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Hexa-X-II architecture overview and NTN related activities

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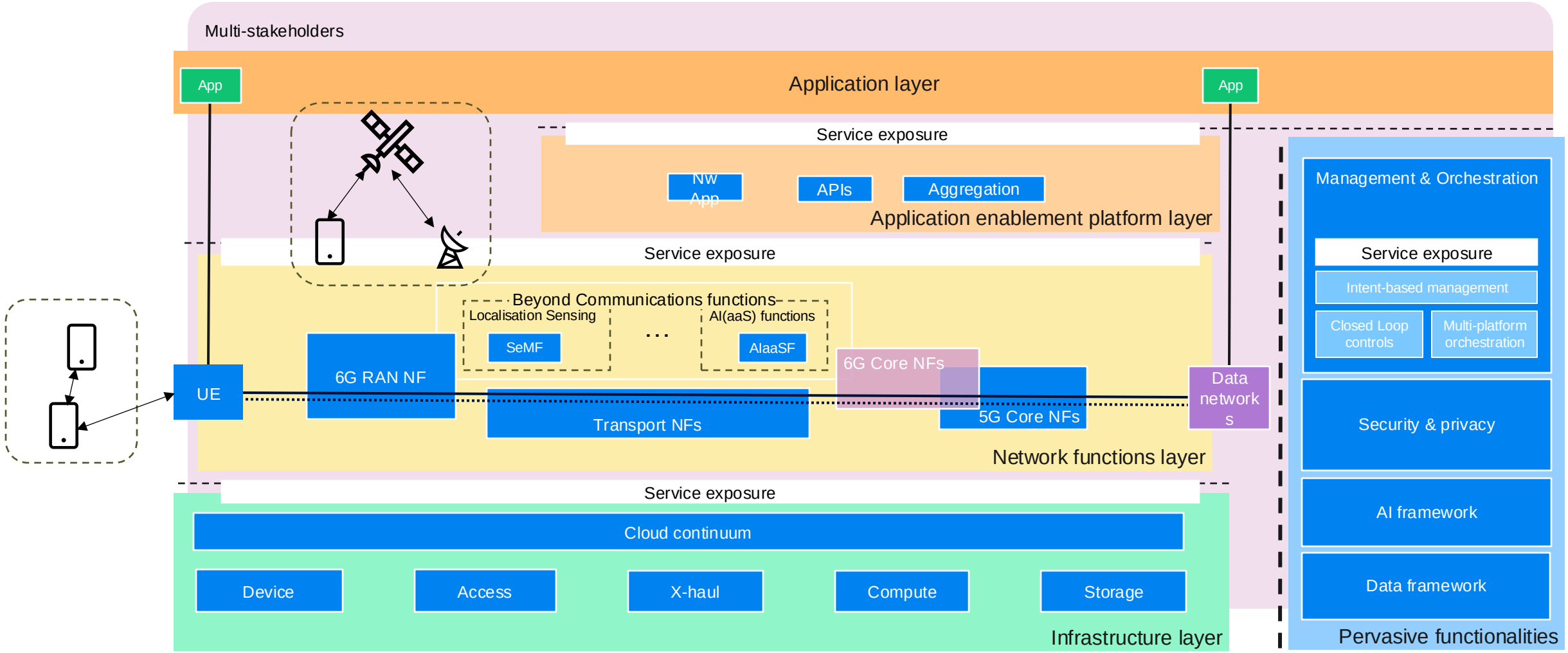
Objectives of this presentation

