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EEE512

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.

ARCHITECTURE OF 3G

The Third Generation Systems will provide both speech and data at the very high speed. Though the second generation system provide with data transmission, the data rate offered is quite low and is unsuitable for today's needs. The third generation systems promise to integrate all kind of services like speech, data, audio, video, facsimile etc. through the mobile handsets. These systems will provide much better service quality than the second generation systems and will provide much smaller call set up delay. They will be suitable both for bursty and streamed data and will give much better utilization of channels. The users will be billed based on the utilization of channel rather than the time of call. This is very important for today's service demands like Internet and mail services. Therefore the goal of the third generation cellular systems is to provide better service quality at low cost, smaller call set up time, user friendly billing and access to a wide variety of services through wireless.

The third generation systems will support high speed packet switched data (up to 2Mbps) and will be next step beyond the GPRS. In fact GPRS is considered to be a transition step from second generation cellular systems to third generation cellular systems. The 3G systems are expected to be accepted world-wide and the subscriber would be able to get the mobile services from anywhere in the world without replacing his handset or SIM card. The subscriber would also get same environment and services in the visiting network as in his home network also being independent of the terminal. Apart from this, the modern generation cellular systems will provide with the framework to build various kind of services (like VPN and conferencing) on the top of core cellular networks. Currently the 3G cellular systems are being evolved from the existing cellular networks. Despite the efforts of standardization, UMTS (Universal Mobile Telecommunication System) and CDMA2000 are the two main networks which are likely to exist. Both these systems use CDMA technology. The UMTS system is being promoted by ETSI (European Telecommunication Standards Institute) and is a successor of GSM. CDMA-2000 is successor of IS-95 and is expected to be used in North America. In this report we will consider the features and architecture of UMTS system.

UMTS Architecture

UMTS system uses the same core network as the GPRS and uses entirely new radio interface. The new radio network in UMTS is called UTRAN (UMTS Terrestrial Radio Access Network) and is connected to the core network (CN) of GPRS via Iu interface. The Iu is the UTRAN interface between the Radio network controller RNC and CN. The figure below shows the UMTS architecture.

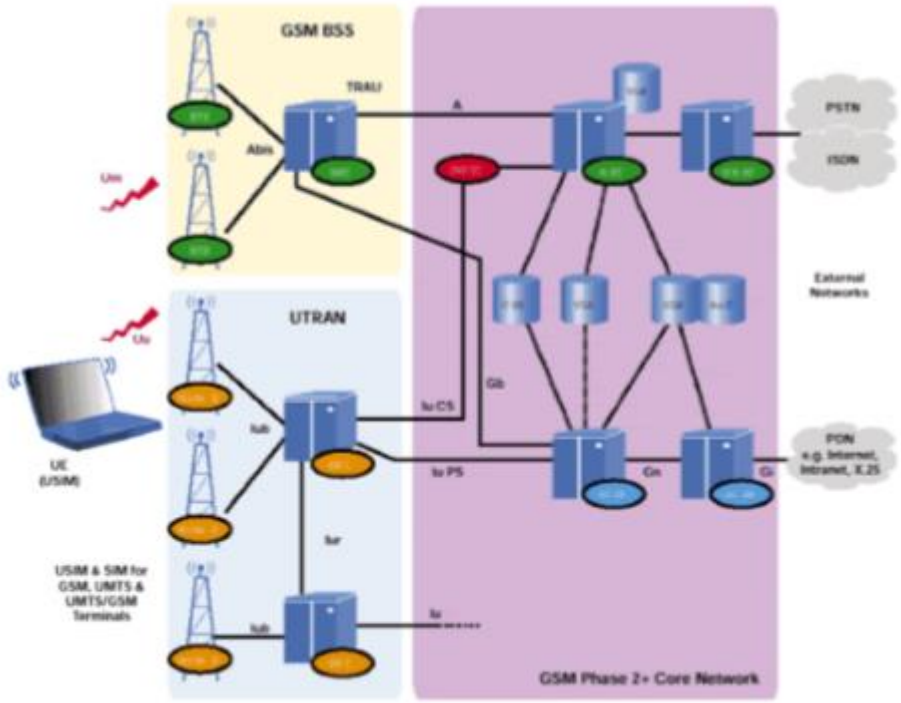


Figure 3.1: UMTS Architecture (Source:www.iec.org)

The mobile terminal in UMTS is called User Equipment (UE). The UE is connected to Node-B over high speed Uu (up to 2 Mbps) Interface. The Node-B are the equivalent of BTS in GSM and typically serve a cell site. Several Node-Bs are controlled by a single RNCs over the Iub interface. The RNCs are connected to CN through Iu interface. The packet switched data is transmitted through Iu-PS interface and circuit switched data is transferred over Iu-CS interface. One of the new interfaces in UTRAN is Iur interface which connects two RNCs and has no equivalent in GSM system. The Iur interface facilitates handling of 100 percent of RRM (Radio Resource Management) and eliminates the burden from CN. UMTS also supports GSM mode connections in which case the MS connect to the CN through Um interface to BSS and BSS connects through A (Gb interface in GPRS) interface to CN.

