Question 6: Function of SAE

Answer: LTE – System Architecture Evolution (SAE) functions

The System Architecture Evolution (SAE) Gateway performs the following functions for LTE:
•Termination of LTE U(User)-plane packets for paging reasons

•Switching of U-plane for supporting UE mobility

•QoS handling and tunnel management

Question 7: Advantage of VOLTE over LTE

Answer: It's easy to see that VOLTE is superior technology. he has followed the great benefits of LTE:
•Voice quality is better in VOLTE.

•You can keep the data connection during a voice call.

•VOLTE can connect calls faster.

•The 4G VOLTE operates on higher frequencies like 800 MHz and can therefore make the connections much further away from the mobile tower.

•In previous technologies, it was sometimes difficult to find a mobile signal.

•Use of VOLTE may save phone's battery.

•VOLTE allows you to make video calls without using third-party applications.

VOLTE one can make calls over LTE network.

With simple words, take whatsapp calls. By using the internet and the application (here whatsapp), you make calls to other people. other people are also connected to the internet. So here, via the internet, calls are placed. Your voice is converted to data and transmitted.

Likewise, using the internet and your dialer phone application, you place calls on LTE. VOLTE is software that allows your telephone dialer to make calls over the internet.

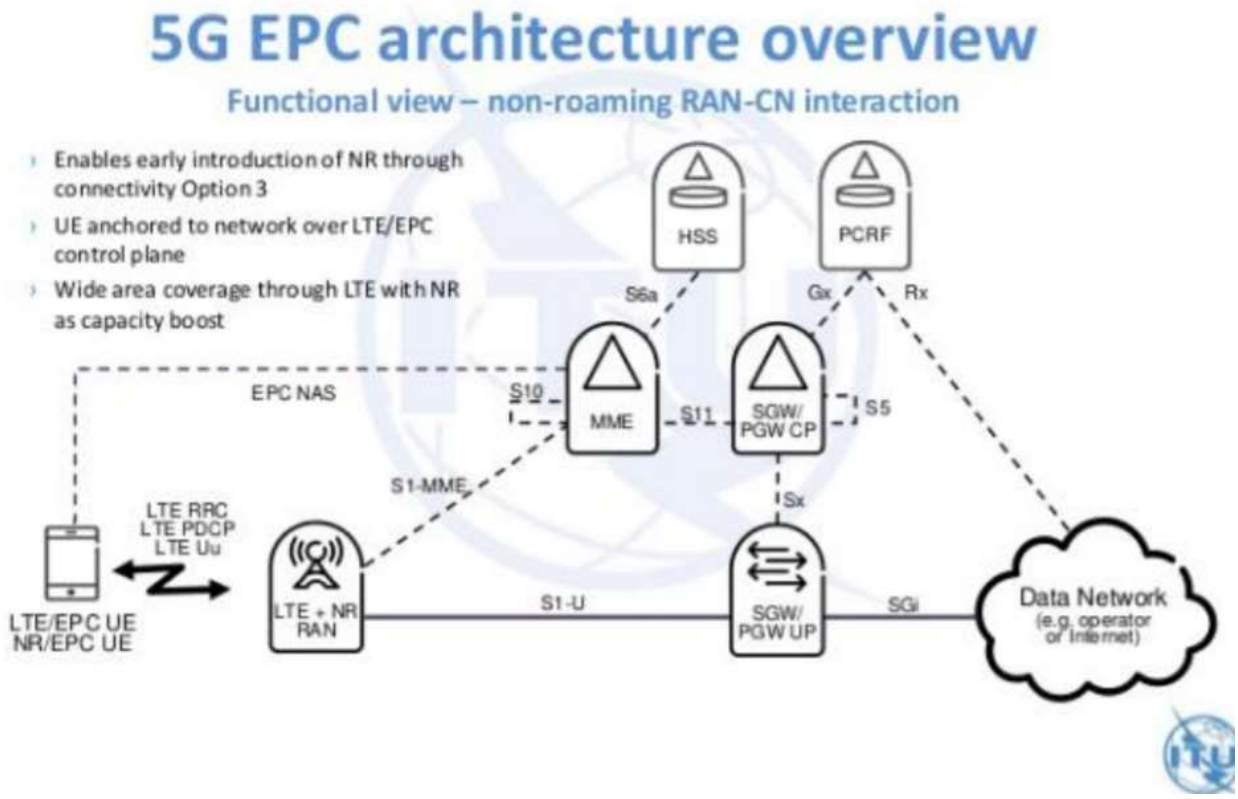
•Consider WhatsApp is an application that allows to send only messages via the Internet (4G) and not for calls.

