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4G cellular network applications and architecture (Dept. of IT, BEC)

Initiated in 2010, the 4th generation is based completely on an IP based network system.

> **The goal of 4G is to provide high speed, improve security, along with a lower cost of voice and data services over IP. 4G provides two technology types LTE and WiMAX , of which both share the same pre-mentioned goals. However, the predominant technology in use today is LTE. In terms of data transfer speeds, LTE provides 100 Mbit/s for high mobility communication and 1 Gbit/s for low mobility communication**

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With 4G the infrastructure changes somewhat, both with regards to the RAN and the core. First, let us look at the 4G RAN. **Traditionally, a NodeB has minimum functionality and is controlled by a Radio Network Controller (RNC). However, with an eNodeB, there is no separate controller element. This simplifies the architecture and allows lower response times** .

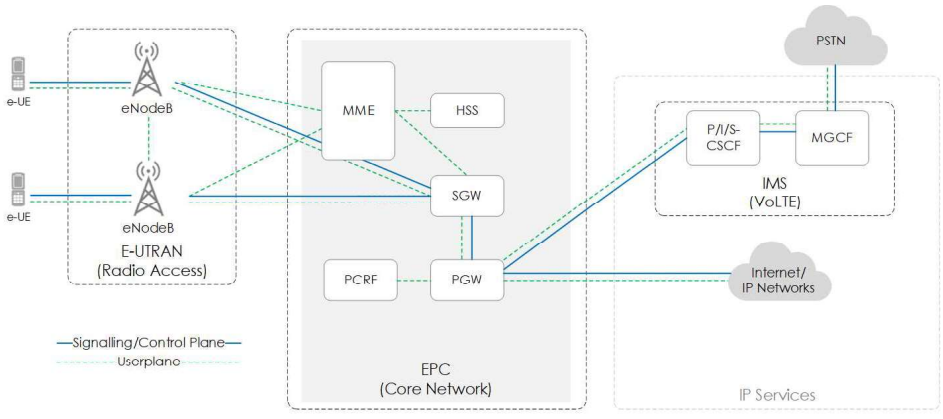


Figure 5 4G Infrastructure

Evolved Packet Core (EPC) unifies voice and data on an Internet Protocol (IP) service architecture and voice is treated as just another IP application.

The key components to the EPC are:

- **Home Subscriber Server (HSS)** - a central database that contains information about all the network operator's subscribers.
- **Mobility Management Entity (MME)** - manages session states and authenticates and tracks a user across the network.
- **Serving Gateway (SGW)** - The serving gateway (SGW) acts as a router and forwards data between the base station and the PDN gateway. In addition, the SGW will also connect to other SGSN's and RNC's for previous generation infrastructures.
- **Packet Data Node Gateway (PGW)** - acts as the interface between the LTE network and other packet data networks, manages **quality of service (QoS)** and provides **deep packet inspection (DPI)** .
- **Policy and Charging Rules Function (PCRF)** - supports service data flow detection, policy enforcement and flow-based charging.

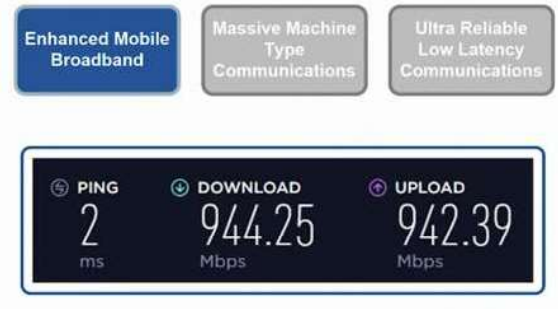
VoLTE/IMS

Voice over LTE, or VoLTE is a standard for the delivery of services (voice/sms), currently provided via Circuit Switched (2G/3G) over the Packet Switched only network of LTE, leveraging the core network IP Multimedia Subsystem (IMS).

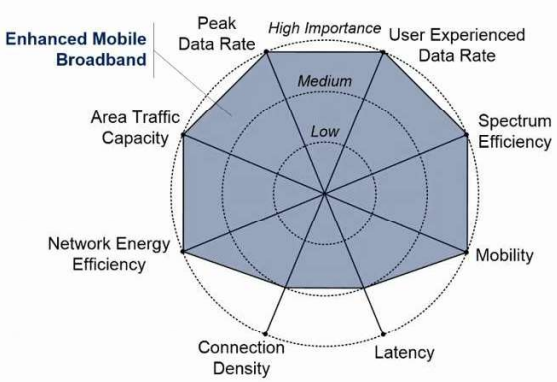
The IP Multimedia Subsystem (IMS) is a reference architecture defined by 3GPP for delivering communication services built on the Internet Protocol (IP). Along with providing a framework for

5G cellular network applications and architecture (Dept. of IT, BEC)