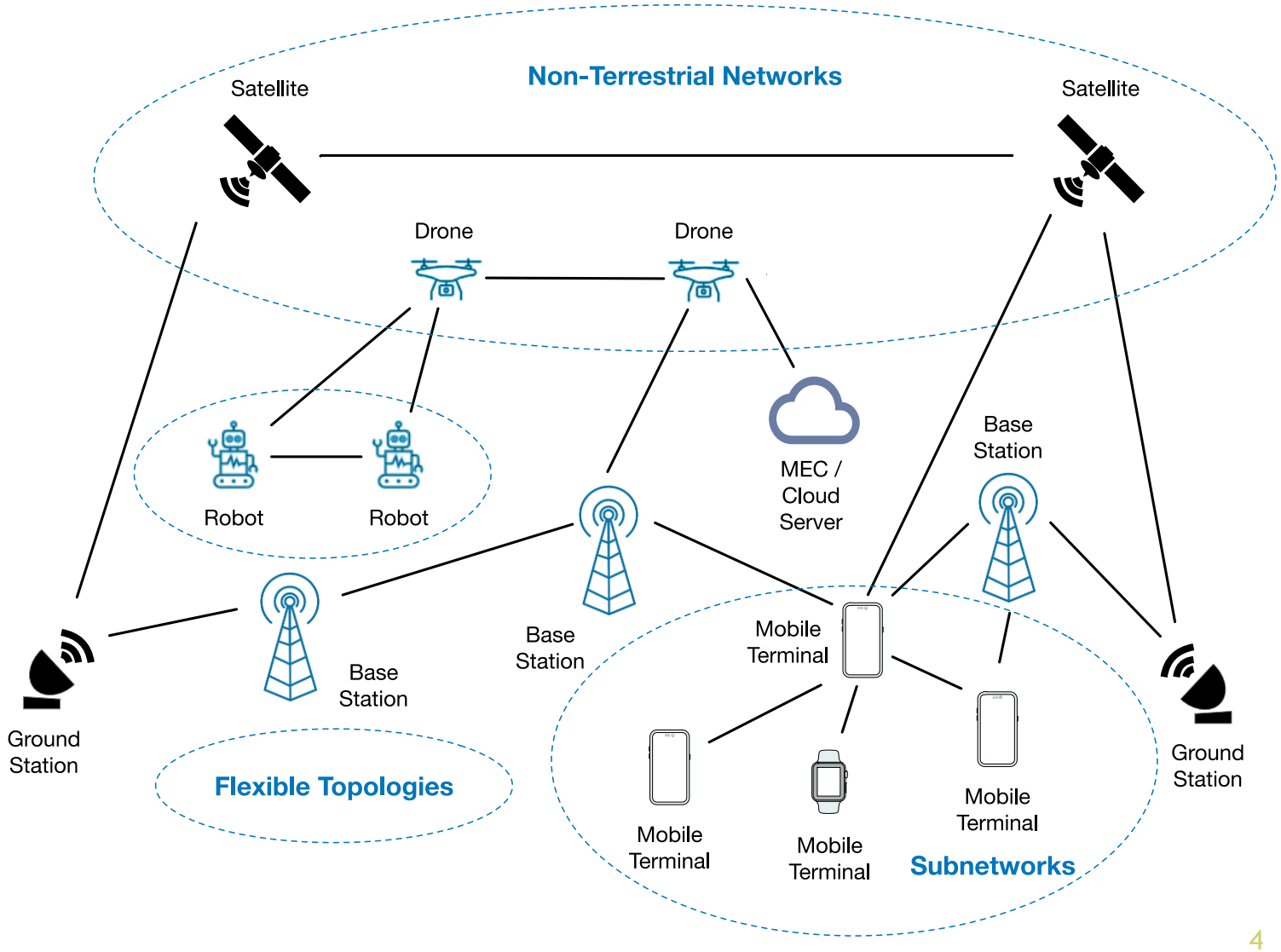
- Give an overview of the Hexa-X-II architecture view
  - And the relation to NTN
- Showcase some Hexa-X-II NTN related studies

