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EEE 512 - Digital Communications

Question 1

(i) *With the aid of a well labelled architectural diagram, provide detailed explanation on the working principle of 3G, 4G and 5G networks.*

3G ARCHITECTURE

UMTS (Universal Mobile Telecommunications System) 1. UMTS, short for Universal Mobile Telecommunications System, is a 3G networking standard used throughout much of the world as an upgrade to existing GSM module.

1. UMTS makes use of WCDMA, a technology that shares much with CDMA networks used throughout the world, though it is not compatible with them.
2. Base level UMTS networks are generally capable of downlink speeds as 384 kbps.
3. The UMTS architecture takes advantage of the existing GSM and GPRS networks which serve as a core network in UMTS infrastructure.

The UMTS is made up of 3 main components: a) User Equipment:

It is assigned to a single user and contains all the functions needed to access UMTS services. It contains: – Mobile Equipment (ME) : It is a radio terminal which is used to connect the UMTS subscriber with the fixed part of UMTS system via the radio interface Uu.

a) UMTS Subscriber Identity Module (USIM): A smartcard which contains the subscriber identity, authentication algorithms, encryption keys etc.

b) UMTS Terrestrial Radio Access Network (UTRAN):

It handles cell-level mobility. It is a system of base station and controller handling function related to mobility. It contains:

1. Nodes B (Base Stations):

• It converts the data between Uu radio interface and the Iub interface connecting a Node B with the RNC. • It performs physical level processing such as channel coding, data interleaving, rate matching, modulation etc.

2. Radio Network Controllers (RNC):

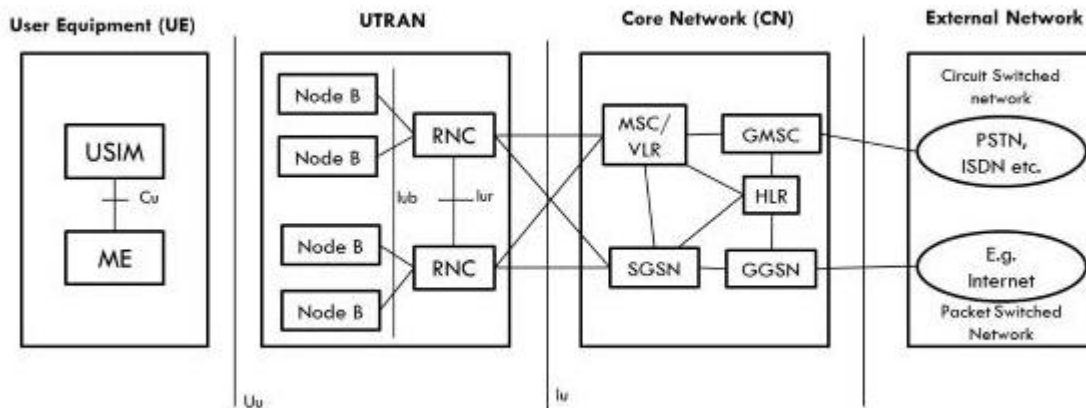
• RNC's controls and manages radio resources to Node B. • RNC performs the data-link layer processing and participates in handover operations. • RNC is considered a single access point of UTRAN for the core network. • It's connected to a single MSC/VLR to route circuit-switched traffic and to a single SGSN to route packet switched traffic.

c) Core Network (CN):

The core network is shared with GSM and GPRS. The CN contains functions for intersystem handover, gateways to other networks and performs location management. It contains:

1. Home Location Register (HLR)
2. Mobile Station Controller / Visitor Location Register (MSC/VLR).

3. Gateway MSC: Connect UMTS to external circuit switch n/w (e.g PSTN)
4. Serving GPRS Support Node (SGSN): It serves the Packet-switched traffic.
5. Gateway GPRS Support Node (GGSN): Connects UMTS to external packet switched. (e.g. Internet)



4G ARCHITECTURE

The fourth generation (4G) of mobile networks will offer mobile services based on high-speed wireless connections, IP mobility, intelligent terminals, and World Wide Web type services. 4G operators are the most likely service and content providers to use different kinds of radio access technologies. Radio access can be based on private corporate LANs, public wireless LANs or mobile LANs installed on trains, airplanes, and so on. Handhelds, laptops, and mobile phones will be used to access the Internet and local services. **4G location area (4GLA)** diameter can be from 100m to 1 kilometer. Figure 5 presents the 4G-network architecture. The idea is to use Session Initiation Protocol (SIP) [2]. Every home location area contains a SIP redirect server, which is responsible for maintaining the current location of users. The home SIP redirect server is analogous to HLR in GSM network architecture. When a call is made, the home SIP redirect server returns the current address of called party. The SIP client of the caller then makes another call to this particular address (or addresses - SIP redirect server can return several addresses).