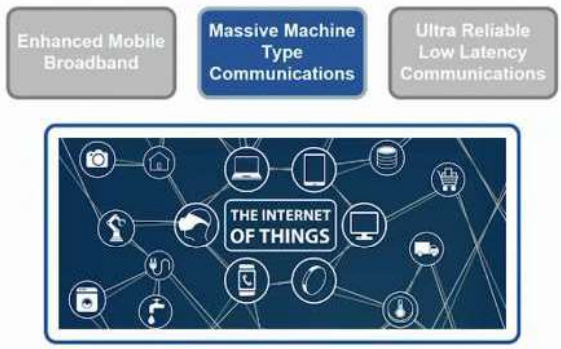
Usage scenarios



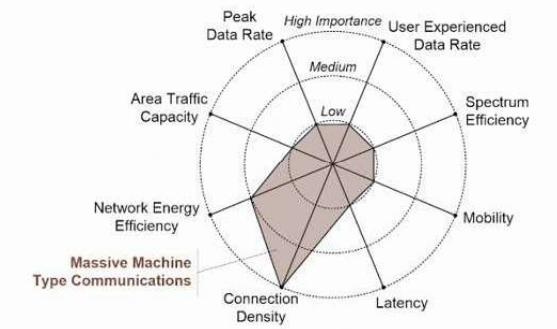
5G Usecase - Enhanced Mobile Broadband (eMBB)



Requirements for Enhanced Mobile Broadband (eMBB)

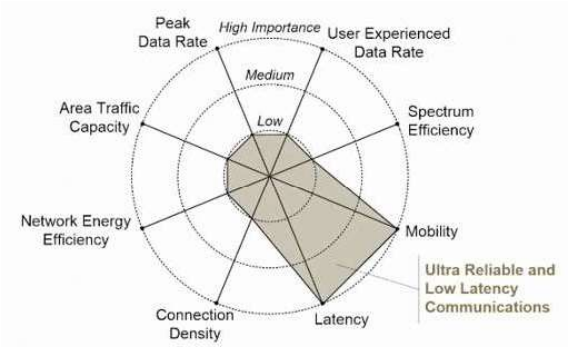


5G Usecase - Massive Machine Type Communications (mMTC)



Requirements for Massive Machine Type Communications (mMTC)

5G Usecase - Ultra Reliable Low Latency Communications (URLLC)



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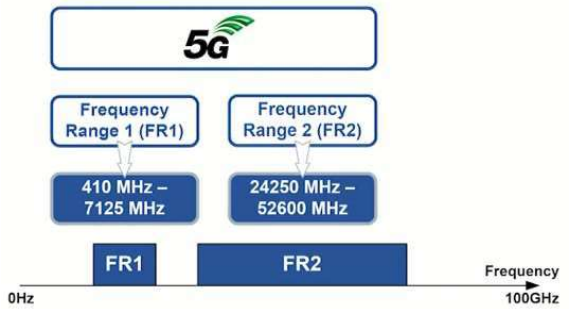
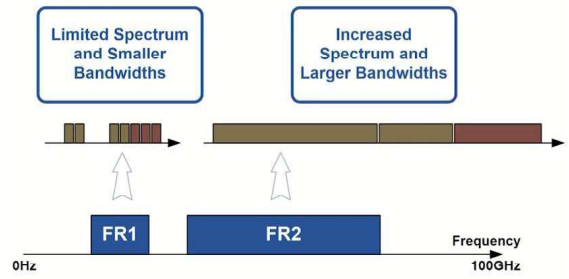


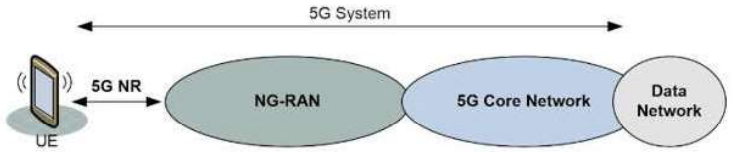
5G Frequency Bands



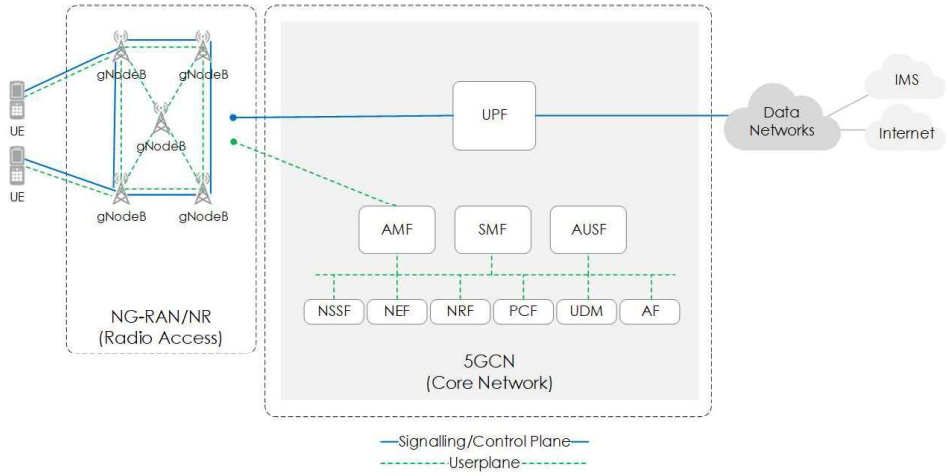
5G Frequency Bands

Primary Objective	Frequency Band	Typical Applications	Benefit
Coverage Layer	Low Frequency (Below 2 GHz)	URLLC	Wide-area & deep indoor coverage
Coverage & Capacity Layer	Medium Frequencies (2 - 6 GHz)	mMTC	Best compromise between capacity and coverage
Super Data Layer	High Frequencies (Above 6 GHz)	eMBB	Addressing specific use cases requiring extremely high data rates.