Hexa-X-II 6G System blueprint view
With example deployments

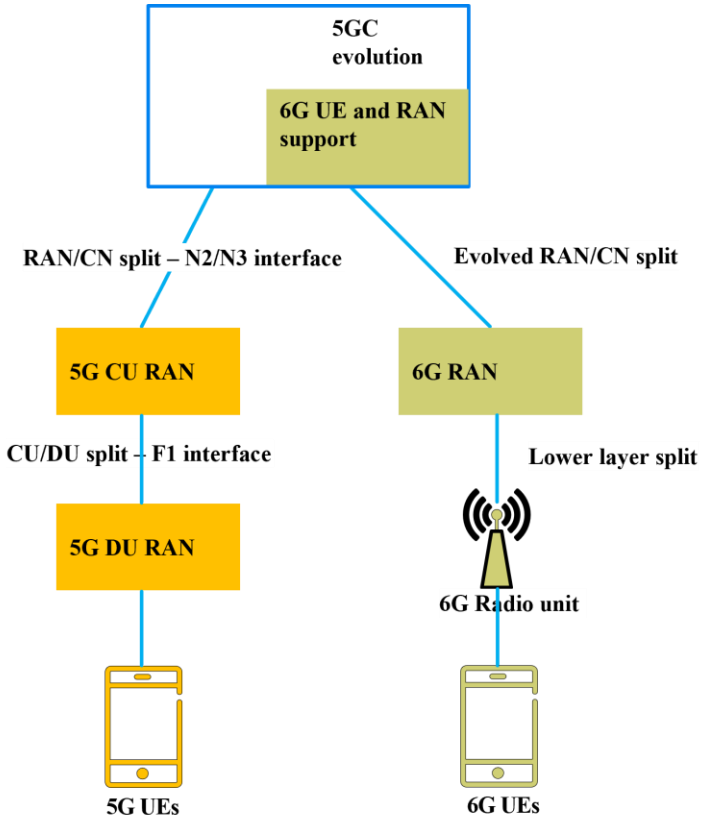


Introduction
Hexa-X-II Network of Networks paradigm

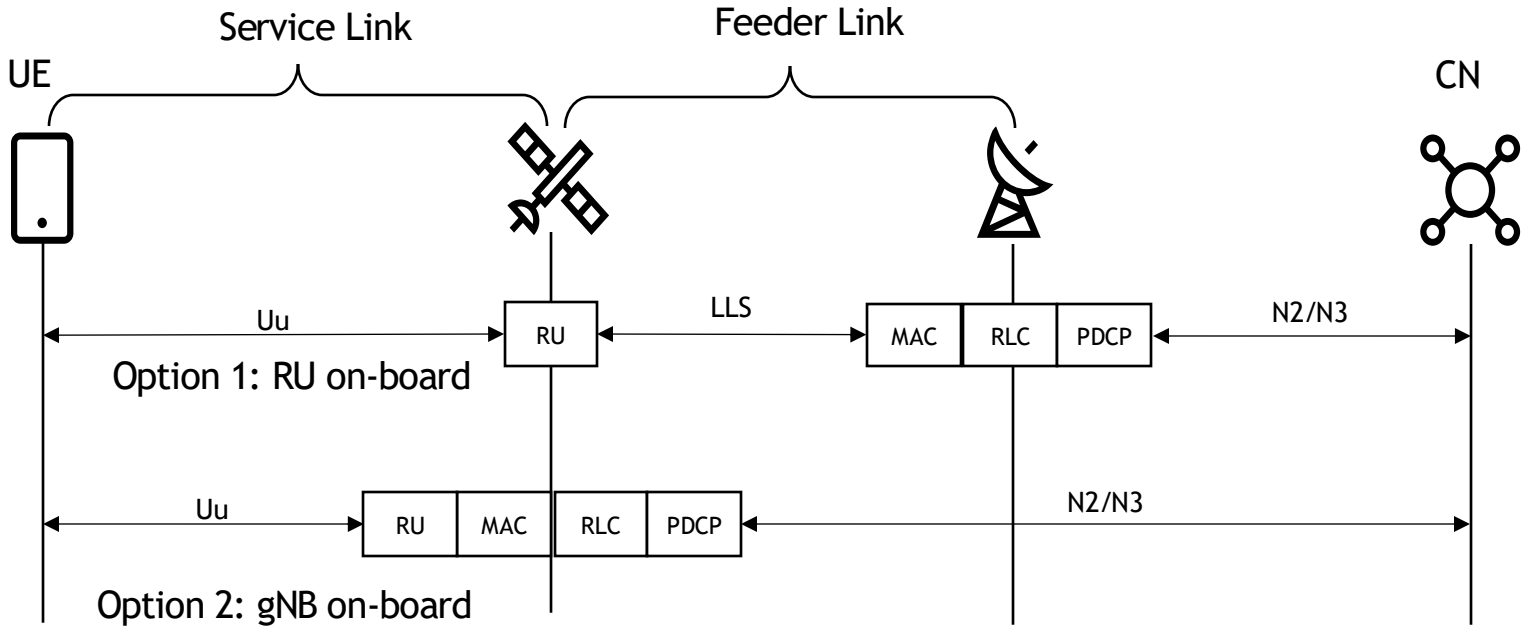
- Network of networks enables:
  - integration of multiple subnetworks, including terrestrial, aerial and non-terrestrial nodes
  - a seamless and unified, ubiquitous network of networks



