EEE 512 ASSIGNMENT 1

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

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

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

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)

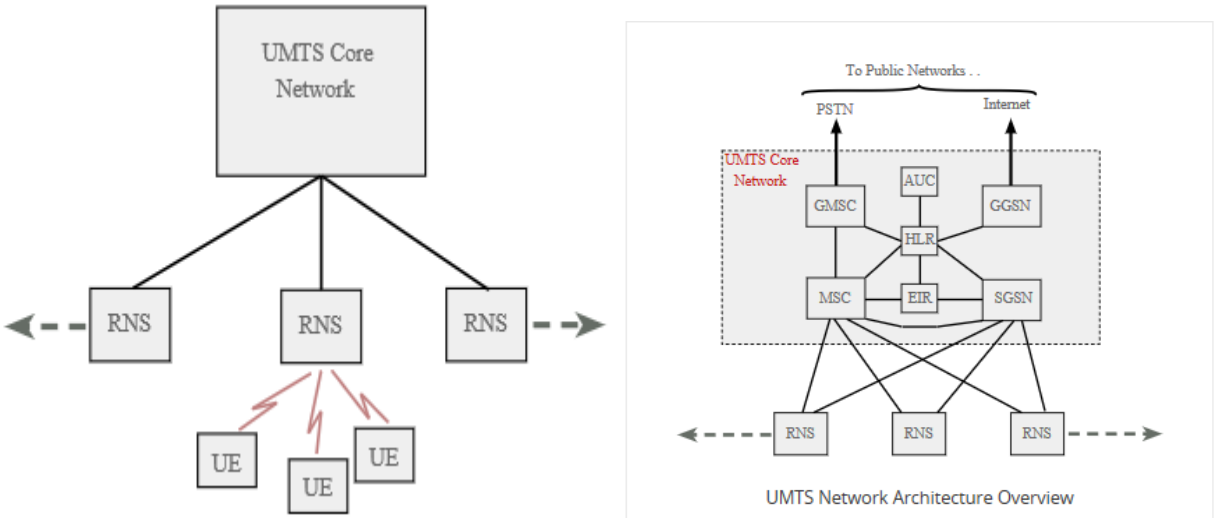
ANSWERS

3G Architecture

The UMTS network architecture can be divided into three main elements:

- **User Equipment (UE):** The User Equipment or UE is the name given to what was previous termed the mobile, or cellphone. The new name was chosen because the considerably greater functionality that the UE could have. It could also be anything between a mobile phone used for talking to a data terminal attached to a computer with no voice capability.
- **Radio Network Subsystem (RNS):** The RNS also known as the UMTS Radio Access Network, UTRAN, is the equivalent of the previous Base Station Subsystem or BSS in GSM. It provides and manages the air interface fort he overall network.
- **Core Network:** The core network provides all the central processing and management for the system. It is the equivalent of the GSM Network Switching Subsystem or NSS.

The core network is then the overall entity that interfaces to external networks including the public phone network and other cellular telecommunications networks.



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. In view of the far greater number of applications and facilities that it can perform, the decision was made to call it a user equipment rather than a mobile. However, it is essentially the handset (in the broadest terminology), although having access to much higher speed data communications, it can be much more versatile, containing many more applications. It consists of a variety of different elements including RF circuitry, processing, antenna, battery, etc.

There are a number of elements within the UE that can be described separately:

- **UE RF circuitry:** The RF areas handle all elements of the signal, both for the receiver and for the transmitter. One of the major challenges for the RF power amplifier was to reduce the power consumption. The form of modulation used for W-CDMA requires the use of a linear amplifier. These inherently take more current than non linear amplifiers which can be used for the form of modulation used on GSM. Accordingly to maintain battery life, measures were introduced into many of the designs to ensure the optimum efficiency.

- **Baseband processing:** The base-band signal processing consists mainly of digital circuitry. This is considerably more complicated than that used in phones for previous generations. Again this has been optimised to reduce the current consumption as far as possible.

- **Battery:** While current consumption has been minimised as far as possible within the circuitry of the phone, there has been an increase in current drain on the battery. With users expecting the same lifetime between charging batteries as experienced on the previous generation phones, this has necessitated the use of new and improved battery technology. Now Lithium Ion (Li-ion) batteries are used. These phones to remain small and relatively light while still retaining or even improving the overall life between charges.

- **Universal Subscriber Identity Module, USIM:** The UE also contains a SIM card, although in the case of UMTS it is termed a USIM (Universal Subscriber Identity Module). This is a more advanced version of the SIM card used in GSM and other systems, but embodies the same types of information. It contains the International Mobile Subscriber Identity number (IMSI) as well as the Mobile Station International ISDN Number (MSISDN). Other information that the USIM holds includes the preferred language to enable the correct language information to be displayed,

especially when roaming, and a list of preferred and prohibited Public Land Mobile Networks (PLMN).

The USIM also contains a short message storage area that allows messages to stay with the user even when the phone is changed. Similarly "phone book" numbers and call information of the numbers of incoming and outgoing calls are stored.

