

3GPP RAN Rel-19 Workshop

RWS-230178

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Agenda Item: 5

# NR and IoT NTN

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# Summary of proposals - NR NTN

- **DL coverage enhancement including pre-paging notification**
  - In certain scenarios (e.g. phone in pocket or backpack, non-LOS), downlink coverage may be limited.
  - A more robust channel may be used to notify the end user of MT call/data.
  - Other enhancements to accommodate e.g. smaller satellite power can be considered.
- **Improved UL capacity (OCC)**
  - In coverage limited scenarios, usage of a large number of repetitions limits the uplink capacity.
  - When operating at low coding rate, we can use orthogonal cover codes (OCC) to multiplex multiple UEs in the same RB.
  - Uplink capacity gains of up to  $\sim 10x$  are possible in this scenario.
- **HD-RedCap over NTN**
  - Due to large TA of NTN, the HD collision rules need to be redefined.
  - Our assumption is that FD-RedCap would work without any change
- **UE PowS with discontinuous coverage**
  - Extension / adaptation of NTN IOT mechanisms for discontinuous coverage.
- **TBD: Rel-18 Leftovers (e.g. mobility)**
- **SA2 alignment:**
  - System level / architectural changes (e.g. local switch without feeder link) may need corresponding RAN changes.

# Pre-paging notification & DL coverage enhancements

- **Pre-paging notification: scenario description**

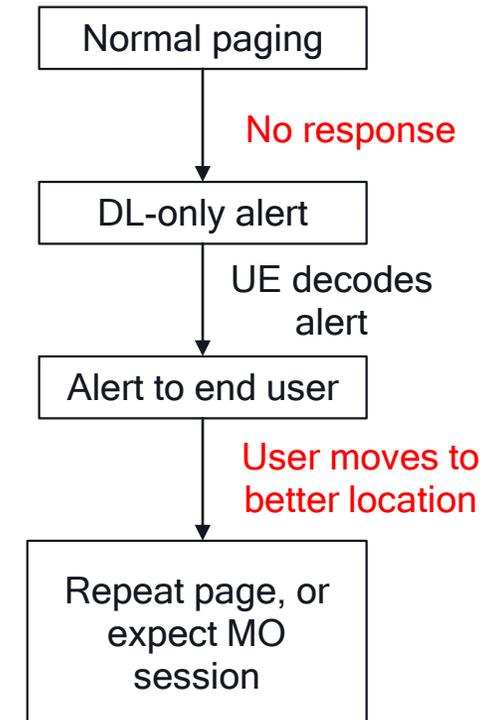
- Even with Rel-17 coverage enhancements, the link budget, especially the UL link budget has thin margins
- For MO calls/sessions, the user is expected to move into a preferred location and to attempt to minimize blockage
- The above doesn't work for MT calls/sessions
- **Paging may not be successful if the smartphone is in a pocket or in backpack**

- **Proposed enhancement**

- Introduce a 'pre-paging' alert
- Try to reuse Rel-17 power saving enhancement, if applicable
- Needs sufficient repetition level
  - Although the paging failure is most likely due to insufficient UL link budget
  - Need to provide close to zero false alarm to avoid annoyance factor

- **DL coverage enhancements:**

- On top of the above, some small enhancements may be considered for downlink channels to accommodate e.g. power limit. Target coverage enhancement level should be clear from the WID.