1. 4G stands for fourth generation cellular system.
2. 4G is evaluation of 3G to meet the forecasted rising demand.
3. It is an integration of various technologies including GSM,CDMA,GPRS,IMT-2000 ,Wireless LAN.
4. Data rate in 4G system will range from 20 to 100 Mbps.

Features:

1. Fully IP based Mobile System.
2. It supports interactive multimedia, voice, streaming video, internet and other broadband service.
3. It has better spectrum efficiency.
4. It supports Ad-hoc and multi hop network.

4 G Architecture

1. Figure shows Generic Mobile Communication architecture.
2. 4 G network is an integration of all heterogeneous wireless access networks such as Ad-hoc, cellular, hotspot and satellite radio component.
3. Technologies used in 4 G are smart antennas for multiple input and multiple output (MIMO), IPv6, VoIP, OFDM and Software defined radio (SDR) System.

Smart Antennas:

1. Smart Antennas are Transmitting and receiving antennas.
2. It does not require increase power and additional frequency.

IPV6 Technology:

1. 4G uses IPV6 Technology in order to support a large number of wireless enable devices.
2. It enables a number of application with better multicast, security and route optimization capabilities.

VoIP:

1. It stands for Voice over IP.
2. It allows only packet to be transferred eliminating complexity of 2 protocols over the same circuit.

OFDM:

1. OFDM stands for Orthogonal Frequency Division Multiplexing.
2. It is currently used as WiMax and WiFi.

SDR:

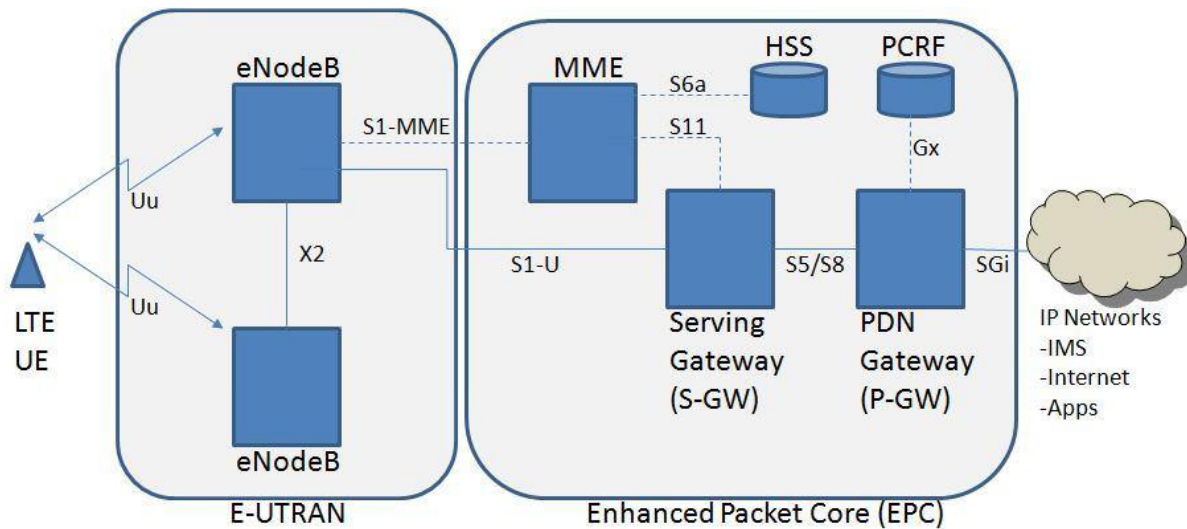
1. SDR stands for Software Defined Radio.
2. It is the form of open wireless architecture.