6G reference architecture and NTN architecture



5G-6G migration



Possible 6G NTN architecture options

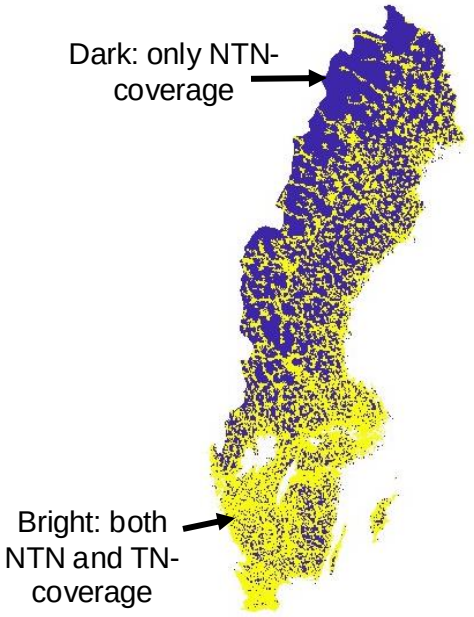
NTN activities in Hexa-X-II

Coverage Inequality Index

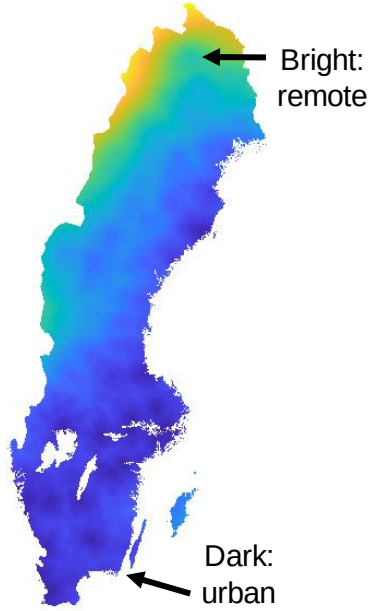
Results in coming D3.5

- A new quantitative index that combines 6G coverage map and rurality map into single scalar index
- Features/properties:
  - compare fairness in regions
  - compare fairness over years
  - compare fairness of 6G operators
  - a new regulation tool
  - 6G network planning tool