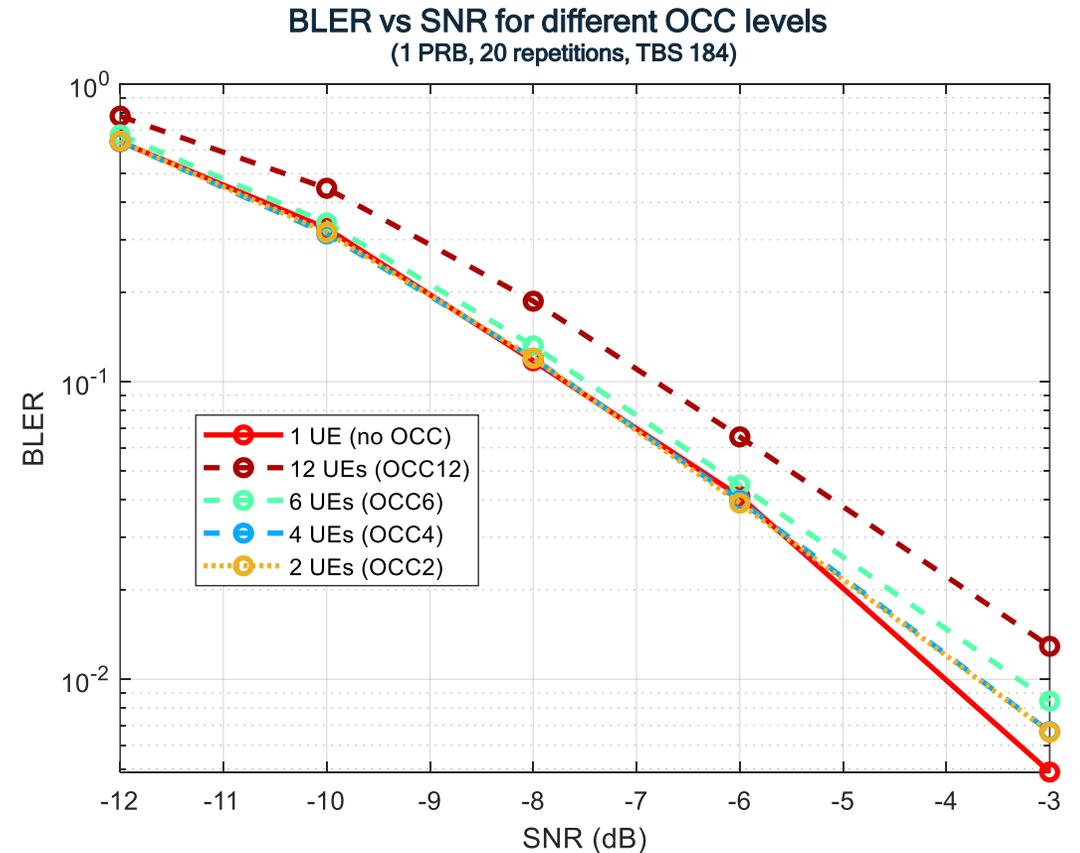
# Improved uplink capacity - OCC

- Long repetitions = low spectral efficiency

- During the Rel-17 study in coverage enhancements, for NTN, it was determined that a large number of repetitions are needed to close the link in uplink.
- For the same data rate, the same per UE performance can be achieved while drastically increasing the capacity / spectral efficiency of the system by using OCC

