Non-Terrestrial Networks for 5G New Radio

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NTN for Public Safety

- Extending coverage to places without terrestrial coverage
- Supporting mission critical services
- Providing 5G reliability and resilience
NTN for 5G New Radio

- Study item on NR to support Non-Terrestrial Networks completed in 38.811
- Potential solutions are being evaluated in Rel-16 - study item report in 38.821
- Specification work is expected to start in Rel-17
Nokia HAPS Related Experience

• Nokia actively involved in 3GPP and other NTN projects

• Nokia and High Altitude Platform Stations (HAPS) – GEO’s, MEO’s, LEO’s, Airplanes and Balloons

• HAPS Project using Balloons
  • Uses LTE to cover unserved areas

• Mission to the Moon (MttM)
  • E2E solution with Nokia’s small cell LTE eNB and UE (with partners)
  • Hardened to operate in harsh environment (vacuum, radiation) and survive launch, transit and landing mechanical stresses.

• Public Safety High-Altitude Deployments
  • Use Flexi Zone Micro Platform for providing coverage from stratosphere

• UAV
  • Aerial Radio Channel measurement using real live LTE commercial networks
NTN Architecture

• NTN Architecture comprises of
  • Service Link
  • Feeder Link
  • Ground Gateway

• Airborne communication payload
  • Transparent: Change signal carrier frequency, filter, and amplify it between UE and GW. Digital processing is done at gNB at GW.
  • Regenerative: Perform digital processing function of gNB. The gNB functionality can be split between DU at satellite or HAPS and CU at GW.
Overview of LEO Challenges

Recap of LEO at 600 km/1200 km

**Large Distances:**
- Up to 1932 / 3131 km
- Link Budget

**Large Delays:**
- Up to 12.9 / 20.9 ms
- CSI may be out-of-date
- Large HARQ buffer required

**High Speed:**
- Mobility
- Timing Advance
- Doppler

**Cell Size:**
- RACH/TA Range
- Country Identification

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High Altitude Platform Stations

- HAPS can use a balloon or solar powered drone to operate in the stratosphere with typical altitude of 20 Km.
- Compared to LEO satellites, HAPS has the advantages:
  - Short propagation delay (<0.4 ms)
  - Low path loss
  - Negligible Doppler shift
- Spectrum: <6 GHz for service link, mmWave for feeder link
- Challenges
  - Equipment is subject to strict weight, size, and power budget
  - Equipment needs to operate in extremely cold temperature (≈-70°C)
  - Large antenna arrays and high transmit power may not be possible
  - Feeder link using high frequency band may experience large rain fade (>25 dB)
- Phased array can be used to form steerable beams to serve fixed cells
- Preliminary study shows with light weight radio and antenna can achieve good throughput in a large coverage area.
HAPS Service Link Capacity and Coverage

- Center cell has higher peak throughput.
- Outer cell throughput depends on the azimuth angle $\phi$ to its antenna panel boresight ($|\phi| \leq 30^\circ$).

![Antenna gain of the center cell](image)

![Antenna gain of the outer cell](image)

DL throughput using 20 MHz bandwidth. An outer is covered in azimuth angle $|\phi| \leq 30^\circ$.
Conclusion

• Feasibility of supporting non-terrestrial communication in 5G NR is being studied in 3GPP. LEO and HAPS are promising deployment scenarios due to their relatively shorter propagation delay.

• NR PHY layer needs to be extended to support the longer delay, large beam footprint of LEO.

• Mobility related impacts, e.g., cell reselection, handover, feeder link switch, also need to be studied for higher layer protocol.

• Compared to LEO, HAPS poses less impact to NR standard, but implementation is constrained by power, size, and weight of the HAPS platform.

• Preliminary study shows light weight radio equipment and antenna design can achieve good throughput and coverage for LOS users (15 Mbps with 20 MHz bandwidth at 100 Km distance).