•Now the company provides an update.

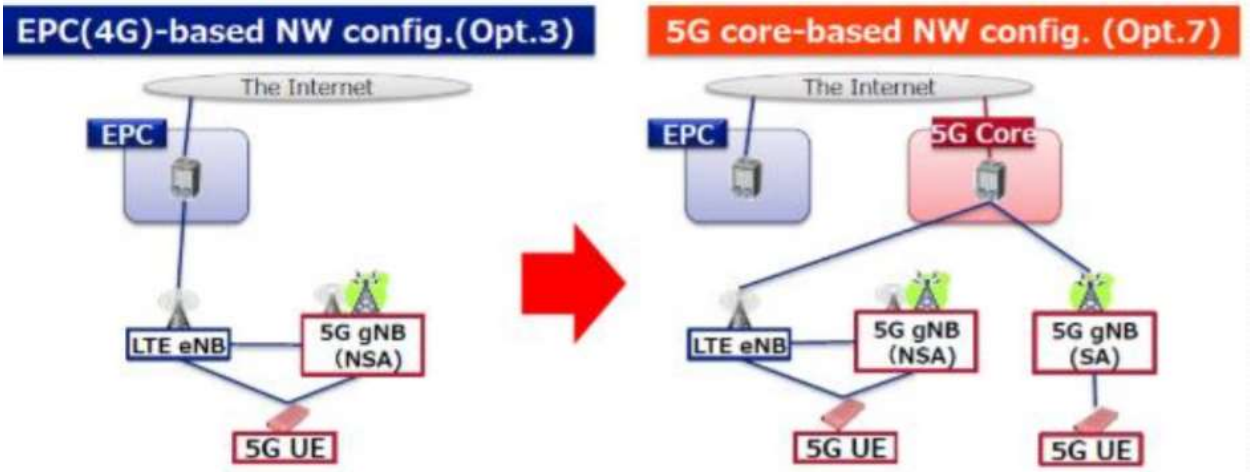
•The update brings a new feature. The feature is to call another person using WhatsApp.

Question 8: Draw 5G EPC Architecture overview and show overview with example of migration and brief explanation?

Answer:



Examples of migration from 4G to 5 G



Question 9: Functional Architecture of 5G with diagram

Answer:

Figure 1 shows the system model that proposes design of network architecture for 5G mobile systems, which is all-IP based model for wireless and mobile networks interoperability. The system consists of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies. Within each of the terminals, each of the radio access technologies is seen as the IP link to the outside Internet world. However, there should be different radio interface for each Radio Access Technology (RAT) in the mobile terminal. For an example, if we want to have access to four different RATs, we need to have four different access-specific interfaces in the mobile terminal, and to have all of them active at the same time, with aim to have this architecture to be functional.