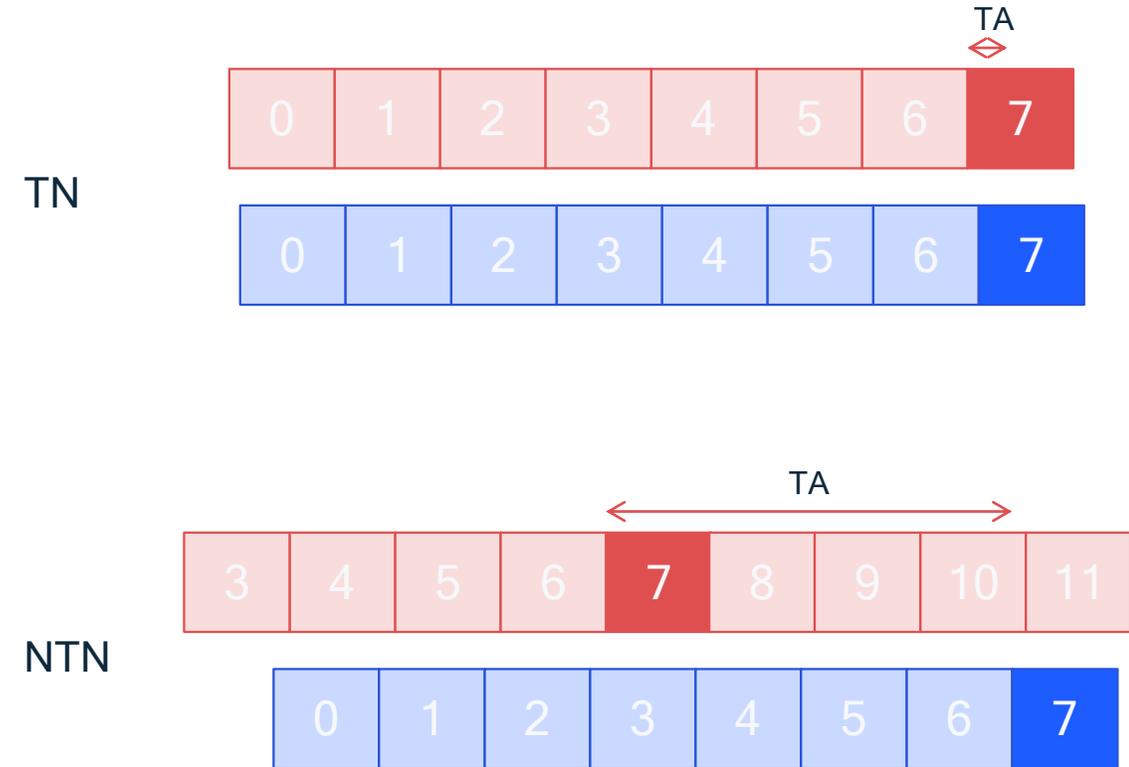
- Proposal: orthogonal spreading

- Allows for multiplexing multiple UEs in a single PRB.
- No performance impact at low code rates, no loss with OCC of up to 6 UEs.
- Sub-PRB can be seen as a particular case of spreading.



# Support of HD-FDD NTN Redcap UEs

- From RAN1 specifications, it is already possible to deploy Redcap UEs in non-terrestrial networks.
- One gap in the specifications is the handling of half-duplex UEs:
  - Due to large and open loop TA in NTN, the uplink slots may collide with multiple DL slots, even for initial access.
  - The rules for HD collision may need to be redefined, similar to what was done for eMTC / NB-IoT NTN.



