margin when satellite TX power reduction is not applied (cf. R1-2208268)
    - PDCCH and Msg4 PDSCH, Msg2 PDSCH have the least margin among downlink channels
    - With the adjustment of UE antenna gain from -5 dBi to -5.5 dBi, coverage margin:
      - Msg2 PDSCH: 6.7 to 10.3 dB
      - Msg4 PDSCH: 3.3 to 6.2 dB
      - PDCCH: 5.4 to 9.7 dB
  - Satellite total transmission power:
    - Set-1 LEO-1200 satellite: 10 dBW/MHz without Tx antenna gain
      - In case of 20 MHz bandwidth, satellite Tx power is upper bounded 23 dBW or 200 Watts.
  - Satellite transmission power per beam
    - Multiple beams per cell is supported in NTN
    - If satellite transmits on more than 4 beams simultaneously, then PDCCH will start to have coverage issue
      - More transmission power needs to be allocated to beams with smaller elevation angles

Rel-19 NR NTN | Topic 1: DL Coverage Enhancement

Number of simultaneous beams	Tx power per beam (dBW)	EIRP density per beam (dBW/MHz)	Tx power reduction amount (dB)	PDCCH coverage gap
1	23	40	0	-6
2	20	37	3	-3
4	17	34	6	0
8	14	31	9	3
16	11	28	12	6
32	8	25	15	9

Rel-19 NR NTN | Topic 2: Robust Paging Alert

- **Justification:**
  - Coverage is the most important issue for successful NTN commercialization
  - Rel-19 NR NTN enhancement should focus on further coverage enhancement, especially DL coverage enhancement
  - Mobile terminated (MT) call or messaging may experience lower SNR due to lower user cooperation.



- **Objective:**
  - Specify schemes of robust paging alert [RAN1, RAN2]
    - Enhance downlink physical channel to deliver robust paging alert to a particular UE or a subset of UEs
    - Note: Enhancements to existing SSB signal are not considered in this scope

Rel-19 NR NTN | Topic 3: Uplink Capacity Enhancement

- **Justification:**
  - Uplink coverage is ensured with multiple repeated transmissions
    - Multiple repetitions reduces system capacity

- **Objective:**
  - Specify PUSCH enhancement to increase system capacity, including [RAN1, RAN2]
    - Procedure and signaling related to use Orthogonal Cover Code
    - Schemes to support sub-PRB allocation

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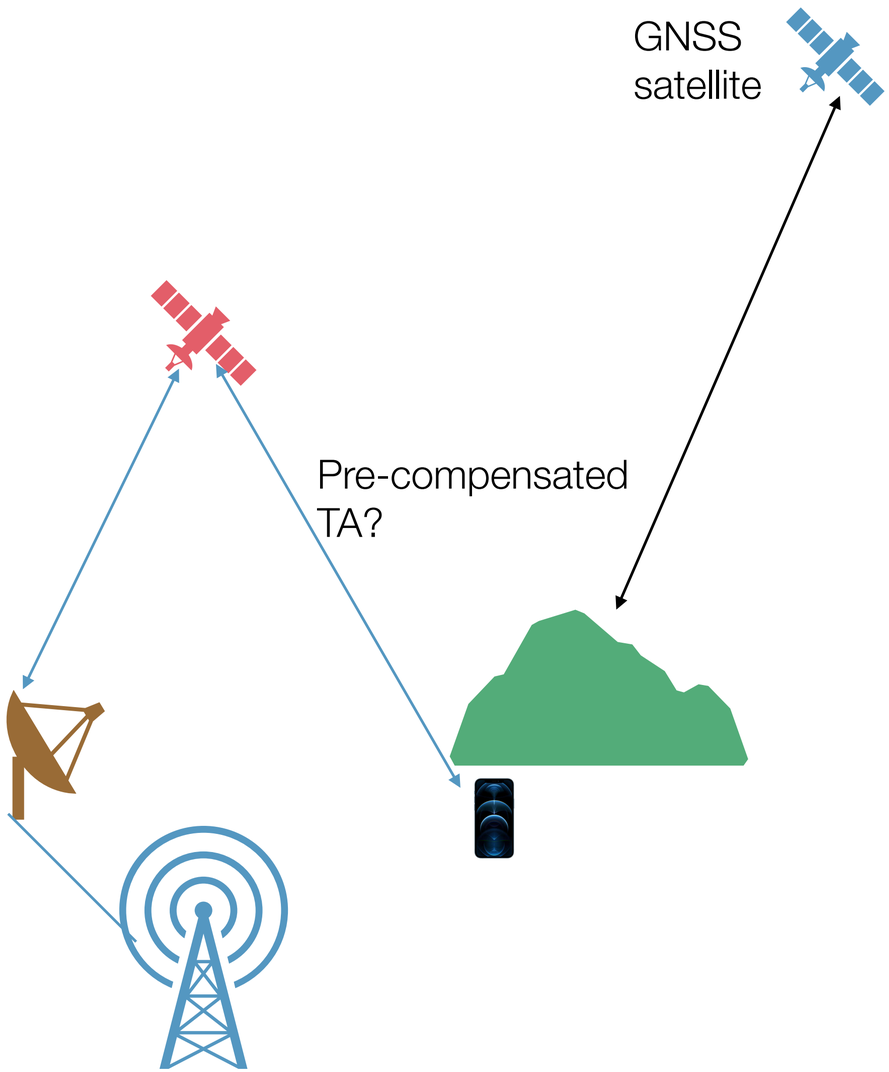
Rel-19 NR NTN | Topic 4: Operation without GNSS

- **Justification:**
  - R17/18 NTN assumes UE has GNSS capability
  - Uplink time and frequency synchronization is based on UE's GNSS location and satellite ephemeris
  - UE may not always receive GNSS signals due to
    - Power saving
    - GNSS measurement gap
    - Infeasible GNSS signal
  - GNSS independent operation is one of the use cases in R19 SA1 study.