The UE can take a variety of forms, although the most common format is still a version of a "mobile phone" although having many data capabilities. Other broadband dongles are also being widely used.

3G UMTS Radio Network Subsystem

This is the section of the 3G UMTS / WCDMA network that interfaces to both the UE and the core network. The overall radio access network, i.e. collectively all the Radio Network Subsystem is known as the UTRAN UMTS Radio Access Network.The radio network subsystem is also known as the UMTS Radio Access Network or UTRAN.

3G UMTS Core Network

The 3G UMTS core network architecture is a migration of that used for GSM with further elements overlaid to enable the additional functionality demanded by UMTS.

In view of the different ways in which data may be carried, the UMTS 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. This enables much higher network usage as the capacity can be shared and data is carried as packets which are routed according to their destination.

Some network elements, particularly those that are associated with registration are shared by both domains and operate in the same way that they did with GSM.

4G Architecture

4G stands for fourth generation cellular system, 4G is evaluation of 3G to meet the forecasted rising demand,It is an integration of various technologies including GSM,CDMA,GPRS,IMT-2000 ,Wireless LAN and 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:

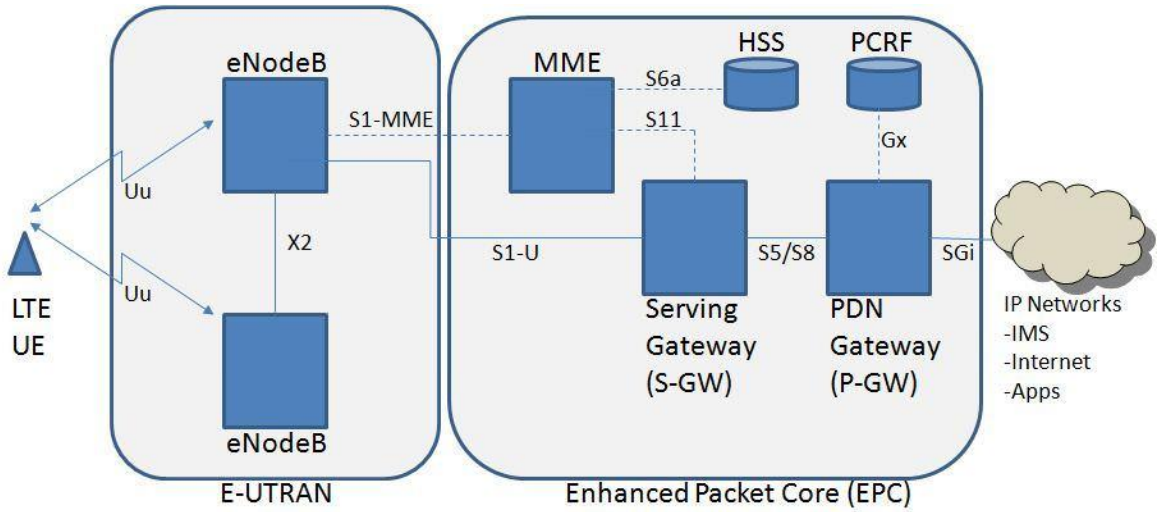
1. It stands for Voice over IP.
2. It allows only packet to be transferred eliminating complexity of 2 protocols over the same circuit.

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.



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

5G Architecture

The 3rd Generation Partnership Project (3GPP) covers telecommunication technologies including radio access, core transport networks and service capabilities. Multiple frequency ranges are now being dedicated to 5G new radio (NR). The portion of the radio spectrum with frequencies between 30 GHz and 300 GHz is known as the millimeter wave, since wavelengths range from 1-10 mm. Frequencies between 24 GHz and 100 GHz are now being allocated to 5G in multiple regions worldwide. In addition to the millimeter wave, underutilized UHF frequencies between 300 MHz and 3 GHz are also being repurposed for 5G.

Multi-Access Edge Computing (MEC) is an important element of 5G architecture. MEC is an evolution in cloud computing that brings the applications from centralized data centers to the network edge, and therefore closer to the end users and their devices. This essentially creates a shortcut in content delivery between the user and host, and the long network path that once separated them. This technology is not exclusive to 5G but is certainly integral to its efficiency.

Characteristics of the MEC include the low latency, high bandwidth and real time access to RAN information that distinguish 5G architecture from its predecessors.

The 5G core network architecture is at the heart of the new 5G specification and enables the increased throughput demand that 5G must support. The new 5G core, as defined by 3GPP, utilizes cloud-aligned, service-based architecture (SBA) that spans across all 5G functions and interactions including authentication, security, session management and aggregation of traffic from end devices. The 5G core further emphasizes NFV as an integral design concept with virtualized software functions capable of being deployed using the MEC infrastructure that is central to 5G architectural principles.