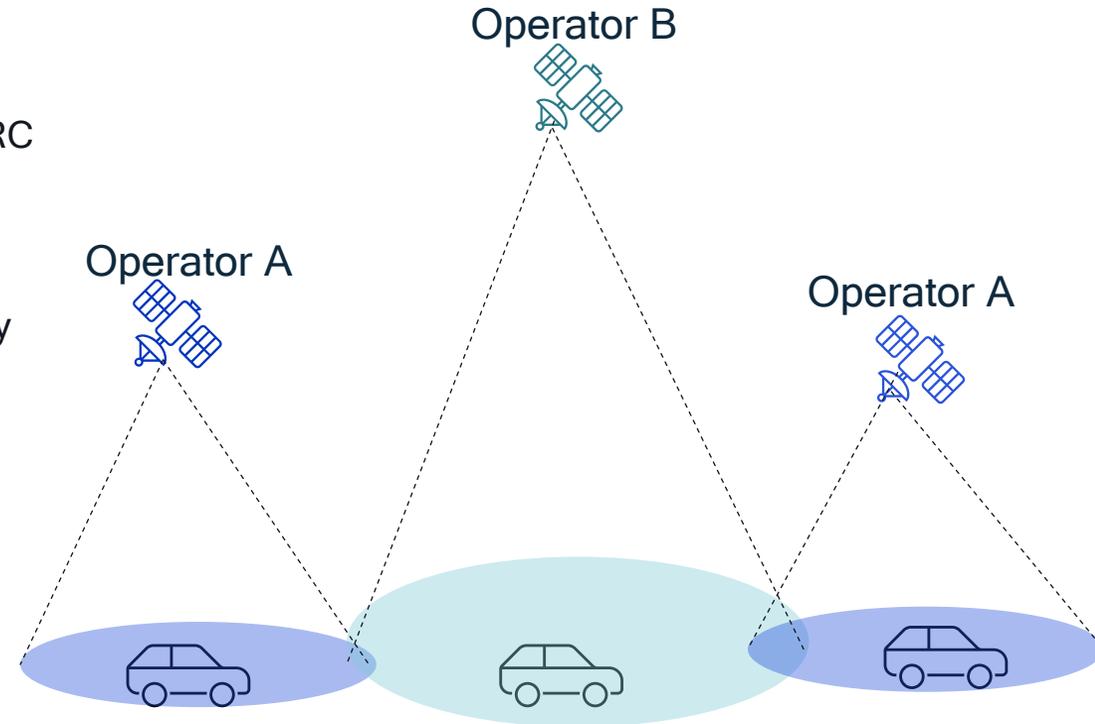
# Discontinuous coverage for NR NTN

- Coverage information via SIB/RRC

- Discontinuous coverage solution adopted in IoT NTN can be baseline.
- Discontinuous coverage information delivery can be supported by SIB or RRC signaling.
- This can be per PLMN, e.g., HPLMN vs EPLMN.
- This can be based on user's type, mobility prediction or subscription.
- When a UE is in discontinuous coverage from a satellite operator, it could try to access other operators.

- Proposed enhancement

- Support delivery of discontinuous coverage information to UE via SIB and RRC messages and specify its use.



# Alignment with SA2 - regenerative payload

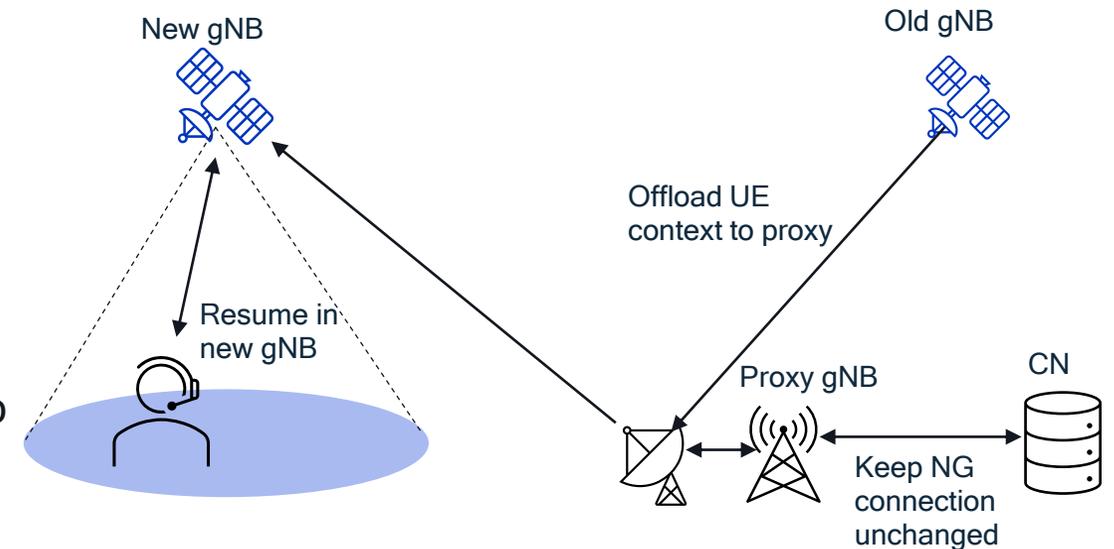
- New features potentially introduced by SA2 need the corresponding work in RAN2/RAN3 (lead WG should be SA2). Some examples include:

- **Regenerative payload architecture**

- On-board gNB can reduce round trip delay.
- Due to movement of gNB, some further enhancements for RRC\_CONNECTED and RRC\_INACTIVE state can be considered.
  - For example, pre-configured target gNB, gNB context relocation/proxy gNB on ground to avoid frequent NG-AP setup with core network.
- Support of CU/DU architecture.