Advantages:

1. It provides better spectral efficiency.
2. It has high speed, high capacity and low cost per bit.

Disadvantage:

1. Battery usage is more.
2. Hard to implement.



MME- Mobility Management Entity

It is used for Paging ,Authentication, Handover and Selection of Serving Gateway

SGW- Serving gateway

It is used to Routing and Forwarding user data packet.

PDN-GW Packet Data Network Gateway

It is used for user equipment (UE) IP allocation

HSS -Home Subscriber Server

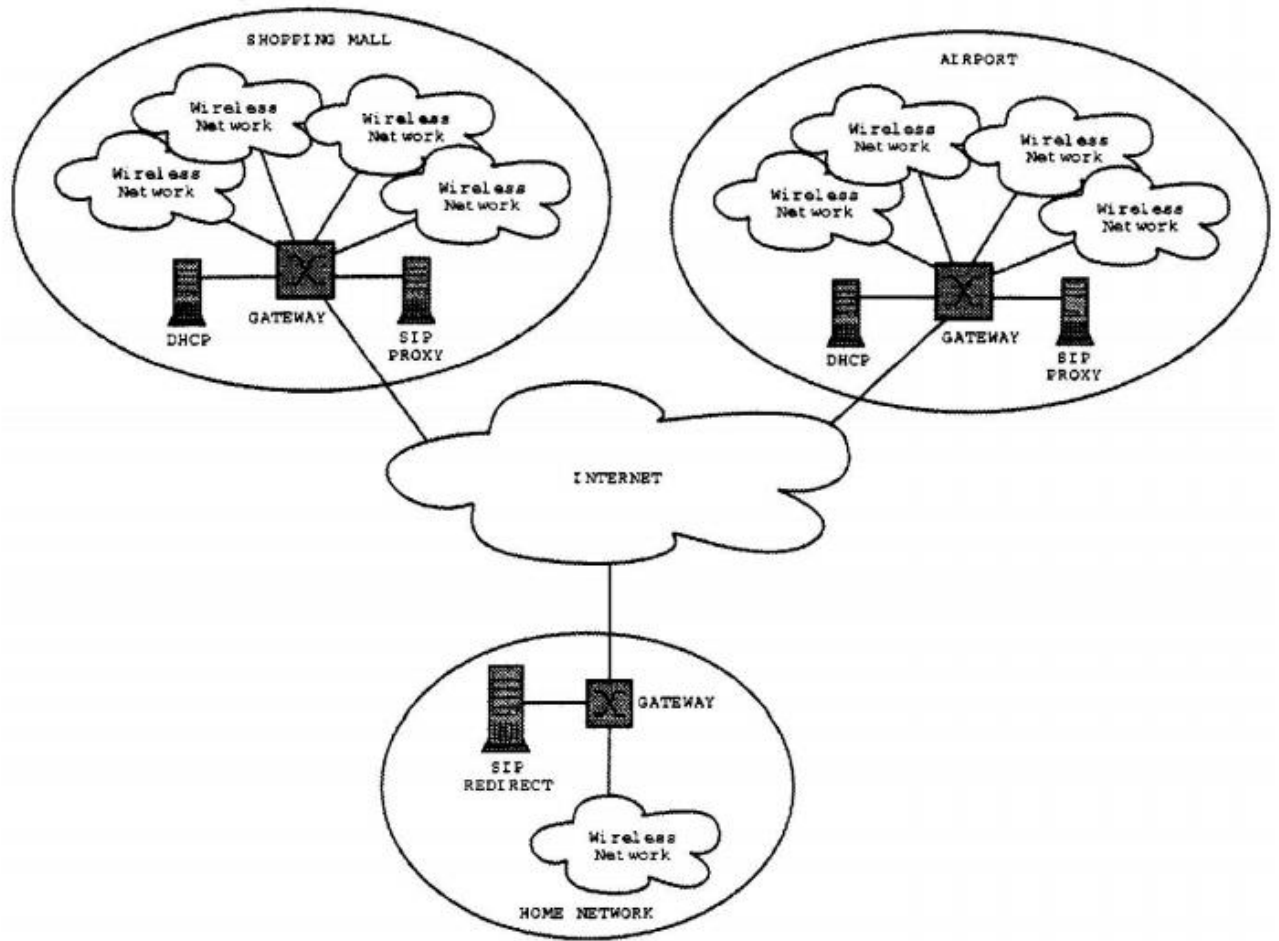
It is a user Database used for service subscriber, user identification and addressing

