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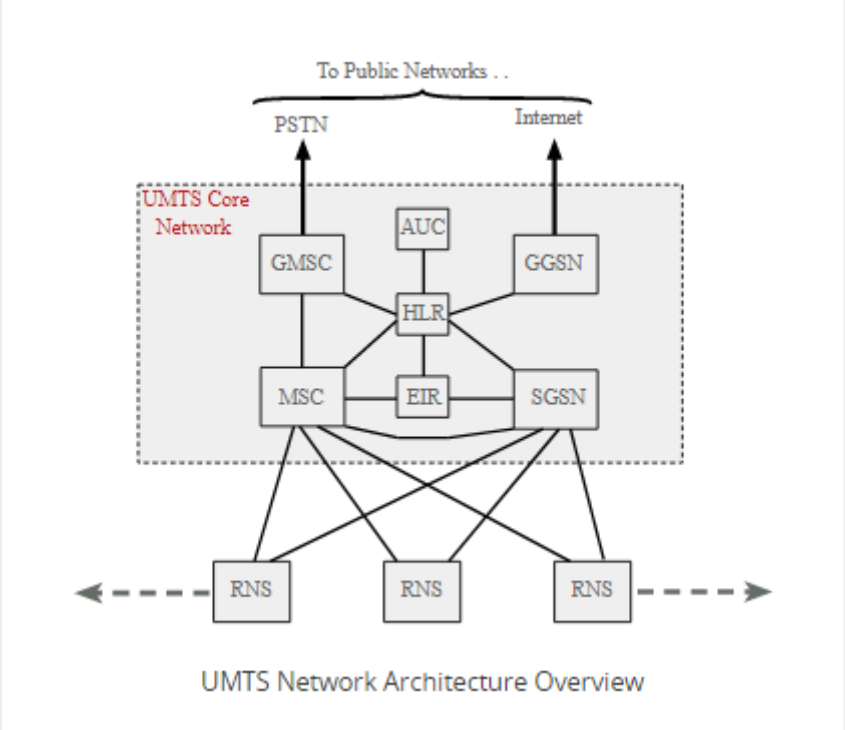
Title: Answers on assignment

Course: Digital Communication (EEE 512)

1(i). Working principle of 3G, 4G, and 5G

3G Technology

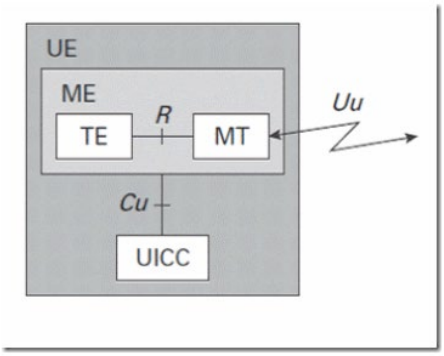


UMTS Network Architecture Overview

The 3G UMTS architecture is divided into three main elements

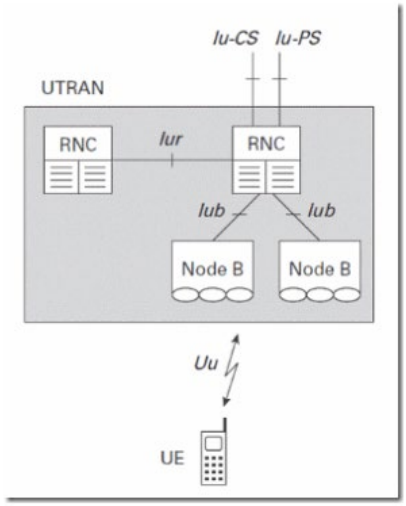
- User Equipment (UE)
- Radio Network Substation (RNS)
- Core Network

User Equipment (UE): The USER Equipment or UE is a major element of the overall 3G UMTS network architecture. It forms the final interface with the user. It consists of a variety of different elements including RF circuitry, processing, antenna, battery, etc.



