5G Standardization and Satellites

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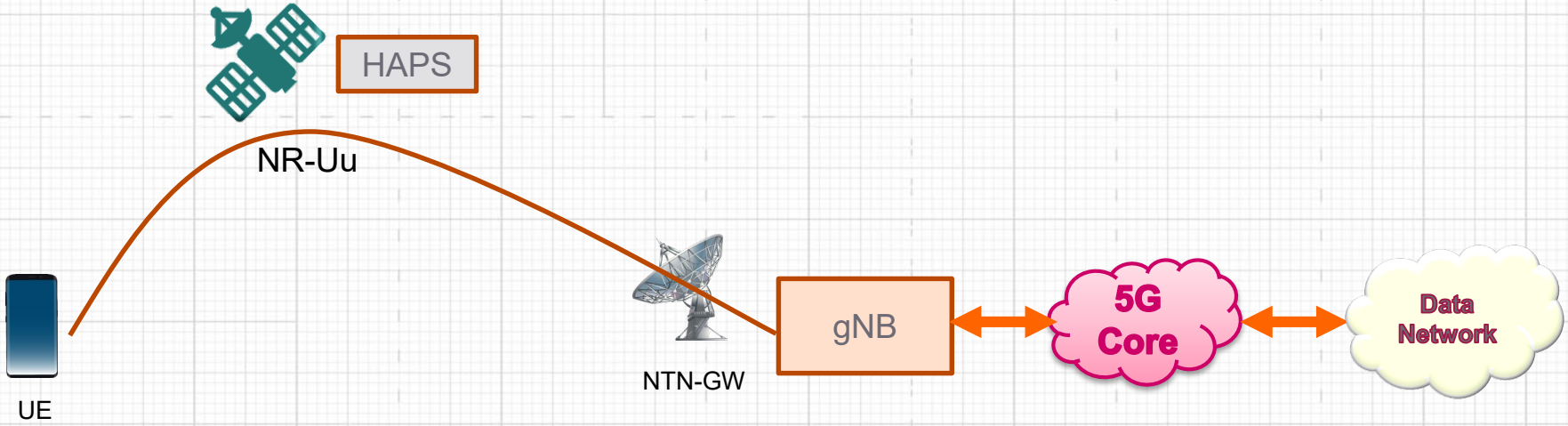
What is an NTN?

- ✓ NTN: A network that utilizes a communications platform at the altitude of more than tens of kilometers
- ✓ Platforms: Satellites (Ex: GEO, MEO, and LEO) and High Altitude Platform Station (HAPS)



Transparent Payload (gNB on the ground with the platform as a repeater; Focus of Release 17)
Future Releases: Regenerative (gNB or gNB-DU on the platform)

3GPP Standardization Status

- Release 15: Introduction of 5G (5G Phase 1) (2019)
- Release 16: 5G Phase 2 and Completion of the “NTN” Study Item (2020)
- Release 17: Introduction to the NTN as a formal feature. Target completion: First Half of 2022 (delayed due to COVID-19)
- Initial Scope
  - Architecture: Transparent Payload (bent pipe)
  - Beams or Cells: Earth-fixed (Ex: GEO and HAPS), Quasi-Earth-Fixed (Ex: LEOs), and Earth-Moving (Ex: LEOs)
  - UEs are GNSS-capable