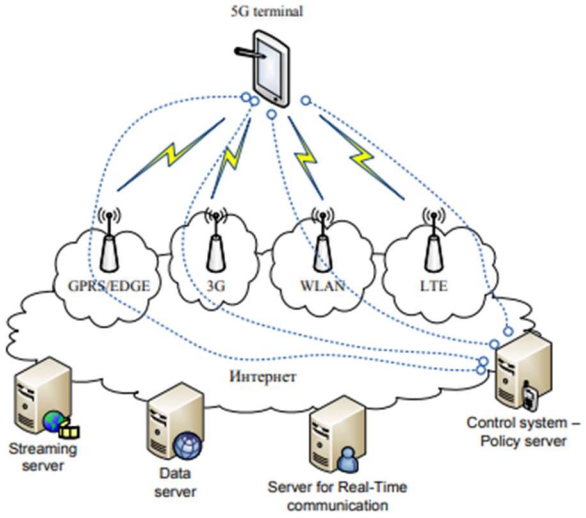


Figure 1 Functional Architecture for 5G Mobile Networks

The first two OSI levels (data-link and physical levels) are defining the radio access technologies through which is provided access to the Internet with more or less QoS support mechanisms, which is further dependent upon the access technology (e.g., 3G and WiMAX have explicit QoS support, while WLAN has not). Then, over the OSI-1 and OSI-2 layers is the network layer, and this layer is IP (Internet Protocol) in today's communication world, either IPv4 or IPv6, regardless of the radio access technology. The purpose of IP is to ensure enough control data (in IP header) for proper routing of IP packets belonging to a certain application connections - sessions between client

applications and servers somewhere on the Internet. Routing of packets should be carried out in accordance with established policies of the user.

Question 10: LTE architecture with brief functionalities with brief block

Answer:

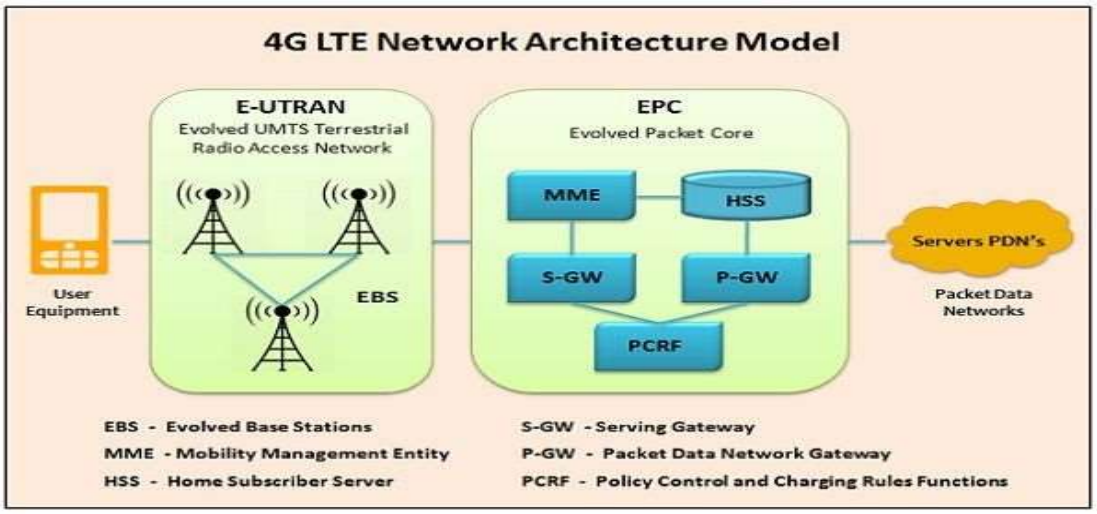


Figure 1. LTE Network Model

The key parts of 4G LTE network are

- **User Equipment (UE)**: It can be any device that can establish communication functions such as mobile phones, tabs, computers, etc.

  From the internal architecture you can see that the end devices for LTE is used UMTS and GSM, which is actually mobile equipment (ME). The ME comprised two important modules which are:

  - **Mobile Termination (MT)**: It is actually terminating or stops the streams of data.
  - **Terminal Equipment (TE)**: It is actually connecting the system or controlling the communication function.

  - **Universal Integrated Circuit Card (UICC)**: Also known as SIM card for LTE devices. It is the system or application run is known as the Universal Subscriber Identity Module (USIM). A USIM collect or preserve the user-specific data which is similar to a 3G USIM. This stores information about the user's phone number, home network identity, and security keys, etc.