- UE RF circuitry: The RF areas handle all elements of the signal, both for the receiver and the transmitter
- Baseband Processing: The baseband signal processing consists mainly of digital circuitry. It processes the signals received from the cell tower into meaningful information for use by the user equipment.
- Universal Subscriber Identity Module, USIM: It contains the International Mobile Subscriber Identity number (IMSI) as well as the Mobile Station International ISDN Number (MSISDN).

Radio Network Substation (RNS): This section of the 3G UMTS / WCDMA network interfaces both the UE and the core network. It is also known as the UTMS Radio Access Network or UTRAN. It has two main nodes, NodeB and RNC.



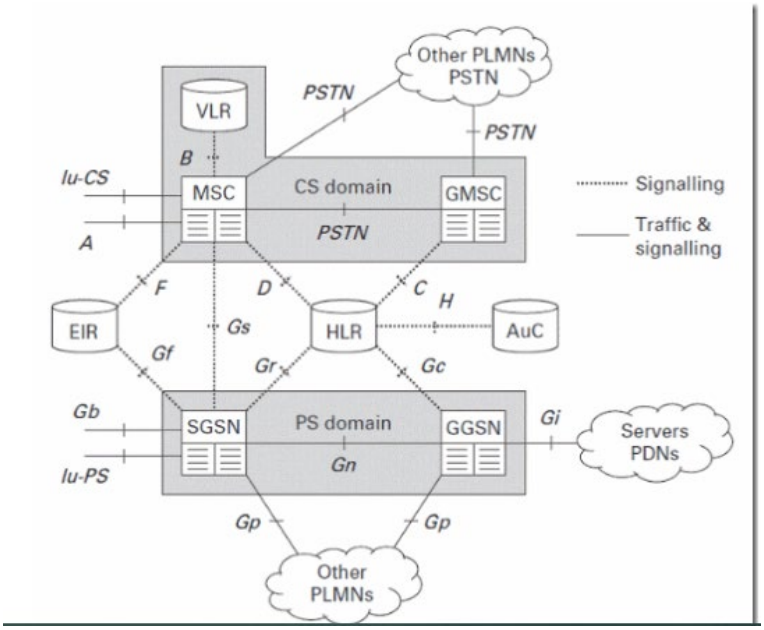
- NodeB: This is a physical unit for radio transmission and reception with cells. It may on or more cells depending on sectoring. It connects to the UE through the Uu interface.

- RNC (Radio Network Controller): The RNC owns and controls the radio resources in its domain. It is an intermediate component between NodeB and the CN. The RNC has three main functions: Controlling RNC for controlling each NodeB, Serving RNC for exchanging signaling messages with the mobiles it serves. Drift RNC, uses the lur interface to carry UE specific signaling information between the NodeBa and the Serving RNC.

Core Network: The core network may be split into two different areas

- Circuit-switched elements: These elements are primarily based on the GSM network entities and carry data in a circuit-switched manner, i.e. a permanent channel for the duration of the call.
- Packet-switched elements: These network entities are designed to carry packet data, enabling much network usage

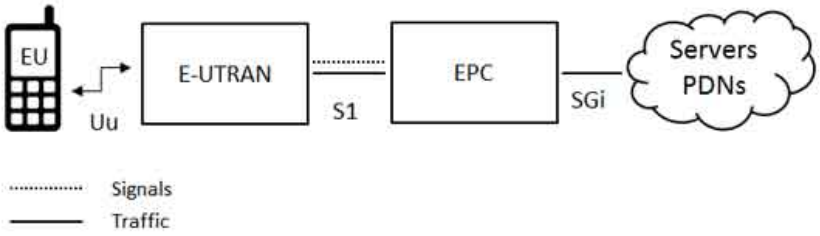
The core network contains the following entities: Home Location Register, Authentication Centre, Equipment Identity Register, Mobile switching center/Visitor Location register