Challenges & Technical Innovations

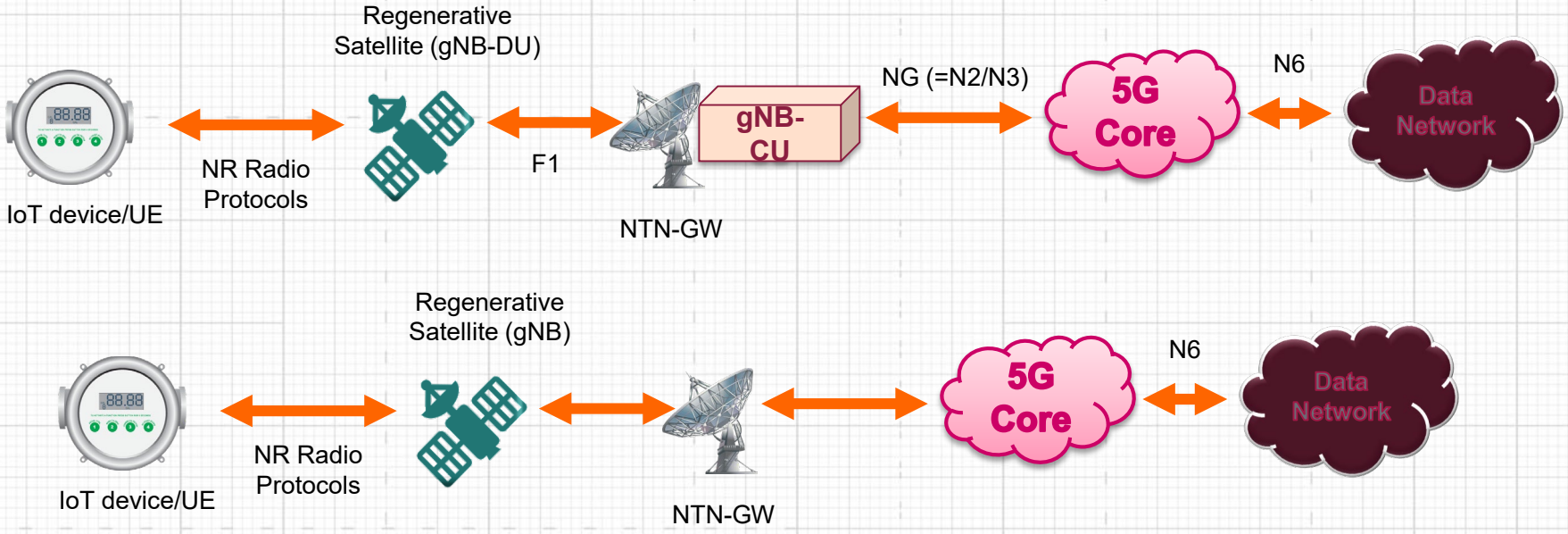
- Challenges
  - Long and time-varying propagation delays (Ex: GEO vs. LEOs)
  - 3 types of beams/cells: Earth-fixed, Quasi-Earth-Fixed, Earth-Moving
  - Large cells (Ex: 1000 km in diameter, fewer resources/user)
  - Moving cells (moving cell identities, frequent and massive handover)
  - Large Doppler shifts (satellite speed: 7 km/s)
- Solutions/Enhancements
  - Timing and frequency pre-compensation
  - Adjustments to timers
  - Enhanced Tracking Area/Registration Area management
  - Enhanced cell reselection
  - Enhanced handover (new measurements)
  - Enhanced uplink scheduling
  - Relaxed QoS

NTN Use Cases

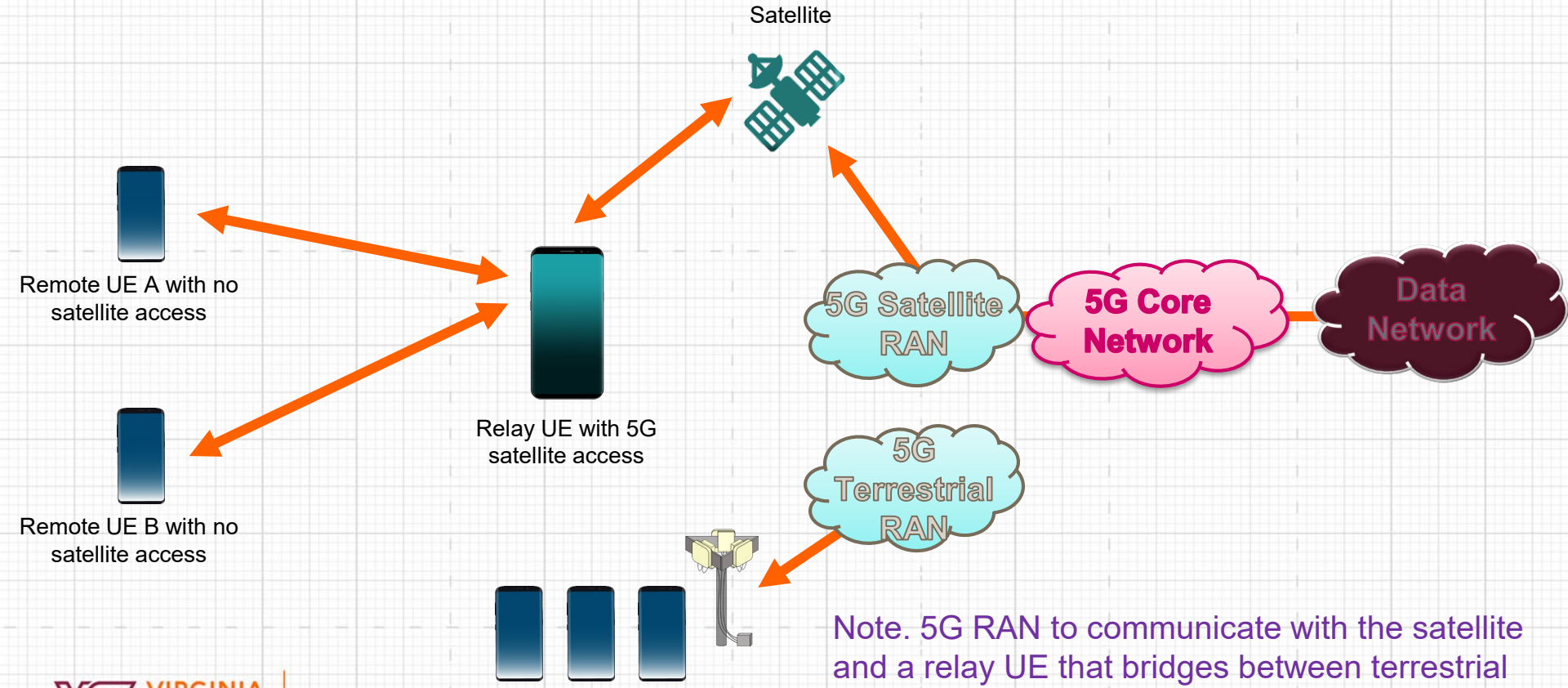
- Service Ubiquity: Ubiquitous coverage
  - Remote rural communities
  - Airplane communications
  - Maritime communications
  - Backhaul (Ex: rural areas and cells on trains)
- Service Scalability (Ex: Broadcast and multicast for efficiency)
- Service Continuity (between terrestrial and non-terrestrial networks)

