Discussion on 6G RAN

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Agenda

- Practical learnings from 5G
- Key developments in 6G RAN
- Emerging concepts in RAN/vRAN/ORAN
- Research initiatives, (Beyond 6G)

Practical learnings from 5G

- Slow Adoption of Standalone 5G:
  - Push for a "standalone-first" approach with a clear migration path.
  - Avoid specifying multiple MR-DC / NSA migration options.
- Specifying more than one solution to a given problem.
  - MR-DC, mobility etc
- High Cost and Complexity of FR2 (eg: mmWave) deployments
  - Simplify initial access and mobility (e.g., SSB search, beam management).
  - Adopt a balanced spectrum strategy: prioritize mid-band (7–20 GHz) for coverage/capacity; high-frequency spectrum for direct LoS deployments.
- Lack of prioritization of key features:
  - AI/ML standardization largely left to proprietary implementations or later releases.
  - NES features standardized very late.
  - LTM arrived too late, duplicating baseline mobility.
- Backward compatibility issues.
  - Re-evaluate backward compatibility of later-release features.
  - Asymmetric UL/DL (5 MHz DL / 3 MHz UL) usable only by Rel-18 UEs; pre-Rel-18 UEs cannot attach, hindering commercialization.
  - Rel-18 OD-SIB1 NES cells inaccessible to pre-Rel-18 UEs.

Key developments in 6G RAN

- Migration and spectrum:
  - Multi-Radio Spectrum Sharing (MRSS) as a Day-1 migration solution.
  - Interoperable MRSS at least for low-band FDD and mid-band TDD.
- AI-native RAN:
  - AI-native air interface and integrated AI-driven RAN use cases.
  - Make AI/ML integral to network cognitive capabilities.
- TN–NTN integration:
  - Seamless TN–NTN harmonization for mobility and ubiquitous coverage.
  - Minimize NTN-specific aspects; specify NTN as part of the base release.
- Mobility enhancements:
  - Unified mobility framework enhanced by multi-TRP.
  - Toolbox approach: pre-configuration, preprocessing, early UL/DL sync, early CSI acquisition, UE-autonomous execution.
- Energy Efficiency
  - Energy efficiency as a core design principle for both network & UEs.
  - NES features like OD-SIB1, CELL DTX/DRX, OD-SSB etc considered as Day1 features.
  - UL-WUS for UE power savings

Emerging concepts in RAN/vRAN/ORAN

- Flexible and Scalable RAN architecture.
  - Disaggregated architecture enabling virtualization, pooling, multi-vendor sourcing and cloud-native design.
  - Standardized fronthaul (HLS & LLS) will promote open RAN and accelerate 6G productization.
- Re-use of 5G hardware.
  - Enables cost-effective 6G and continuity from 5G.
  - 5G split-RAN architecture supports hardware reuse.
- vRAN
  - Hardware-agnostic 6G RAN with software-based RAN functions on cloud infrastructure.
  - Distributed cloud computing across edge and central clouds.
  - Split-RAN architecture central to NFV, SDN, and cloud-native deployments.
- ORAN:
  - ORAN remains highly relevant for 6G, complementing 3GPP.
  - DU–RU separation recognized by 3GPP but specified outside 3GPP.
  - ORAN narrows solution space forging multi-vendor interoperability.

Research initiatives (6G and beyond)

- AI-Native Wireless Networks
  - AI is expected to be deeply integrated into future wireless networks.
  - Predictive mobility management, Traffic prediction and network automation, AI-driven beamforming etc
- Post Quantum Cryptography (PQC) delivers Quantum-resilient wireless networks
  - Challenges : PQC uses much larger keys and signatures, larger authentication messages, Higher control-plane overhead => massive IoT, URLLC, high-mobility users impacted.
  - Additional delay, memory, processing overhead are other challenges to be addressed.
- UE-centric Cell-less RAN architecture for massive MIMO
  - No fixed cells or single serving BS; Multiple antennas serve users on the same time–frequency resources using beams, co-ordinated by Access points.
  - Challenges – AP Synchronization, mobility, Pilot contamination, interference etc
- TN ⇔ NTN integration
  - Satellite link latency can be up to ~250 ms (GEO) compared to <1 ms in terrestrial links.
  - LEO/MEO satellites introduce mobility and Doppler effects.
  - HARQ, Timing advance, and frame structure differ significantly.
  - Coverage, mobility, beamforming, and power control are also fundamentally different.
  - TN–NTN radio characteristics divergence makes integration a long-term research topic.

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