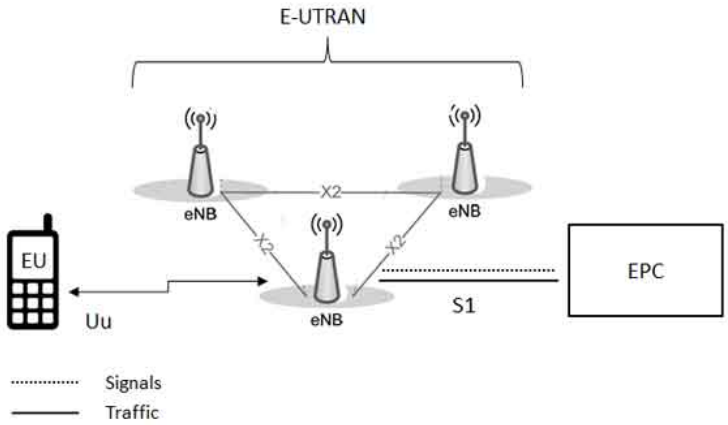
4G Technology

The LTE or 4G network architecture is comprised of these three main components: The User equipment (UE), the Evolved UMTS Terrestrial Radio Access Network (E-UTRAN), and the Evolved Packet Core (EPC).

- **User Equipment (UE):** The user equipment similar to the one used in 3G consists of the **Mobile Termination (MT)** for handling all communication functions, **Terminal Equipment (TE)** for data stream termination and the **Universal Integrated Circuit Card (UICC)**, known as the sim card for LTE equipment running the USIM application.

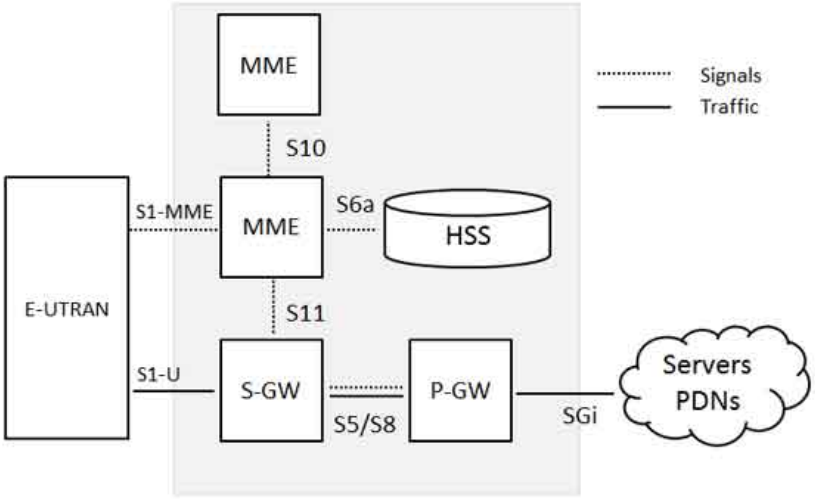


- **The E-UTRAN (The access network):** It handles the radio communication between the mobile and the evolved packet core. It consists only of the evolved base stations (eNodeB or eNB). Each eNB is a base station controlling the mobiles in one or more cells. The LTE mobile communicates with just one base station and one cell at a time. The eNB sends and receives radio transmissions to all the mobiles using the analog and digital signal processing functions of the LTE air interface. It also controls the low-level operation of all its mobiles, by sending them signaling messages such as handover commands.



