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4G (LTE)

- LTE stands for Long Term Evolution
- Next Generation mobile broadband technology
- Data transfer rates of 100 Mbps
- Based on UMTS 3G technology
- Optimized for All-IP traffic

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Advantages of LTE

for Network Operators	*for* End Users
High network throughput Low latency Plug & Play architecture Low Operating Costs All-IP network Simplified upgrade path from 3G networks	Faster data downloads/uploads Improved response for applications Improved end-user experience

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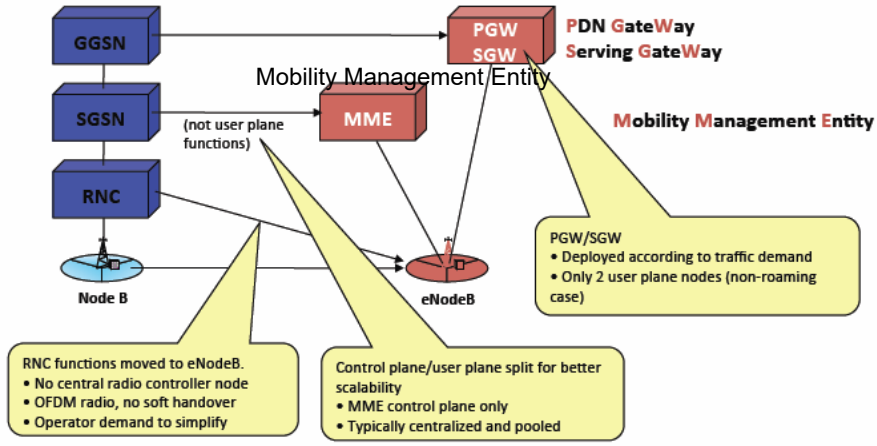
LTE vs UMTS

- Functional changes compared to the traditional UMTS architecture



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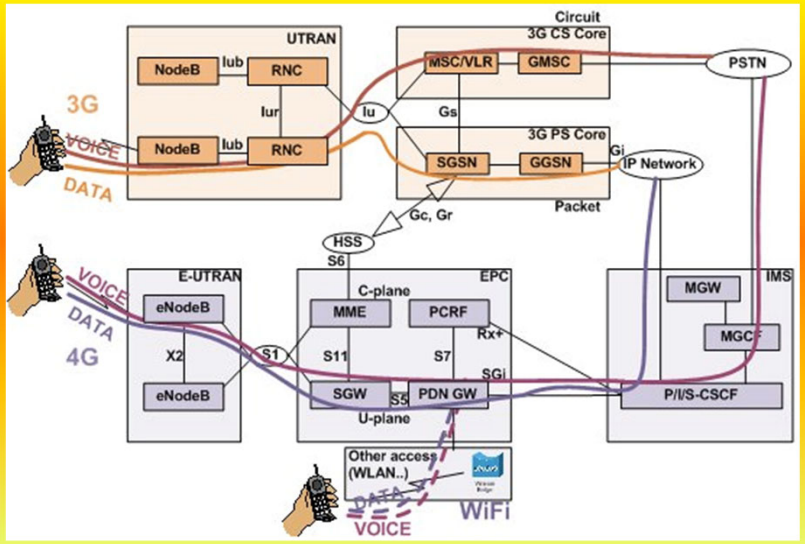
LTE vs UMTS



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UMTS vs LTE

- LTE with simplified RAN architecture - with only Base stations, called eNodeB; UMTS uses Base stations (NodeB) and Controllers (RNC). In this case, eNB captures the functions of both UMTS NB and UMTS RNC - e.g. scheduling of the radio resources
- LTE uses OFDMA as radio access scheme, while UMTS uses WCDMA
- LTE supports “flexible system BW” - 1.4 to 20MHz, while UMTS uses fixed carrier BW - 5MHz
- LTE is an IP only system, while UMTS supports “old voice” core network and data core network.