6G coverage map: local service quality in joint NTN/TN



Rurality map: weighted distances to population clusters



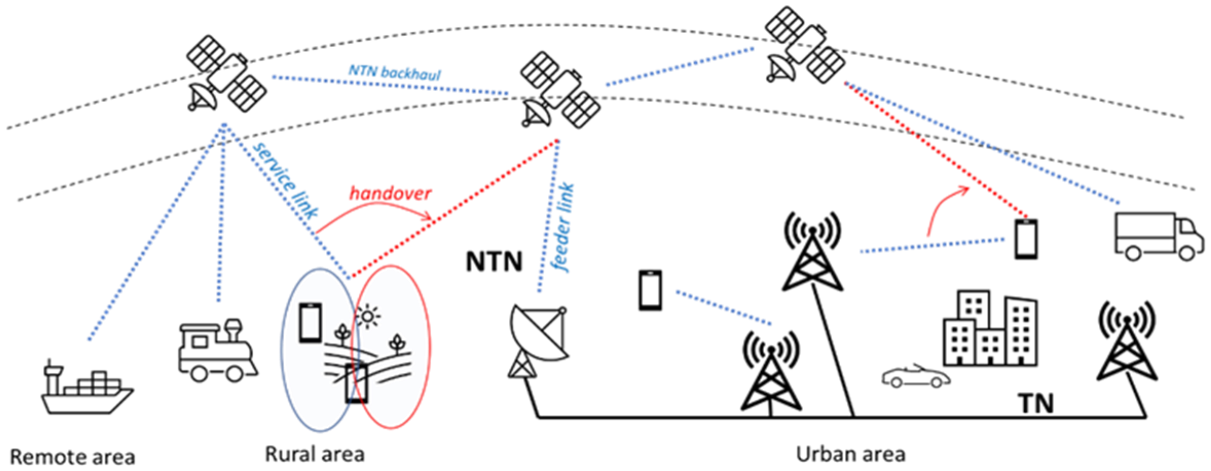
A *new coverage inequality index* reflects the rural-urban service fairness for an NTN/TN-served large-scale region and reveals residual inequalities and remaining nuances of the '6G fully-connected world' vision.

NTN mobility

Results in D4.3

NTN Mobility problems

- Interruption time due to frequent HO
- Large number of UEs may need to perform HO concurrently
- Handover signalling overhead



