Reimagining Indoor Mobile Access with Infrastructure and Spectrum Sharing

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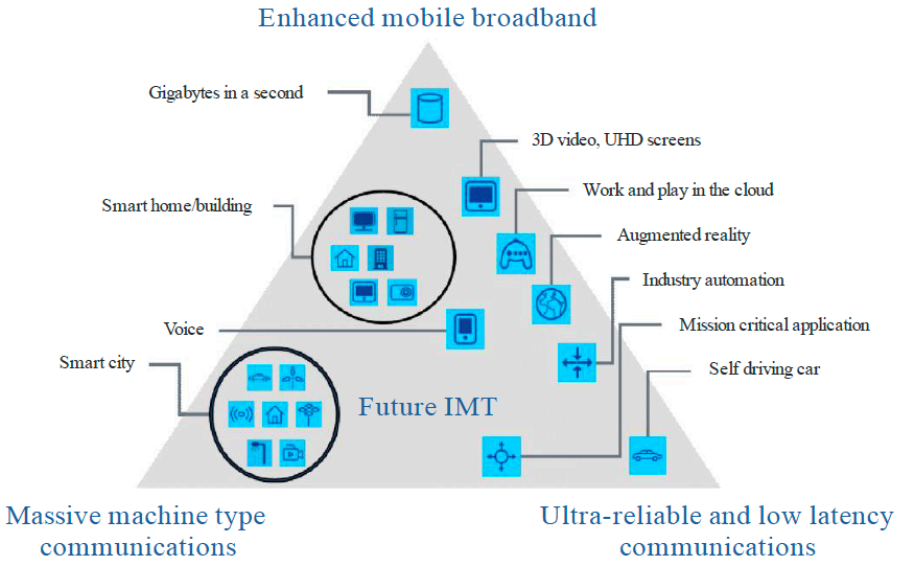
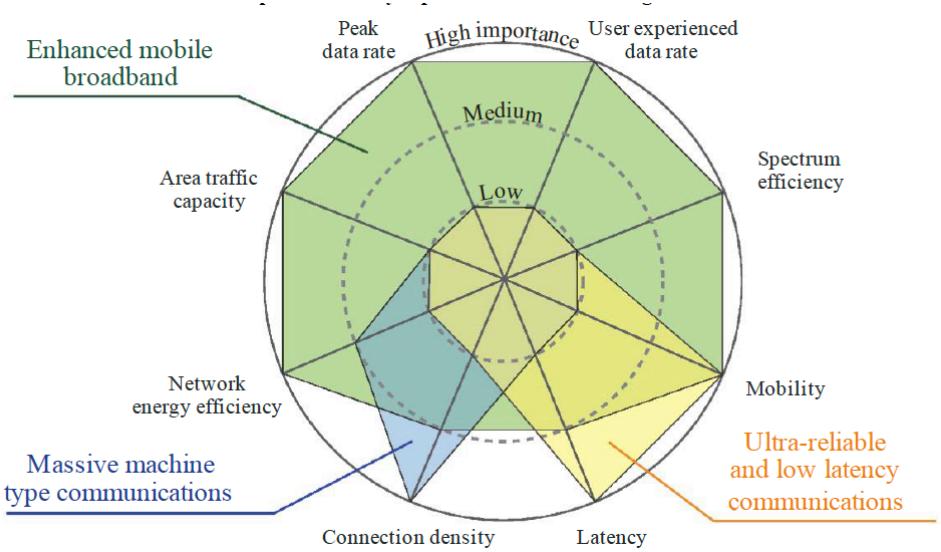
A View of 5G

KPI	ITU-R IMT-2020 Target Requirements
Downlink/Uplink Peak Data Rate	20/10 Gbps
Downlink/Uplink User Experienced Data Rate in Dense Urban setting	100/50 Mbps
Downlink/Uplink Peak Spectral Efficiency	30/15 bits/s/Hz
One-Way User Plane Latency over the Air Interface	1-4 ms
Control Plane Latency	20 ms
Connection Density	1000,0000 per km^2
Mobility Interruption Time	0 ms
System Bandwidth	≧ 100 MHz and up to 1 GHz
…	…