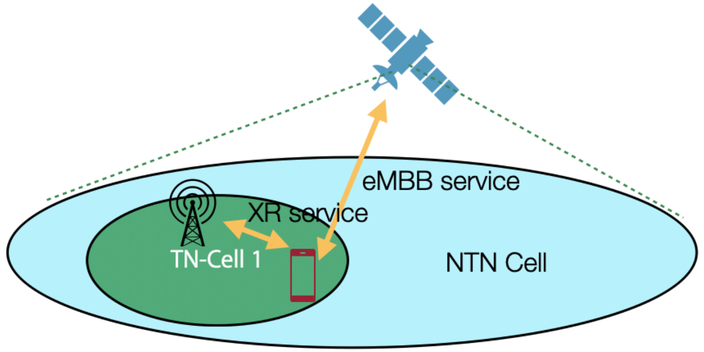
- **Objective:**
  - Keep UE in RRC_connected mode for some time with unavailable GNSS or reduced GNSS accuracy [RAN2, RAN1]
    - Supplementary UE-based positioning method is not precluded
  - Uplink synchronization in RRC connected mode [RAN1, RAN2]
    - Time and frequency synchronization maintenance enhancement
  - RRM enhancement for NTN UE operation without GNSS [RAN4]
    - Cell identification/measurement enhancement
    - UE Tx timing enhancement



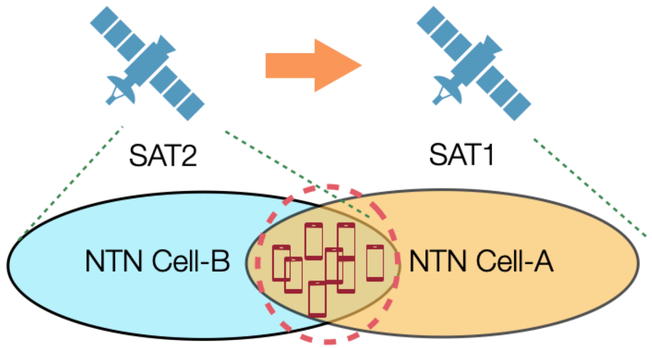
Rel-19 NR NTN | Topic 5: NR NTN Mobility Enhancement

- **R18 progress**
  - Support IDLE/INACTIVE mobility from TN to NTN (i.e. support broadcasting SIB19 with neighbor NTN cell info in TN cell)
  - Support hard and soft satellite switch with unchanged PCI.
  - **Observation: There is no leftover issue in R18 NTN mobility enhancement**

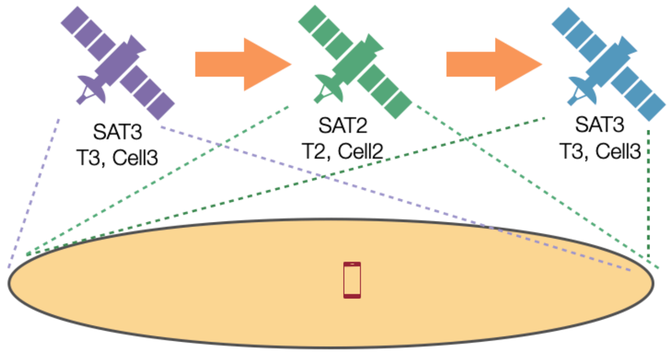
- **Further mobility enhancements**
  - Justification
    - User experience improvement during TN-NTN mobility
    - Further signaling handover overhead reduction for group UE handover
  - Objective
    - TN-NTN mobility enhancement to improve user experience based on QoS requirement
    - Handover enhancement to support a group of UEs simultaneously switch to the same cell
    - Mobility enhancement in the scenarios of the predictable future service satellites (e.g. subsequent CHO/SAT switch)



QoS based cell type selection



Group handover



Subsequent CHO/SAT switching

Rel-19 NR NTN | Others

- **Further uplink coverage enhancements**
  - Background: Rel-18 NR NTN enhances uplink coverage
    - Msg 4 PUCCH repetition
    - DMRS bundling for PUSCH taking into account NTN-specifics
  - **Justification**
    - Msg 5 PUSCH may experience coverage issue, if dedicated PUSCH configuration is not provided
  - **Objective**
    - Specify schemes (e.g., repetitions) to enhance Msg 5 PUSCH coverage [RAN1, RAN2]
      - Note: This can be part of Rel-19 coverage enhancement WI if supported.

Rel-19 NR NTN | Conclusion

- **Objective 1: DL coverage enhancement [RAN1, RAN2]**
- **Objective 2: Robust paging alert [RAN1, RAN2]**
- **Objective 3: Uplink capacity enhancement [RAN1, RAN2]**
- **Objective 4: Operation without GNSS [RAN2, RAN1, RAN4]**
- **Objective 5: Further mobility enhancement [RAN2, RAN1, RAN4]**
- **Objective 6: Leftover RRM requirements from Rel-18 NTN enhancement [RAN4]**

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