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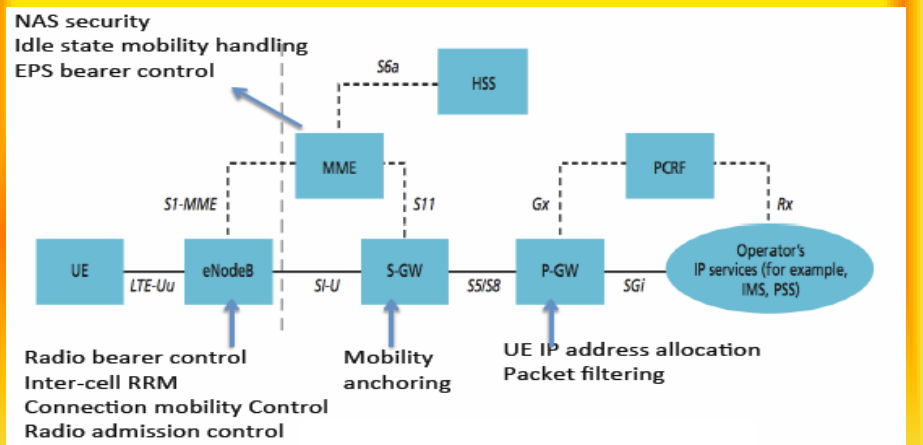
LTE Architecture



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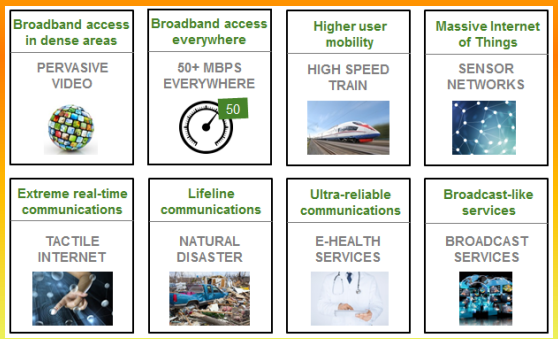
5G: what's different?

- Service, application and business case-led definition

5G Vision defined around Business Context, and Characterisation based on Use Cases, Business Models and Value Creation



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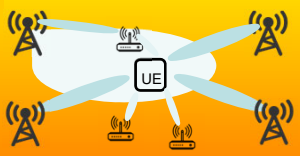
5G RAN Architecture Extensions



New Air Interface

- Cyclic Prefix-OFDM – to introduce flexibility in OFDM and mitigate Inter Symbol Interference
- Massive MIMO – large numbers of bearers to increase bandwidth in sub-6GHz bands
- mmWave – provides access to broad frequency bands for higher bandwidths
- Beam Forming – extends range/cell size for mmWave bands
- Shortened Transmission Time Interval (TTI) – reduces latency
- Flexibility in band sizing – allows previously unavailable bands to be used

Other RAN innovations

- CoMP (Coordinated Multipoint) – UE attached to multiple cells to provide greater reliability
- Small cell support – greater indoor coverage, increased cell density, self-backhauling
- 5G-NR in unlicensed bands – extension of mobile ecosystem
- Session management split from mobility management – enabler for RAN slicing
- D2D, V2X – devices connecting directly, with no network

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Non-Radio 5G

- Software Defined Networking (SDN)
- Network Function Virtualization (NFV)
- Mobile Edge Computing (MEC)
- Cloud Radio Access Network (C-RAN)