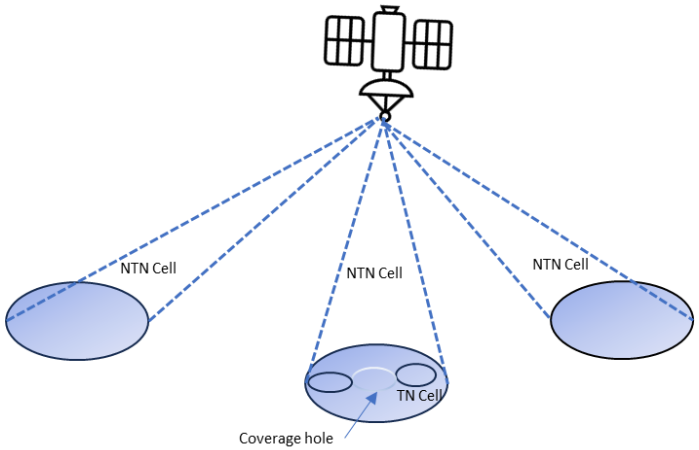
Possible solutions

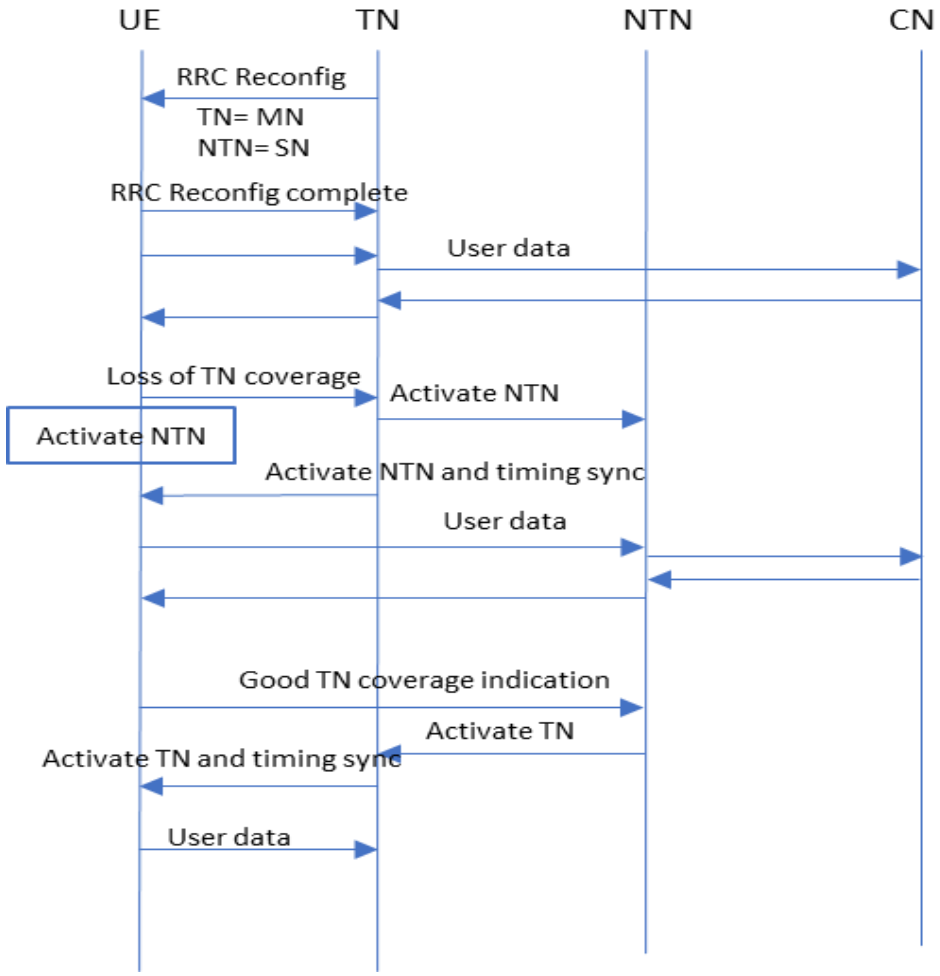
- QoS-aware omission of HO common information
  - for sporadic data, delay tolerant traffic
  - receive common info from SIB broadcasting
- Random time-based conditional HO
  - avoids overloading RACH
  - if not using RACH-less HO
- PCI change only (i.e., cell change without HO)
  - avoids complex DAPS
  - PCI unchanged constraints soft switch

NTN mobility
NTN-TN global coverage and coverage holes

Results in coming D3.5

- As part of global coverage, user may stick to TN coverage as much as possible and NTN may be used to cover the TN coverage holes.
- Fast switch dual connectivity between NTN and TN can handle coverage holes and improve the (possible) interruption time
  - UE anchor/master could be TN or NTN cell
  - The TN and NTN links may have rather different latencies which may impact the connection negatively