- **Other potential features:**

- Store and forward
- Local switching with UPF on board of satellite

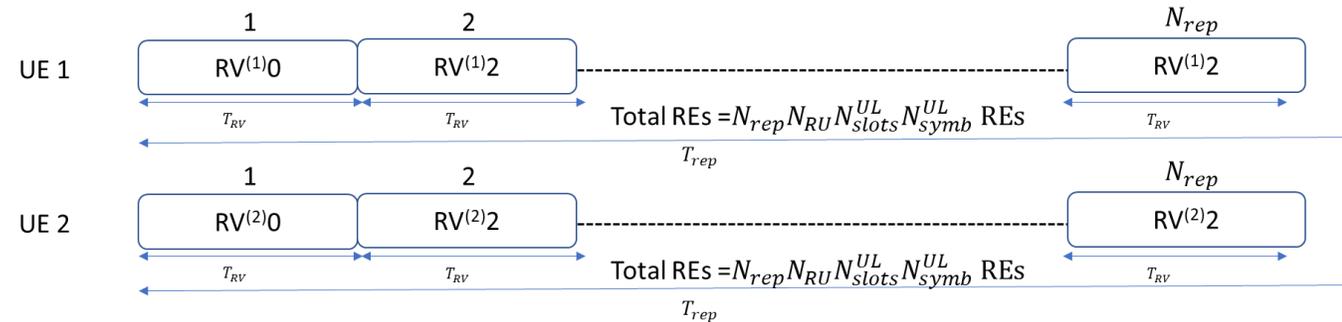


# Summary of proposals - IOT NTN

- **Improved UL capacity (OCC) for NB-IoT**
  - In cases with large number of repetitions, the uplink capacity can be increased by using spreading by orthogonal cover codes (OCC) on top of single subcarrier 3.75kHz.
  - With OCC, the uplink capacity can be increased more than 2x with NPUSCH, and the NPRACH capacity can be increased 3x.
- **Cell DTX - Disc. Coverage**
  - In systems with a large number of beams, it may not be possible to transmit simultaneously in all of them at full power.
  - Especially for unloaded beams, we propose to specify mechanisms to turn off the broadcast channels (including sync) during predetermined periods of time, and convey this information to the UE.
- **UE location without support of LPP**
  - NB-IoT does not support location reporting except by using LPP, which is not implemented in most products.
  - We propose to standardize a mechanism to provide this information to the network outside LPP.
- **SA2 alignment**
  - System level / architectural changes (e.g. store and forward) may need the corresponding RAN2/RAN3 work

# NPUSCH Capacity Enhancements

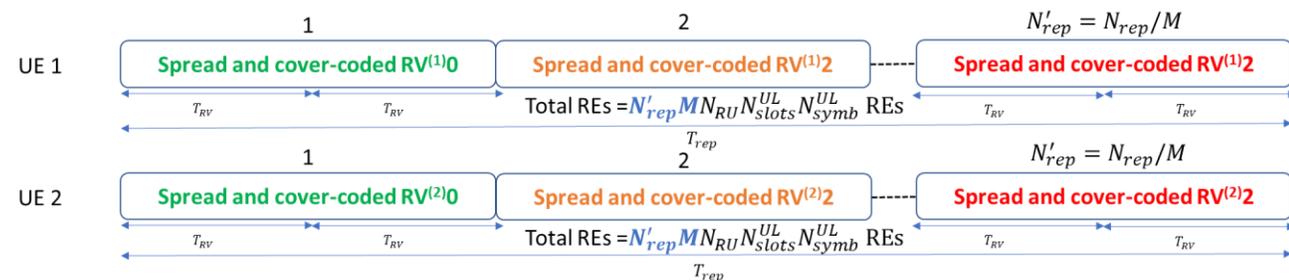
- **Long repetitions = poor spectral efficiency**
  - For NB-IoT single subcarrier with repetitions, a single UE will use a large amount of time-frequency resources.
  - We propose to use **orthogonal cover codes to multiplex multiple UEs** in the same time-frequency resources (increase capacity).
  - Downlink control (NPDCCH) may need enhancing to make use of this extra capacity.