PCRF -Policy and Charging Rule Function

It provide quality of service and charging

eNode B-evolved Node B

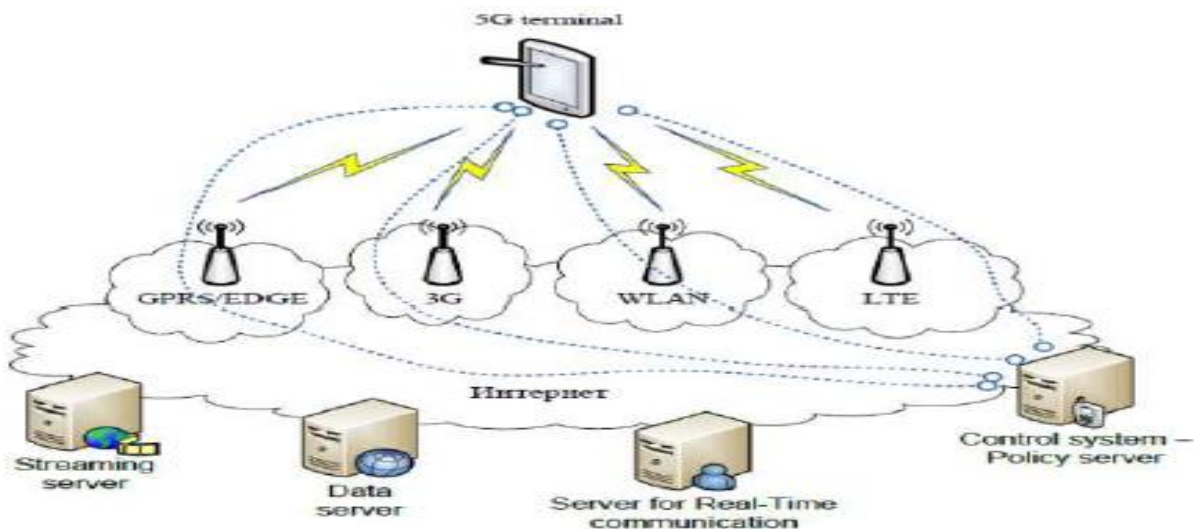
It is used as radio resources management and radio bearer control