ITU IMT-2020 Vision for Diverse Mobile Services

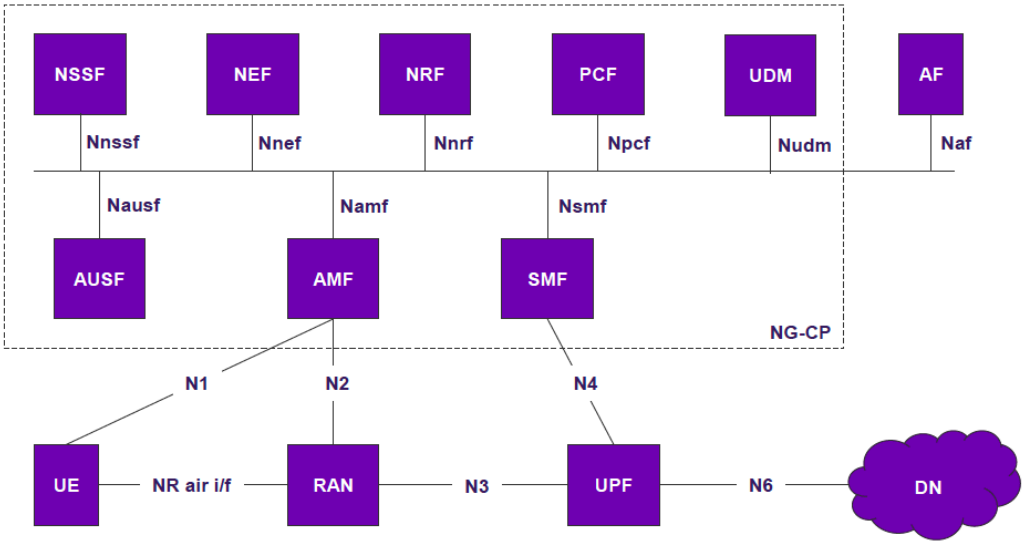




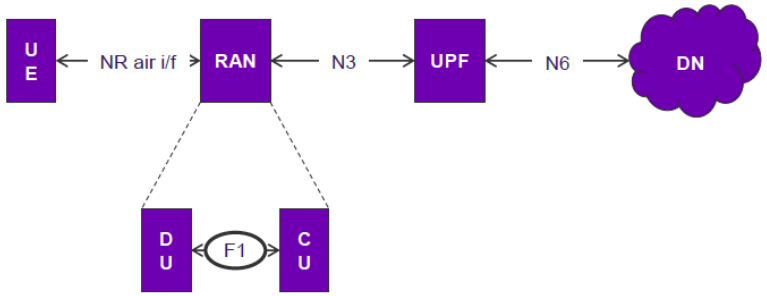
- In some ways born out of necessity for the traditional ecosystem but an opportunity for all
- Meeting all these seemingly conflicting requirements via a one-size-fits-all architecture impractical while bespoke network for each service is not an option

3GPP 5G Network Architecture

- Relative to 4G:
  - Disaggregated, CP-UP separation and virtualized network functions (VNFs)
  - Service based



Functional decomposition of the RAN



Source: Fitch and Sutton, IEEE 5G Summit, May 2018.

Some exciting trends and opportunities en route to 5G

- Network slicing and cloudification of mobile networks
- New entrants to the ecosystem already there in some forms and being actively sought
- Open source platforms playing a big role for the first time in development and testing of 5G ideas with the consequence of de facto standards
- Infrastructure and resource virtualization could also bring about unification between diverse access technologies
- Service assurance and robustness needs a rethink with multiple layers to contend with
- Cheap software radios and availability of open source platforms arm malicious actors

Indoor mobile access

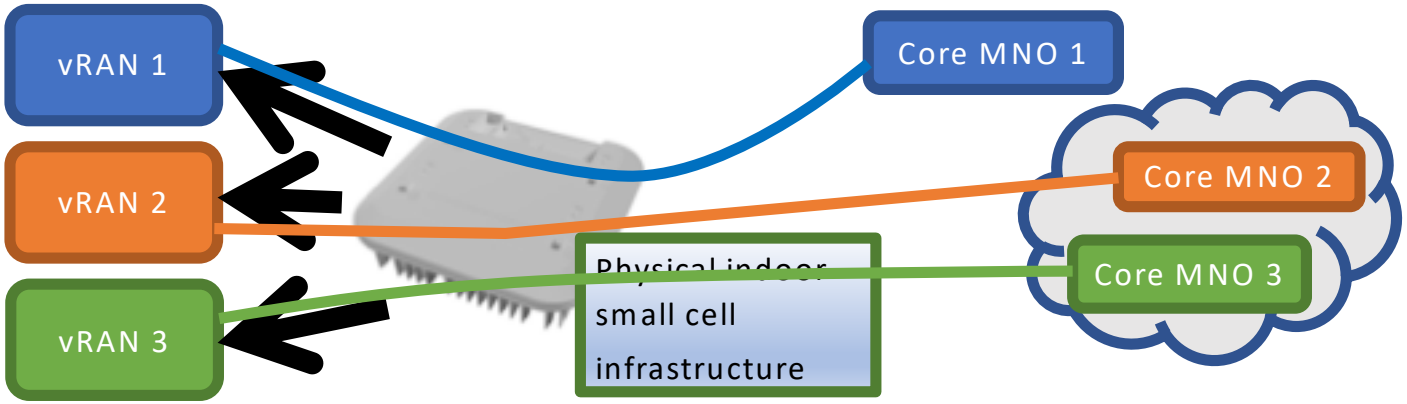
- Mobile data traffic continues to grow rapidly
- 80% of mobile data traffic from indoors as of 2014 and is expected to reach 95% by the time 5G gets deployed [Gartner]
  - Public spaces mainly served by mobile networks [Analysys Mason, 2016]
- Outdoor solutions for indoor mobile access non-ideal due to building penetration losses and increasing data rate requirements
- Traditional distributed antenna systems (DAS) expensive to deploy and inflexible