**Current specs:** UL transmission w/ RV-cycling: UE1, UE2 are scheduled in different time/frequency resources

- **Preliminary evaluation results:**
  - Using RAN4 requirements on timing and frequency errors, and NTN TDL-D channel, the following capacity gains are achieved (multiplexing up to 4 UEs):

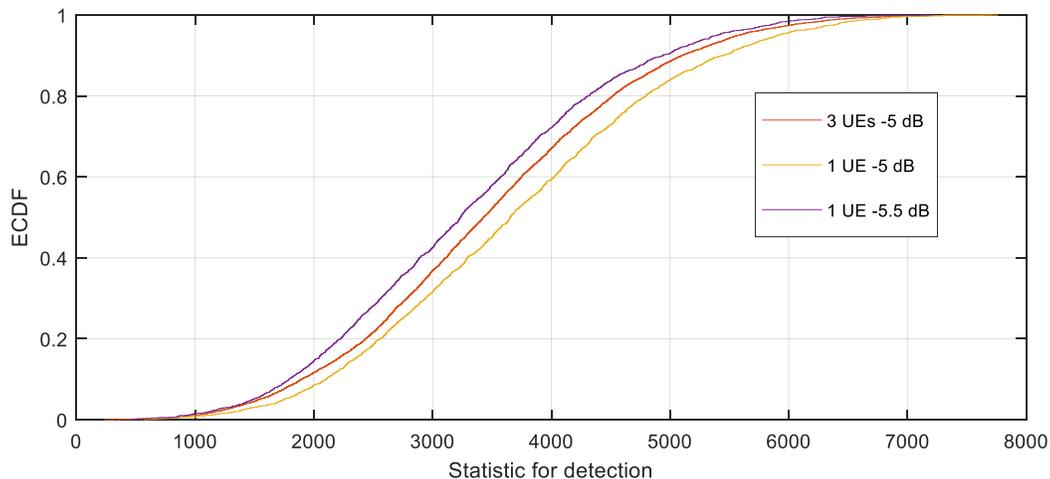
Uplink SINR (3.75kHz SCS)	Capacity gain
3dB	1x (no gain)
0dB	2x
-4dB	2.67x