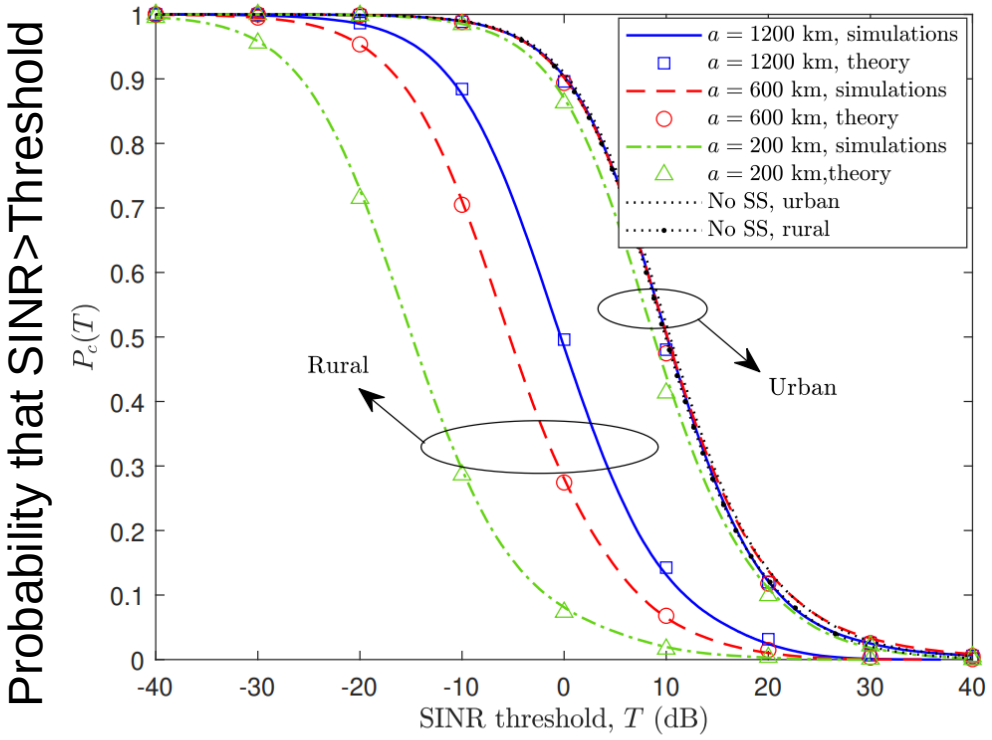




Performance study of TN-NTN integrated networks in S-band NTN and TN share same spectrum (2 GHz band)

Results in D4.3

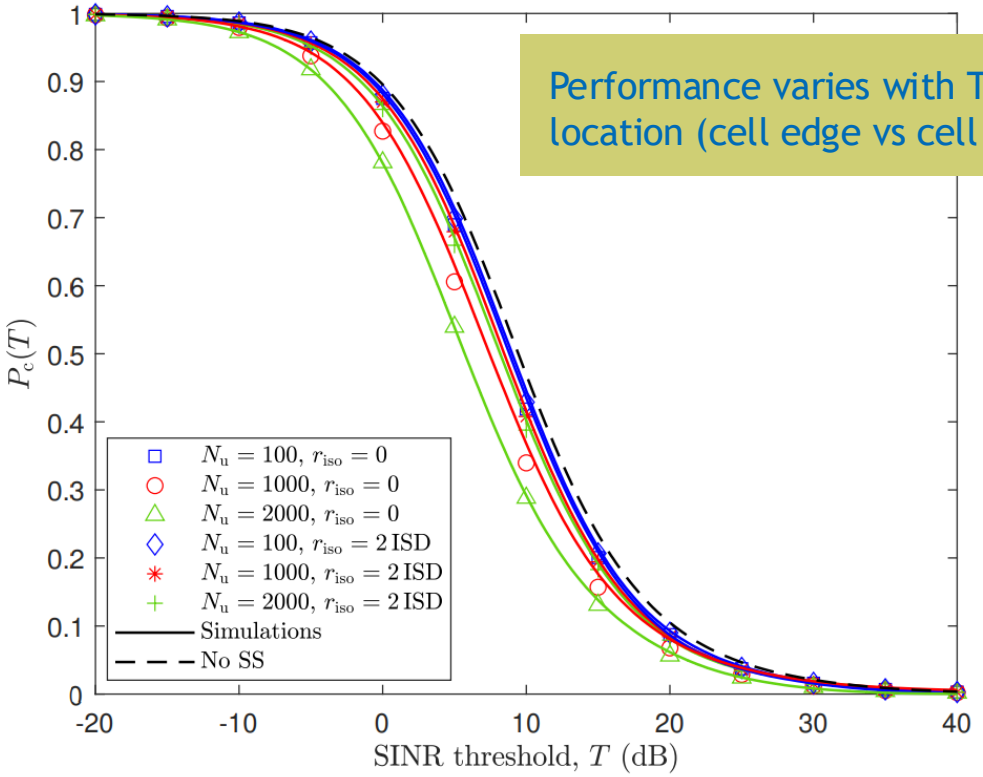
Downlink, NTN DL interferes with TN DL



(a) 100% load.

The altitude of satellites impacts TN rural regions.
Urban regions see less degradation.