5G Architecture



5G System Architecture



5G Architecture

Next Generation-Radio Access Network (NG-RAN)

It is also called as New Radio (NR). Within the NG-RAN we have gNodeB's also known as the transceivers. Due to the need for small cells, a greater number of smaller transceivers (gNodeB's) are placed to that of previous generations (2G, 3G, 4G).

Functional Areas	Description
Inter-cell radio resource management	Allows the UE to detect neighbor cells, query about the best serving cell, and support the network during handover decisions by providing measurement feedback.
Radio bearer control (RBC)	Consists of the procedure for configuration (e.g., security), establishment, and maintenance of the radio bearer (RB) on both the uplink and downlink with different levels of quality of service (QoS). The term radio bearer refers to an information transmission path of defined capacity, delay, bit error rate, and other parameters.

5G Usecase - Ultra Reliable Low Latency Communications (URLLC)

Requirements for Ultra Reliable Low Latency Communications (URLLC)

5G Frequency Bands

5G Frequency Bands

5G Frequency Bands

2.2 5G Architecture

5G System Architecture

5G Architecture

2.3 Next Generation-Radio Access Network (NG-RAN)

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Connection mobility control (CMC)	Functions both in UE idle mode and connected mode. Idle mode is a state in which the UE is switched on but does not have any established connection. Connected mode is the state in which the UE is switched on and has an established connection. In idle mode, the CMC performs cell selection and reselection. The connected mode involves handover procedures triggered on the basis of the outcome of CMC algorithms.

Functional Areas	Description
Radio admission control (RAC)	Decides whether a new radio bearer admission request is admitted or rejected. The objective is to optimize radio resource usage while maintaining the QoS of existing user connections. Note that the RAC decides on admission or rejection for a new radio bearer, whereas the RBC takes care of bearer maintenance and bearer release operations.
Measurement configuration and provision	Consists of provisioning the configuration of the UE for radio resource management procedures such as cell selection and reselection and for requesting measurement reports to improve scheduling.
Dynamic resource allocation (scheduler)	Consists of scheduling RF resources according to their availability on the uplink and downlink for multiple UEs according to the QoS profiles of a radio bearer.

Core Functional Areas	Description
Unified data management (UDM)	Responsible for access authorization and subscription management. UDM works with the AMF and AUSF as follows: The AMF provides UE authentication, authorization, and mobility management services. The AUSF stores data for authentication of UE, and the UDM stores UE subscription data.
Access and mobility management function (AMF)	Includes registration, reachability, and mobility management tasks.
Authentication server function (AUSF)	Performs authentication between UE and the network. The AMF initiates the UE authentication by invoking the AUSF. The AUSF selects an authentication method and performs UE authentication procedures.
Session management function (SMF)	Provides connectivity (i.e., PDU session) for UE as well as control of the user plane for that connectivity (e.g., selection / re-selection of user plane network functions and user path, enforcement of policies including QoS policy and charging policy).

Core Functional Areas	Description
User plane function (UPF)	Performs traffic routing and forwarding, PDU session tunnel management, and QoS enforcement. The PDU session tunnels are used between access network and UPFs, as well as between different UPFs as user plane data transport for PDU sessions.
Policy control function (PCF)	Controls and manages policy rules, including rules for QoS enforcement, charging, and traffic routing. The PCF enables end-to-end QoS enforcement with QoS parameters (e.g., maximum bit rate, guaranteed bit rate, priority level) at the appropriate granularity (e.g., per UE, per flow, and per PDU session).
Network Slice Selection Function (NSSF)	Selects appropriate network slice instances for UE. When UE requests registration with the network, the AMF sends a network slice selection request to the NSSF with preferred network slice selection information. The NSSF responds with a message including the list of appropriate network slice instances for the UE.
Network Exposure Function (NEF)	Exposes capabilities of network functions and network slices as a service to third parties. In order to expose the capabilities, NEF stores the capability information and provides it upon capability discovery request.
Network Repository Function (NRF)	Assists the discovery and selection of required network functions (NFs). Each NF instance registers itself when instantiated and updates its status (i.e., activation/deactivation) so that the NRF can maintain information about the available network function instances. In general, each network slice instance has its own NRF, at least logically. In certain cases, such as when the network slice instances are in the same administrative domain, a single NRF instance can be shared by multiple network slice instances.

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