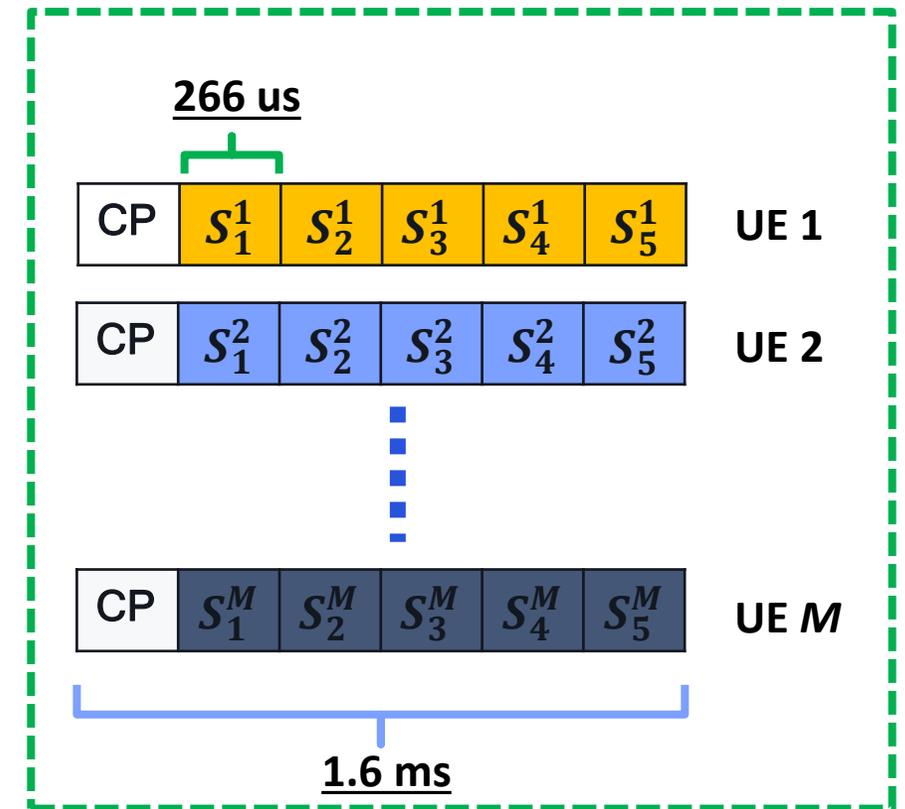
**Proposed UL transmission:**  $M$  (= 2 above) UEs are multiplexed over the same resources by using OCC (e.g. [1 1], [1, -1])

# NPRACH Capacity Enhancements

- **Increasing NPRACH capacity**
  - We propose to apply **orthogonal cover code** over the NPRACH waveform to increase the capacity.
  - For instance, using a cover code of length 3 would increase the NPRACH capacity by 3x (similar to e.g. increasing by 3x the number of allocated subcarriers).
- **Preliminary evaluation results:**
  - Using RAN4 requirements on timing and frequency offset, and NTN TDL-D channel, we observe that a cover code of length 3 offers a 3x gain in NPRACH capacity with negligible performance impact (less than 0.5dB impact vs no OCC)



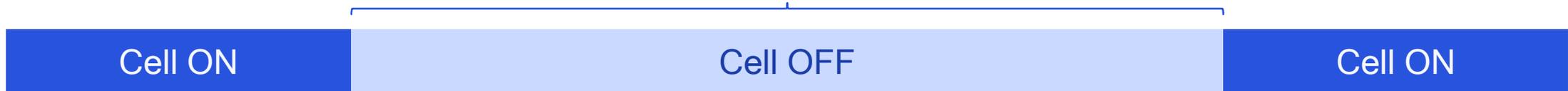
NPRACH preamble with cover codes (format 2)



# Cell DTX - discontinuous coverage

- **Resource saving and power limitation:**
  - In many cases, it is not desirable to transmit in all beams of a satellite continuously due to:
    - **Power limitation:** A satellite may not be able to transmit at full power in all the beams simultaneously.
    - **Light load:** In instances where a beam is unloaded, the satellite still needs to transmit the broadcast signals, which is not efficient from power / bandwidth perspective.
- **Proposed approach:**
  - Extend discontinuous coverage framework to indicate to the UE that the broadcast channels for a beam may not be transmitted during a time period.