- **Evolved UMTS Terrestrial Radio Access Network (E-UTRAN):** It works to communication controlling with EPC and UE. The LTE phone can connect with one base station and only one cell at the same time. Main operations performed by Evolved Base Station (EBS)
  - All LTE devices enabled when in cellular system are used to transmit and receive analog and digital signals.
  - Handles low-level operations by sending messages and signaling commands.

The E-UTRAN section manages to communicate between the mobile phone and the EPC and it has only one component, the evolved base stations, called **eNodeB** or **eNB**. Each eNB is a base station which controls the mobile phones in one or more cells. The base station that is communicating with mobile is known as its serving eNB [2].

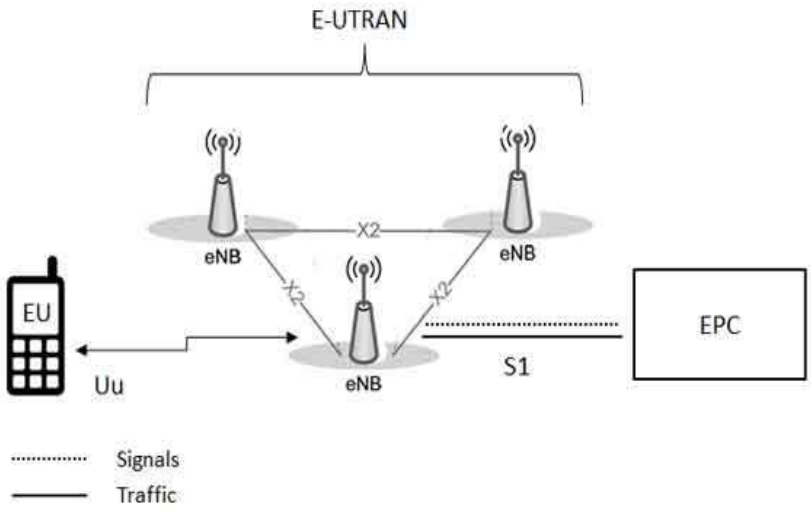


Figure 2. E-UTRAN Architecture [1]

LTE Mobile phone can communicate with one base station and one cell at a time and two main functions supported by eNB:

- For radio transmissions, the eNB transmite and receives by using the analog and digital signal processing functions of the LTE cellular interface.
- The eNB transmite the signal for control the low-level operation of all mobile phones like handover commands.

Each eNB connects to the EPC via the S1 interface and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signaling and packet transfer during handover.

A home eNB has a closed subscriber group (CSG), that can only be accessed by mobile phones with a USIM that also has the closed subscriber group [1].

- **Evolved Packet Core (EPC)**: This EPC communicates with internal and external packet data networks and IP multimedia subsystem. It consists of following blocks:
  - **HSS:** Home Subscriber Server (HSS), it holds all the information about all the network operator's subscribers in a central database.
  - **MME:** Mobility Management Entity (MME), it handles the high-level operation by the signaling messages and HSS.
  - **S-GW:** Signaling Gateway (S-GW), it performs mobility anchoring and send data between PDN Gateway and Base Station.

- **P-GW:** Packet Data Network Gateway (P-GW), it communicates with PDN's employing interfaces. It performs operations such as assigning IP addresses and filtering packets data.

PCRF: Policy and Charging Rule Function is accountable for controlling the flow-based charging operations in the Policy Control Enforcement Function (PCEF) and policy control decision-making.

Question 11: Parameter on which spectral efficiency depend?

Answer: In general spectral efficiency depends upon following parameters.

- Channel spacing in KHz
- Frequency reuse factor
- Cell area in Km^2
- Modulation techniques
- Multiple Access techniques

Following are the two ways to represent the spectral efficiency. Data channel per unit bandwidth per unit coverage area (measured in channels/MHz/Km^2) Total data traffic per unit bandwidth per unit area. (measured in Erlangs/MHz/Km^2)