4G-network architecture

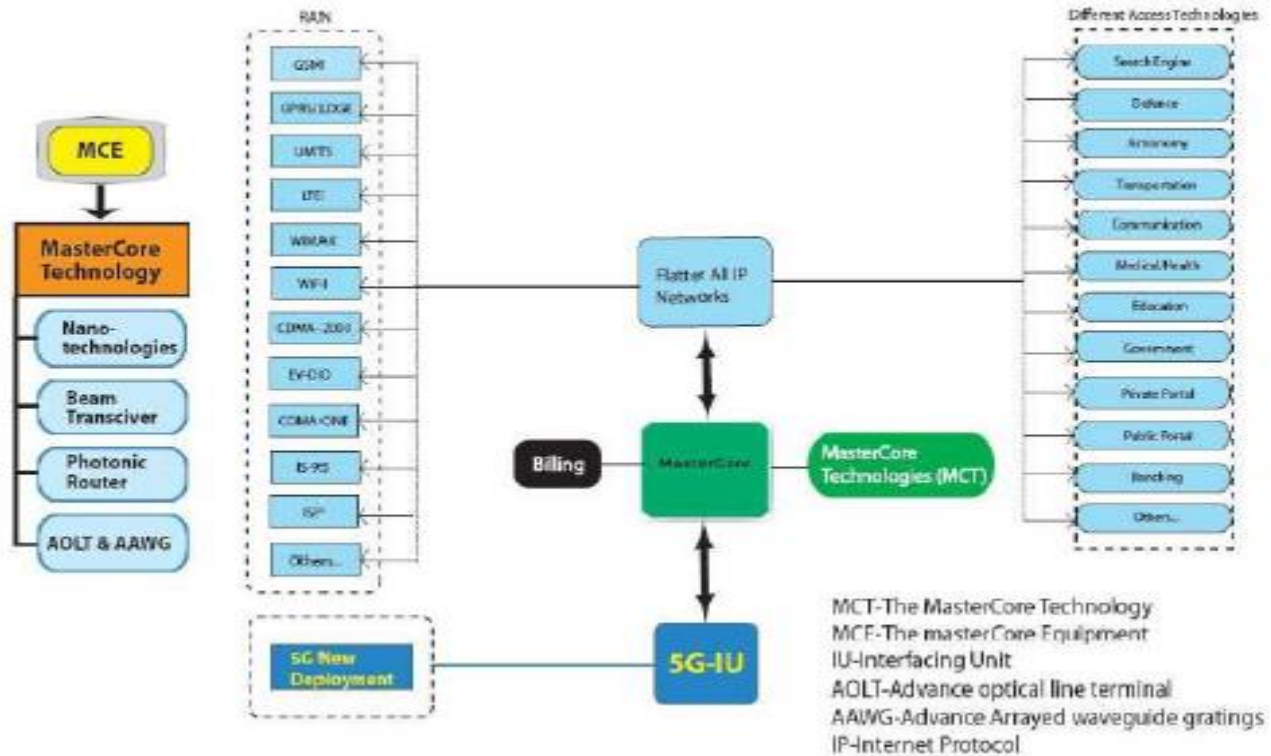
Architecture of 5G

The system model of 5G is entirely IP based model designed for the wireless and mobile networks. The system comprising of a main user terminal and then a number of independent and autonomous radio access technologies. Each of the radio technologies is considered as the IP link for the outside internet world. The IP technology is designed exclusively to ensure sufficient control data for appropriate routing of IP packets related to a certain application connections i.e. sessions between client applications and servers somewhere on the Internet.



The Master Core Technology

As shown in the Figure 5, the 5G MasterCore is convergence point for the other technologies, which have their own impact on existing wireless network. Interestingly, its design facilitates MasterCore to get operated into parallel multimode including all IP network mode and 5G network mode. In this mode (as shown in the image given below), it controls all network technologies of RAN and Different Access Networks (DAT). Since, the technology is compatible and manages all the new deployments (based on 5G), it is more efficient, less complicated, and more powerful.



(ii) Outline the advantages and disadvantages of 3G, 4G and 5G

Advantages of 3G:

- Faster data rates.
- Support multimedia applications such as video and photography.
- Value added services like mobile television, GPS, video call and video conference.
- High speed mobile internet access.
- Increased capacity.

Disadvantages of 3G :

- Requires 3G compatible handsets.
- The cost of upgrading to 3G device is expensive.
- Power consumption is high.

- 3G requires closer base stations which is expensive.

Advantages of 4G:

- Quickly download files over a wireless network
- Extremely high voice quality
- Easily access Internet, IM, social networks, streaming media, video calling
- Higher bandwidth
- 4G is 10 times faster than 3G

Disadvantages of 4G:

- New frequencies means new components in cell towers.
- Higher data prices for consumers
- Consumer is forced to buy a new device to support the 4G
- It is impossible to make your current equipment compatible with the 4G network

Advantages of 5G

- High resolution and bi-directional large bandwidth shaping.
- Technology to gather all networks on one platform.
- More effective and efficient.
- Technology to facilitate subscriber supervision tools for the quick action.

Disadvantages of 5G

- 5G is more costly compared to other Mobile Network Technology because many technical/ official engineers are required to install and maintain it.
- The risk of overcrowding the frequency range of the 5G wireless spectrum is greater as more devices are connected to one channel.
- 5G network Technology will take more time for security and privacy issues.
- Coverage indoor distance up to 2 meters and 300 meters outdoors can be achieved due to greater losses at higher frequencies as 5Gmm wave influences from such losses (rain losses, attenuation due to rain, etc.).
- The high cost of 5G infrastructure