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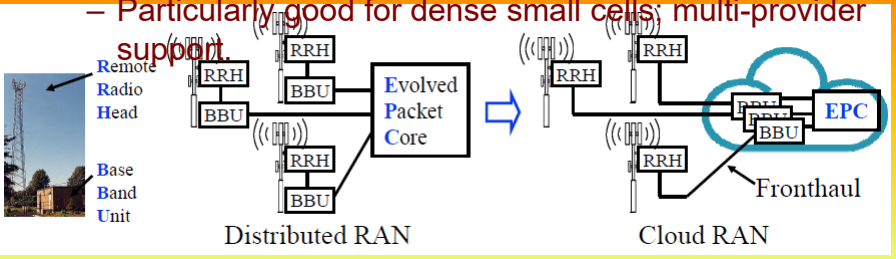
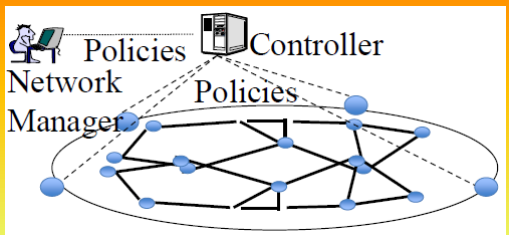
Cloud-Radio Access Network

- Centralize baseband processing in a cloud
  - Need to carry high-bit rate signal (after A-to-D conversion) from tower to cloud site ~ 10 Gbps
- Optical fiber, 10 Gbps Ethernet, Microwave can be used depending upon the distance ~ 1-20 km of **fronthaul**
  - Particularly good for dense small cells; multi-provider support.



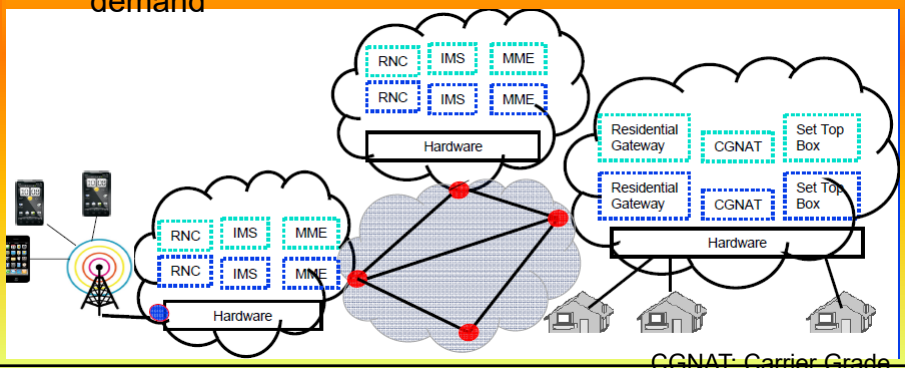
Software Defined Networks (SDN)

- Abstract the Hardware: No dependence on physical infrastructure. Software API.
- Programmable: Shift away from static manual operation to fully configurable and dynamic
- Centralized Control of Policies: Policy delegation and management



Networks Function Virtualization (NFV)

- Standard hardware is fast and cheap → No specialized hardware
- Implement all functions in software
- Virtualize all functions in the Cloud → Create capacity on demand



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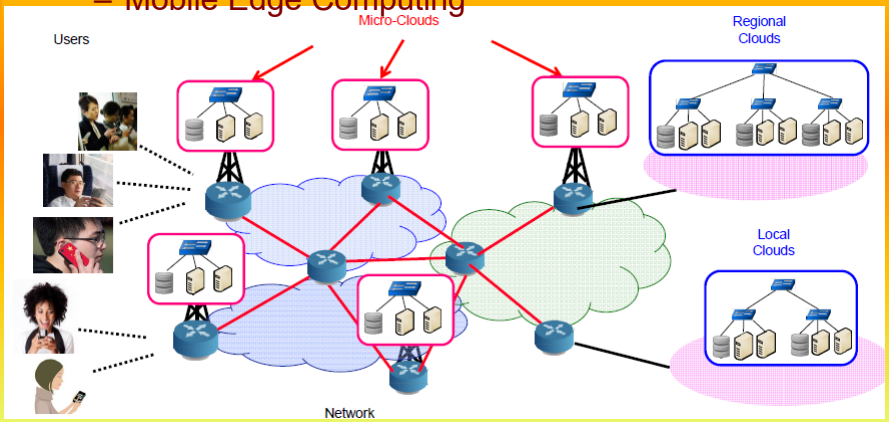
Mobile Edge Computing (MEC)