Alternative is to deploy small cells indoors

- Scale the density of small cells with user density and traffic
- Historically, making cells smaller and denser contributed most to capacity scaling of mobile networks [Zander & Mahonen, 2013]
  - By two orders of magnitude more compared to spectrum and technology (spectral efficiency)
- However several barriers to indoor small cell deployments
  - Deployment costs
  - Site access
  - Backhaul
  - Power
  - Return on investment
  - Multi-operator support
  - Visual acceptability
  - …

Growing consensus around infrastructure sharing to ease indoor small cell deployments

- An entity called "neutral-host" deploys and manages the small cell infrastructure
- Neutral-host as an infrastructure provider offers *small cells as a service* to mobile network operators (MNOs)
  - Provides each MNO with a *virtual RAN (vRAN)*
  - A particular case of RAN/network slicing concept underlying 5G

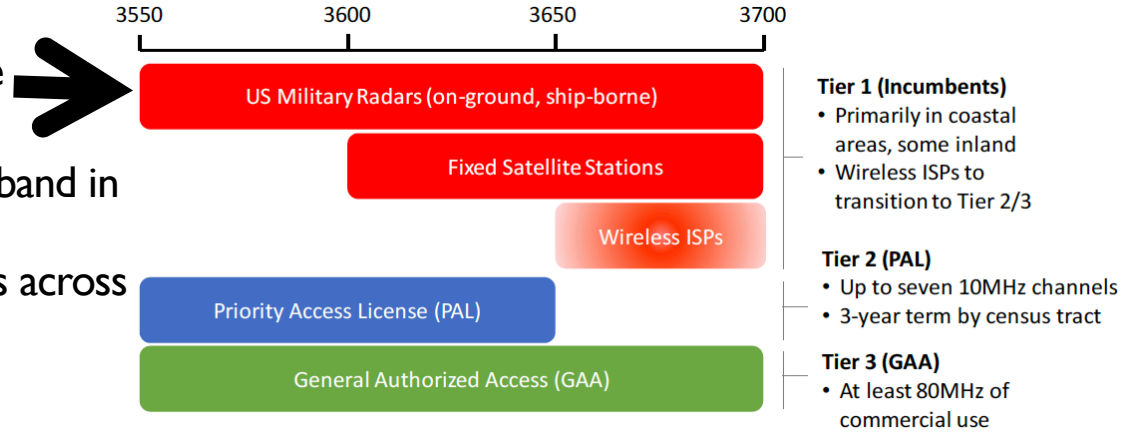


Spectrum sharing amplifies the potential of neutral-host small cells

- Vanilla realisation of neutral-host solution requires operators to bring and use their own licensed spectrum (the current industry approach)
  - Limits incentives for neutral-host and operators
- Spectrum sharing along with neutral-host's infrastructure sharing capability an ideal combination
  1. Traditional MNOs gain access to additional spectrum for offloading and monetise from unutilised owned spectrum
  2. Opens the door for new non-traditional operators with innovative revenue models
  3. Neutral-host can additionally offer dynamic spectrum sharing capability and serve a wider array of operators

Sources of spectrum to share

- Can be comprised of any or combinations of the following:
  1. Licensed spectrum pooled from different traditional MNOs
  2. Unlicensed (e.g., 5GHz) spectrum
  3. Shared access spectrum with low acquisition cost and without complex coexistence issues
     - 3.5GHz Citizen Band Radio Service (CBRS) band in the US
     - 3.8-4.2GHz planned shared access band in the UK
     - Licensed shared access (LSA) bands across Europe (e.g., 2.3GHz band)



Our 5G related research in the past few years

- Systems support for RAN slicing: Orion [MobiCom'17], FlexRAN [CoNEXT'16]
- 5G use cases: indoor mobile access [this talk], universal access [COMPASS'18], …
- Spectrum sharing and coexistence: LTE-U/LAA [MobiHoc'16], LSA [MobiHoc'16], CPRecycle [CoNEXT'16]
- Efficiency and security aspects of NB-IoT [ICDCS'18, IEEE IoT Journal'18]
- Abstractions for software-defined wireless networks [TNSM'15]
- OpenAirInterface as a 5G research platform [CCR'14]