Uplink (reverse configuration), NTN UL interferes with TN DL



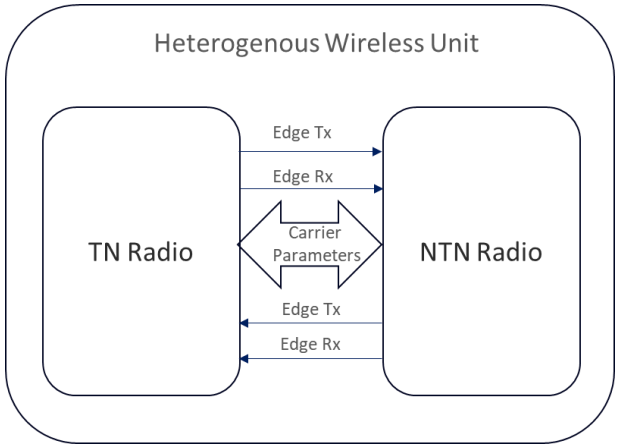
(a) 100% load.

Performance varies with TN user location (cell edge vs cell centre).

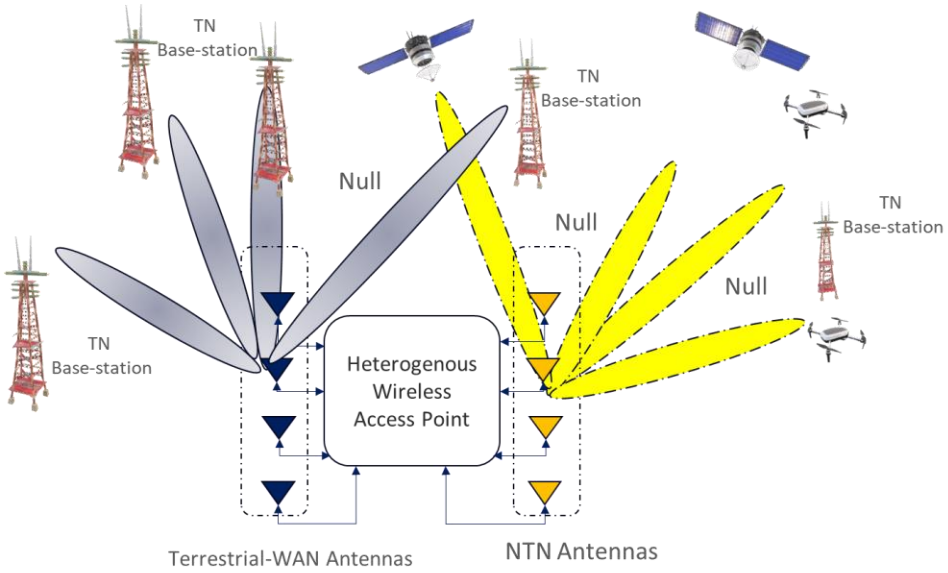
[2401.08453] Co-existence of Terrestrial and Non-Terrestrial Networks in S-band (arxiv.org)

TN/NTN Radio Interference Mitigation

- Both external and internal interference may need to be reduced.
- Potential countermeasures include
  - handshaking between TN and NTN entities
  - antenna beamforming and nulling
  - circuit techniques: filters, bandgap, decoupling
  - signal processing: Tx pre-distortion, Rx post-distortion
- Combination of these mechanisms may be needed



Results in coming D4.5



Conclusions and takeaways

- Hexa-X-II 6G architecture assumes NTN as an integral part
- Hexa-X-II Network of Networks paradigm is a seamless and ubiquitous communication system, with integration of multiple subnetworks, including terrestrial, aerial and non-terrestrial nodes

- NTN mobility can be further improved with various solutions to minimize overhead, signaling and interruption time
- NTN complementing TN coverage via a fast switch connectivity may improve coverage holes but is not without challenges
- Hexa-X-II is developing a Coverage Inequality Index including both NTN and TN
- Spectrum sharing between NTN and TN in 2 GHz band (interference from NTN to TN)
  - Separation distance and power limits must be defined

- More details can be found in deliverables D2.3, D3.3 and D4.3 released on the https://hexa-x-ii.eu/ in H1 2024

HEXA-X-II.EU //

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6GSNS

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