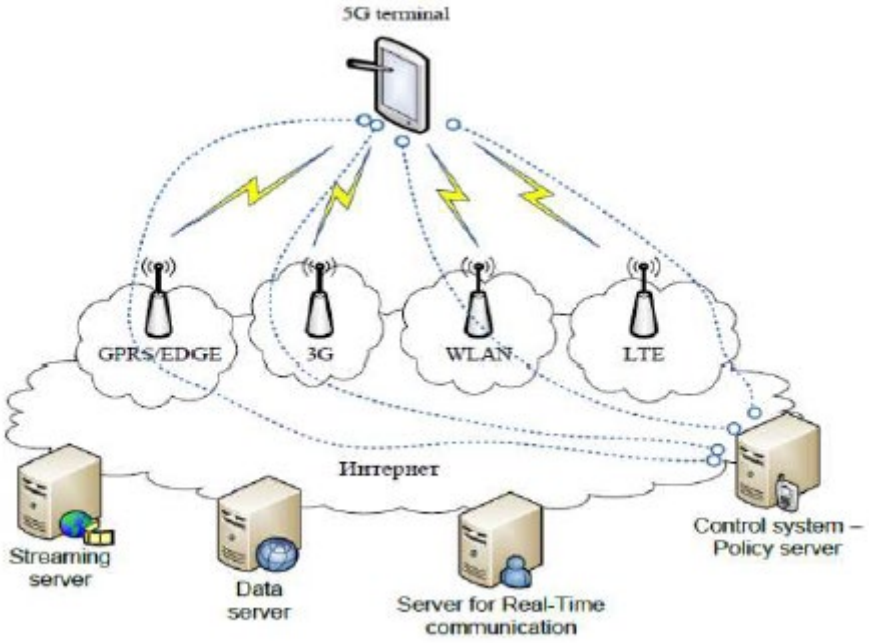
- **The Evolved Packet Core (EPC) (The core network):** It consists of the:
  - **Home Subscriber Server (HSS)** that contains information about all the network operator's subscribers.

- **Packet Data Network (PDN)** used for user equipment IP allocation.
- **Serving gateway (S-GW)**, acting as a router forwarding data between the base station and the PDN gateway.
- **Mobility management entity (MME)**, controlling the high-level operation of the mobile through signaling messages.
- **Policy Control and Charging Rules Function (PCRF)**, responsible for policy control decision making and controlling flow-based charging functionalities in the Policy Control Enforcement Function (PCEF).



5G Technology

The 5G architecture is an entirely IP based model designed for wireless and mobile networks. The system consists of the main user terminal and then many independent and autonomous radio access technologies. Each of the radio technologies is considered as the IP link to the internet. The IP technology is designed exclusively to ensure sufficient control data for appropriate routing of IP packets related to certain application connections i.e. sessions between client applications and servers somewhere on the Internet. Like 4G LTE, 5G is also OFDM-based (Orthogonal frequency-division multiplexing) and will operate based on the same mobile networking principles. However, the new 5G NR (New Radio) air interface will further enhance OFDM to deliver a much higher degree of flexibility and scalability.



1(ii). Advantages and Disadvantages of 3G, 4G, and 5G

3G

Advantages

1. Overcrowding is relieved in existing systems with radio spectrum
2. Bandwidth, security, and reliability are more
3. Provides interoperability among service providers
4. Availability of fixed and variable rates
5. Support to devices with backward compatibility with existing networks
6. Always online devices – 3G uses IP connectivity that is packet-based.

Disadvantages

1. The cost of cellular infrastructure, upgrading base stations is very high
2. Roaming and data/voice work together has not yet been implemented
3. Power consumption is high
4. Requires closer base stations and are expensive

4G

Advantages

1. Much faster than 3G due to increased bandwidth

2. Improved privacy, security, and safety which is beneficial for corporate establishments and business persons
3. 30-mile overlapping coverage range
4. It provides better spectral efficiency
5. Low cost per bit
6. It provides clear video calling and voice facility

Disadvantages

1. Software and updates required for making 4G calls on competing for carrier networks
2. Challenging access to international travel.
3. 4G mobile networks use multiple antennae and transmitters. This may lead to terrible battery life for mobile devices compared with 3G.
4. Difficult to implement due to complex hardware
5. Limited 4G network towers
6. New frequencies need a new installation of components

5G

Advantages

1. More effective and efficient.
2. The fifth-generation cellular Technology has a higher speed than previous generations (1G, 2G, 3G, 4G) and high data rate, low latency, and energy-saving and cost reduction and better system capacity and massive device connectivity.
3. Technology to facilitate subscriber supervision tools for quick action.
4. Most likely, it will provide a huge broadcasting data (in Gigabit), which will support more than 60,000 connections.
5. High resolution and bi-directional large bandwidth shaping.
6. Easily manageable with the previous generations.