The concept of NFV extends to the radio access network (RAN) through for example network dis-aggregation promoted by alliances such as O-RAN. This enables flexibility and creates new opportunities for competition, provides open interfaces and open source development, ultimately to ease the deployment of new features and technology with scale. The O-RAN alliance objective is to allow multi-vendor deployment with off-the shelf hardware for the purposes of easier and faster inter-operability. Network dis-aggregation also allows components of the network to be virtualized, providing a means to scale and improve user experience as capacity grows. The benefits of virtualizing components of the RAN provide a means to be more cost effective from a hardware and software viewpoint especially for IoT applications where the number of devices is in the millions.

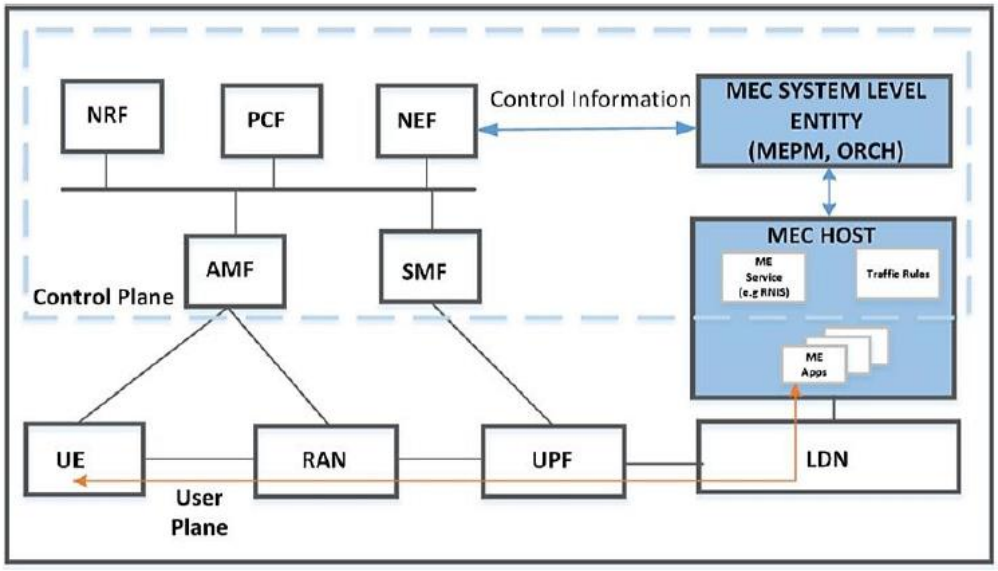


Figure 5: Network Architecture of 5G Systems.

1(ii)

Advantages of 3G, 4G and 5G

3G NETWORK	4G NETWORK	5G NETWORK

Better bandwidth security and reliability are more	Wider bandwidth and higher bit rate	It is globally accessable
Availability of fixed and variable rates	High internet speed	Dynamic information access
3G uses ip connectivity which is packet based	Tight network security	Availability at low cost
Provides interoperability among service provider	It provides flexibility as compared to the 3g	Data bandwidth of 1Gbps or higher
Overcrowding is relieved in existing system with radio spectrum	Better response time, it is 10times better than 3g	It is faster

Disadvantages of 3g,4g and 5g

3G network	4G network	5G network
The cost of cellular infrastructure , upgrading base stations is very high	It is impossible to make current equipment compactible with 4G	High cost of developing infrastructure
Power consumption is high	Higher data consumption	It operates on high frequency which will incur high loss
Requires closer base stations and are expensive	The use of too many antennas and transmitters which drain power on you device	Increase in bandwidth which causes lesser coverage
Needs different handsets.	Its Coverage is limited to certain region	Overcrowding may occur at its frequency range
Expensive cost of operation	It requires expensive infrastructure for operation	it requires more sophisticated techniques in order to ensure isolation of these radio resources.

2

PROPERTIES	2G	3G	4G	5G
BANDWIDTH	14-64kbps	2mbps	200mbps	Above 1gbps
TECHNOLOGY	digital cellular	broad bandwidth/ip technology/CDMA	Unified ip and combination of LAN/WAN/WLAN/PAN	4G+WWWW
SERVICES	Digital, voice and short messaging	Integrated high quality audio, video and data	Dynamic information access, variable devices	Dynamic information access, variable devices with AI capabilities
CORE NETWORK	PSTN	Packet network	internet	internet
MULTIPLEXING	TDMA/CDMA	CDMA	CDMA	CDMA

3

(i) No there is no correlation

(ii) the recent development by conspiracy theorist that the novel corona virus has any connection or relationship to the current implementation of 5g networks in some part of the world is untrue and outrageous. First of all, the virus spreads even in the countries without 5g installed and it works in a frequency that is seemingly large at least larger than its predecessors but not powerful enough to harm humans or damage human cells. In the radio frequency spectrum, 5G,3G and 4G are in the non-ionizing radiation or spectrum unlike the electromagnetic spectrum which are the ionizable radiation, hence they are not strong enough to harm the human cell not even as strong as the rays gotten from the sun which can actually cause more harm than the 5g network.

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