Indication of OFF period using discontinuous coverage framework



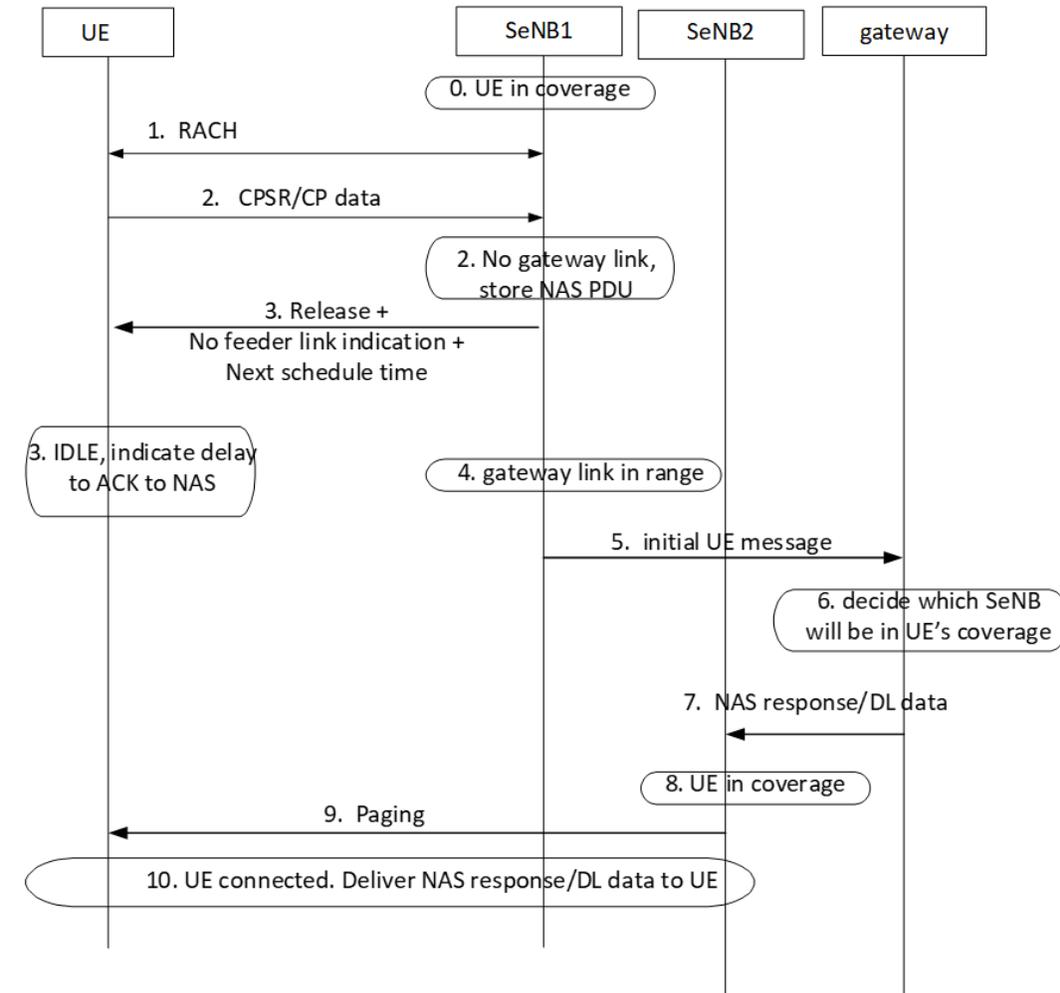
# UE location without LPP support

- **LPP support in NB-IoT:**

- Although supported by specifications, most NB-IoT products do not support LPP.
- For some deployment scenarios (e.g. discontinuous coverage) it is important for the 3GPP system to know the UE location.
- UE location updating procedure may also be needed.
- We propose to introduce an alternative way of reporting UE location outside LPP.

# Alignment with SA2 - store and forward

- New features potentially introduced by SA2 need the corresponding work in RAN2/RAN3 (lead WG should be SA2). Some examples include:
- **Store and forward / intermittent feeder link:**
  - On top of discontinuous coverage, there could also be intermittent feeder link (FL) connectivity with the ground station (GS) in areas where it is not feasible to deploy a ground station or where deployment of ground station is not cost effective.
  - UE needs to be informed on the availability of the feeder link.
  - UE needs to know when it expects the response from core network and when it should perform the next transmission.
  - For this, regenerative payload architecture needs to be supported. It could be full core network functionality on board or just an eNB on board.
- **Proposed enhancement**
  - Based on the regenerative architecture supported by SA2, specify the discontinuous feeder link solution.



Potential call flow for intermittent feeder link



# Thank you

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