Disadvantages

1. Technology is still under process and research on its viability is going on.
2. Developing infrastructure needs a high cost.
3. Security and privacy issues yet to be solved.
4. Highly skilled engineers are required to install and maintain a 5G network

5. The very high frequency from 5G technology means cells will be smaller leading to less coverage. To achieve the proposed bandwidth 5G has to offer, more towers are needed.

2. Differences between 2G, 3G, 4G, and 5G.

Features/Specifications	**2G**	**3G**	**4G**	**5G**
Start/Development	1980/1999	1990/2002	2000/2010	2010/2015
Technology	GSM	WCDMA, UMTS	LTE, WiMax	MIMO, mm waves
Frequency	1.8 GHz	1.6 - 2 GHz	2 – 8 GHz	3 – 30 GHz
Bandwidth	14.4 – 64 kbps	2 Mbps	2000 Mbps to 1 Gbps	1 Gbps and higher
Access System	TDMA/CDMA	CDMA	CDMA	OFDM/BDMA
Core Network	PSTN	Packet Network	Internet	Internet
Switching	Circuit Packet	Packet switching except for air interference	All Packet	All Packet
Service	Digital voice, Higher capacity, packetized data	Integrated high-quality audio, video, and data	Dynamic information access, wearable devices, HD streaming, global roaming	Dynamic information access, wearable devices, HD streaming, smooth global roaming, upcoming technologies
Handoff	Horizontal	Horizontal	Horizontal and Vertical	Horizontal and Vertical
Standards	TDMA, CDMA, GSM, GPRS, EDGE, 1xRTT	WCDMA, CDMA	Single unified standard	Single unified standard
Internet Service	Narrowband	Broadband	Ultra-Broadband	Extremely high Broadband

3(i). There is no correlation between 5G and Coronavirus.

(ii) I do not support the state. The only type of virus that can be transmitted with waves are the ones that affect computer systems. 5G uses frequencies in the 30-300 GHz range. The energy in that range is not enough to break chemical bonds or remove electrons in the human tissue. It is a “non-ionizing” electromagnetic radiation. Radio waves lose energy as they travel in free-

space due to interference, scintillation, and free-space path loss. 5G waves because of its relatively high frequency compared to 3G and 4G, fades rapidly as the transmission distance increases (shorter wavelengths). Radiation is exposed to the skin at a peak level when the mobile phone is put to the ear during a phone call. This exposure is still well below the recommended safety level. 5G radiation cannot penetrate the skin or allow a virus to penetrate the skin.

The protein shell of the Coronavirus is incapable of intercepting 5G radio signals. The two (radiation and virus) exist in different forms (electromagnetic spectrum, biological phenomenon) respectively.

COVID-19 spreads through small droplets released from the nose or mouth of an infected person and transmission occurs when the droplets are exposed to the nose, eyes, or mouth of a healthy person. The virus cannot be transmitted through electromagnetic radiation. Waves do not carry particles and particles do not carry waves.

Radio waves do not have enough energy to weaken immune systems or damage the DNA structure. This is possible with only Ionizing radiations such as Gamma-ray, X-ray, and Ultraviolet light. Very strong RF energy such as from radar transmitters may be dangerous as it can heat parts of the body rapidly causing severe burns but it does not in any way spread, cause, or enhance the Coronavirus in the body. Coronavirus is a physical virus and cannot be transmitted electronically.

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