- To service mobile users/IoT, the computation needs to go to the edge
  - Mobile Edge Computing



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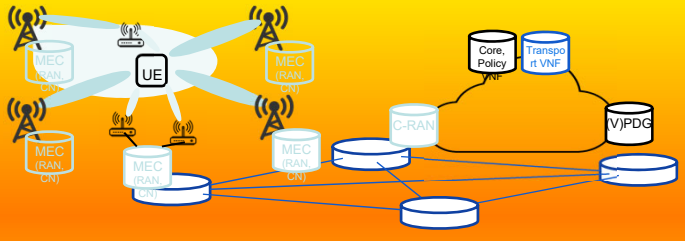
5G Core Architecture Extensions



'Softwarisation' of the network

C-RAN – removal of functionality from cell sites to consolidation point in the network

NFV and SDN – enabling flexibility in where functions are deployed and scaled

MEC – pushing Core Network functions and content ingress to cell sites

CP/UP split – decoupling of user plane traffic from control plane functions

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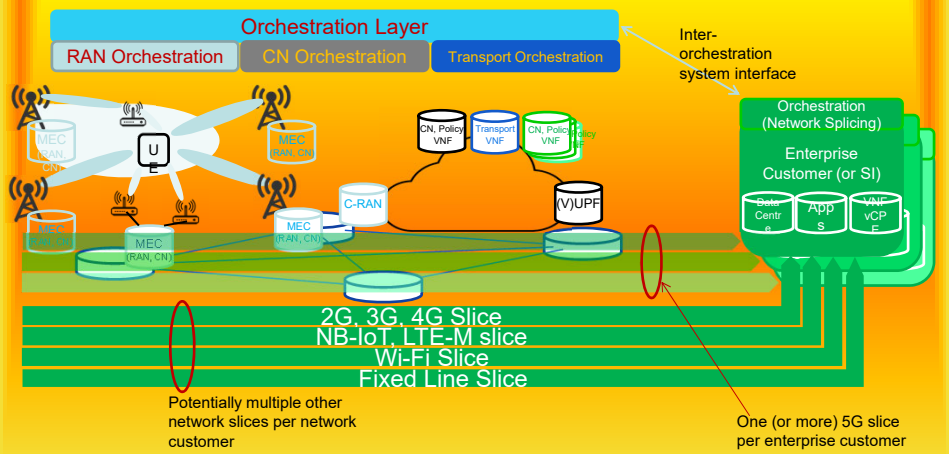
Multi-slicing



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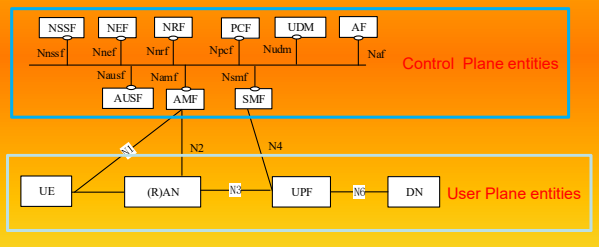
5G Architecture

5G system architecture depicted in the Service Based Architecture (SBA) style (from TS 23.501)



Authentication Server Function (AUSF)
Access and Mobility Management Function (AMF)
Session Management Function (SMF)
Network Slice Selection Function (NSSF)
Network Exposure Function (NEF)
Network Function Repository Function (NRF)
Policy Control Function (PCF)
Unified Data Management (UDM)
Application Function (AF)

Unified Data Repository (UDR)
Unstructured Data Storage Function (UDSF)
5G-Equipment Identity Register (5G-EIR)
Security Edge Protection Proxy (SEPP)
Network Data Analytics Function (NWDAF)

User Plane Function (UPF)
Data Network (DN), e.g. operator services, Internet access or 3rd party services
User Equipment (UE)
(Radio) Access Network ((R)AN)