Question 2

In tabular form, establish adequate differences between 2G, 3G, 4G and 5G

Technology	2G	3G	4G	5G
Requirements	no official requirements Digital Technology	ITU's IMT-2000 required 144 kbps mobile, 384 kbps	ITU's IMT advanced requirements include ability to	At least 1GB/s or more data rates to support ultra-high

		pedestrian, 2Mbps indoors	operate in up to 40 MHz radio channels and with very high spectral efficiency.	definition video and virtual reality, applications, 10GB/s data rates to support mobile cloud service
Data bandwidth	14.4 kbps to 384 kbps	2 Mbps	2 Mbps to 1Gbps	1 Gbps & higher (as demand)
Core network	PTSN Packet network	Packet network	All IP network	Flatter IP network & 5G network interfacing (5G-NI)
Services	Digital voice, Higher capacity, packetized data	Integrated high quality video and data	Dynamic information access, wear-able devices, HD streaming; Global roaming	Dynamic information access, wear-able devices, HD streaming; any demand of users, upcoming all technologies, global roaming smoothly
Standards	GSM, GPRS, EDGE ETC.	WCDMA, CDMA 2000	All access convergence including; OFMDA, MC-CDMA network-LMPS	CDMA & BDMA
Multiple access	TDMA CDMA	CDMA	CDMA	CDMA & BDMA
Starts from	1990	2001	2010	2015
Switching	Circuit Packet	Circuit Packet	Packet	All Packet
Frequency	850-1900MHz	1.6-2.5GHz	2-8GHz	

QUESTION 3

Recently in Nigerian there has been a widespread of opinion that the advent of 5G evolution will aid the spread of the corona virus which has become a pandemic all over the world.

(i) Is there any correlation between 5G and Corona virus

(ii) Do you support the state, if yes or No, in not more than 500 words Justify your answer to

(i) and (ii)

I. No

II. No

Justification for (i) and (ii)

Let me start by saying, there's absolutely no credible evidence for the link. There has been a lot of controversies/theories of the corona virus with its link to 5G.

Conspiracy theories claiming 5G technology helps transmit corona virus have been condemned by the scientific community.

According to the National Health Service (NHS) England Medical Director, Stephen Powis, “The conspiracy theories have been branded ‘the worst kind of fake news’”.

It should be notable to say, “The idea that the 5G lowers your immune system doesn’t stand up to scrutiny”.

We can say; “your immune system can be dipped by all sorts of things, either by being tired one day, or not having good-diet. Those fluctuations aren’t huge enough but can make you more susceptible to catching viruses.”

While very strong radio-waves can cause heating, it should be noted that 5G is nowhere strong enough to heat people up to have any meaningful effect. Because of where 5G fits in the electromagnetic spectrum.

The 5G resides in the Low-frequency band, which has a non-ionizing radiation effect.

It should be noted that, ionizing radiations are linked to ultra-violet rays, x-rays and gamma rays which reside in the high frequency spectrum.

Some of the first conspiracy theories first emerged via Facebook posts in the late January 2020, coincidentally around the same time the first cases were recorded in the US.

But it should be noted that the first reported case of the covid-19 was in December 2019, Wuhan province of china.

One of the theories claim 5G can suppress the immune system, thus making people more susceptible to catching the virus. The other suggest, the virus can somehow be transmitted through the use of 5G technology.

Both of these notions are said to be “complete rubbish”, says Dr. Simon Clark, an associate professor in cellular microbiology at the University of reading.

Adam Finn, a professor of pediatrics at the University of Bristol, says, “It would be impossible for 5G to transmit the virus”. He goes further to say;

“The present epidemic is caused by a virus that is passed from one infected person to another. We know this is true, we even have the virus growing in our lab, obtained from a person with the illness. Viruses and electromagnetic waves that makes mobile phones and internet connections work are different things, as different as chalk and cheese”.

It is important to note another major flaw with the conspiracy theories – corona virus is spreading in UK cities where 5G has yet to be deployed, and in countries like Iran that have yet to roll-out the technology.

It is also important to note that, earlier this year, a study carried out by the International Commission on Non-ionizing Radiation Protection (ICNIRP), says that, “there was no evidence that mobile networks causes cancer or other illnesses”.

We should know that; viruses invade the human or animal cells and use them to reproduce, which is what causes infections. Viruses cannot live very long outside a living thing, so they find a way in – usually via droplets of liquid from cough or sneezes.