Architectures

NTN Architectures for Regenerative Payloads

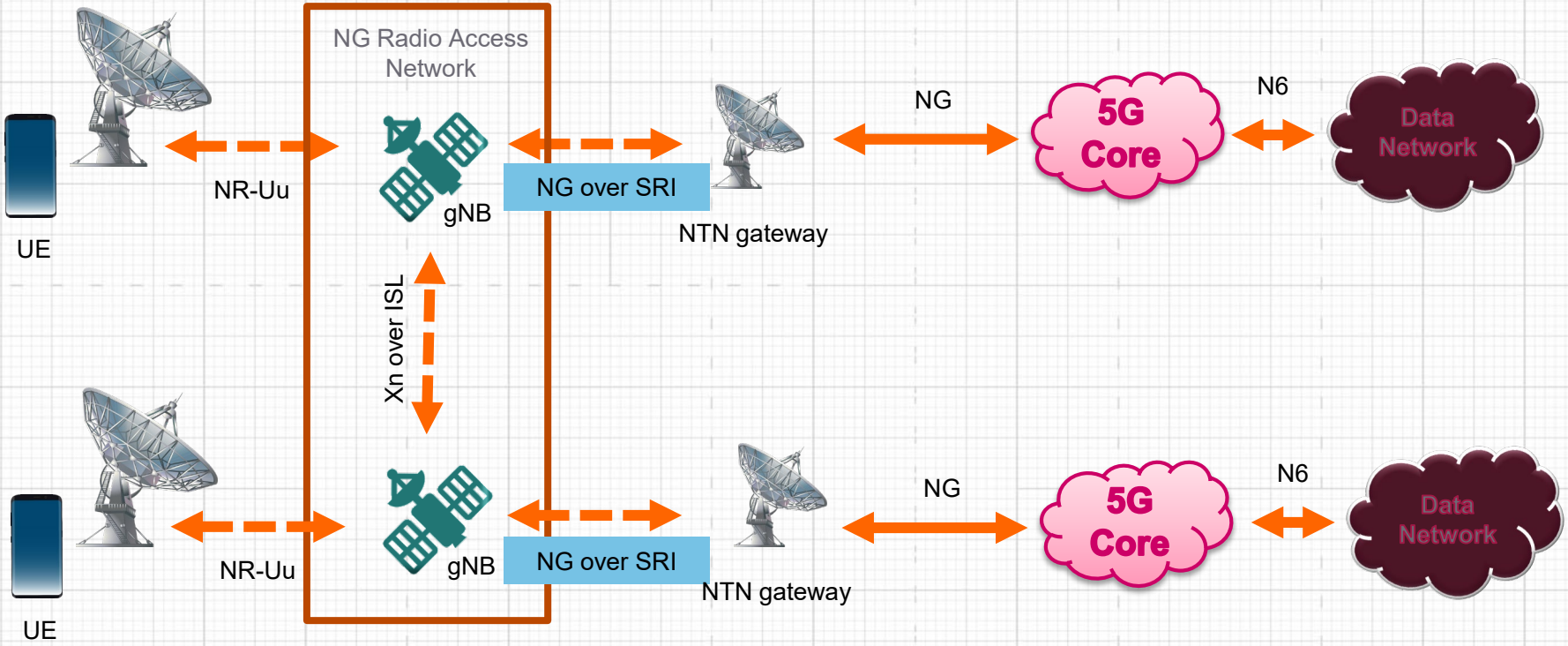


Accommodating Non-Satellite Enable UEs



Note. 5G RAN to communicate with the satellite and a relay UE that bridges between terrestrial UEs and the satellite.

Inter-Satellite Links over the Xn Link



References

Nishith D. Tripathi and Jeffrey H. Reed, “5G Cellular Communications: Journey and Destination, ”The Wireless University, https://thewirelessuniversity.com/ , April 2019.

Flynn, Kevin. “Release 17” 3GPP, www.3gpp.org/release-17.

3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; System architecture for the 5G System (5GS); Stage 2 (Release 15), 3GPP TS 23.501 V15.11.0 (2020-12)