UMTS Interfaces

The Core Network of UMTS is same as that of GPRS. The air interface is totally different. We therefore only discuss the air interface. The air interfaces in UMTS are listed below:

- Uu: UE to Node B (UTRA, the UMTS W-CDMA air interface
- Iu: RNC to GSM Phase 2+ CN interface (MSC/VLR or SGSN) – Iu-CS for circuit-switched data

– Iu-PS for packet-switched data

- Iub: RNC to Node B interface
- Iur: RNC to RNC interface, not comparable to any interface in GSM The Iu, Iub, and Iur interfaces are based on ATM transmission principles.

UTRAN

The UTRAN is the new Radio interface of UMTS. Its constituting element are RNC, Node-B and UE. These elements are described below.

Radio Network Controllers (RNC):

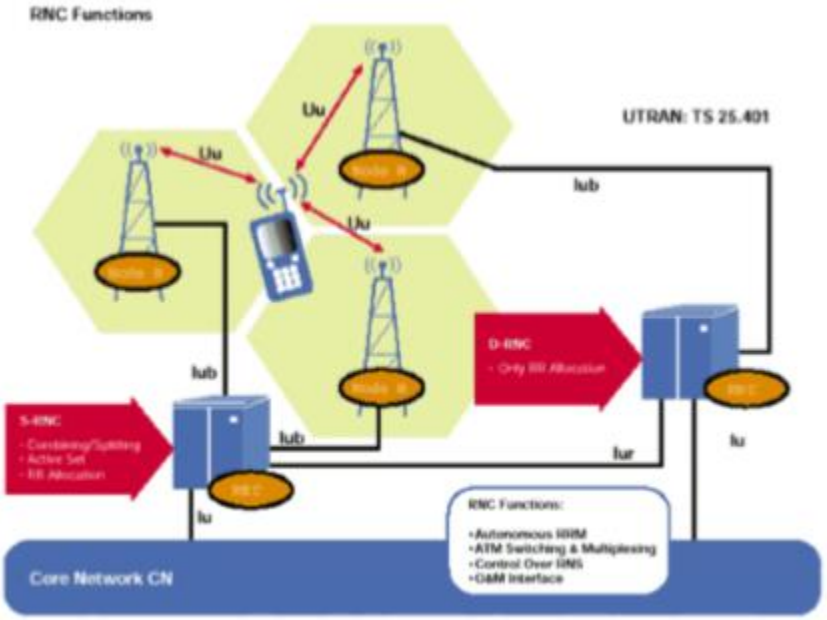
• RNC's controls and manages radio resources to Node B.

• 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.

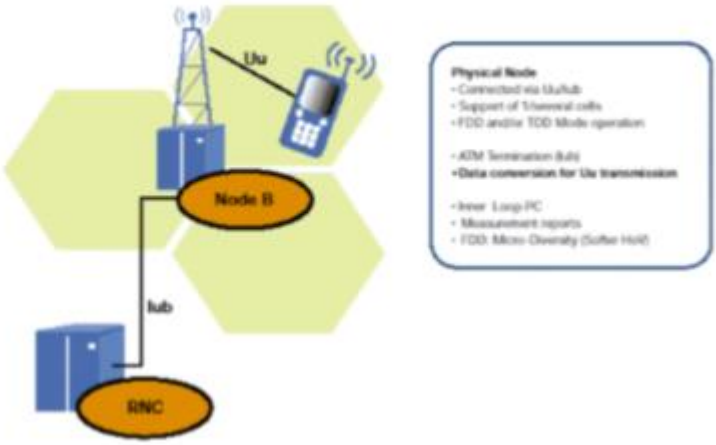
The RNCs enables autonomous radio resource management (RRM) by UTRAN. The RNC and its associated Node-Bs form Radio Network Subsystem (RNS). The UTRAN consists of several such RNSs. RNCs also assist in Soft Handover of the UEs when a UE moves from one cell to another. In soft Handover, the UE is in communication with more than one Node-Bs and RAKE receiver technique can be used to achieve micro diversity, thus eliminating the fading. This is one of several features arising out of CDMA modulation technique. Other advantages of using CDMA technique are higher bandwidth, scalability in the number of users served, power control and easier logical link control (since Time slots are eliminated). The figure below shows the RNC functions along with a soft Handoff scenario.



RNC Function (Source:www.iec.org)

Node-B The Node-B is physical unit of radio transmission/reception with cells. It can support both TDD and FDD modes and can be colocated with GSM BTS to reduce implementation costs. It connects to UE

via Uu W-CDMA radio interface and RNC via Iub ATM interface. The figure below shows the Node B connected to UE and RNC.

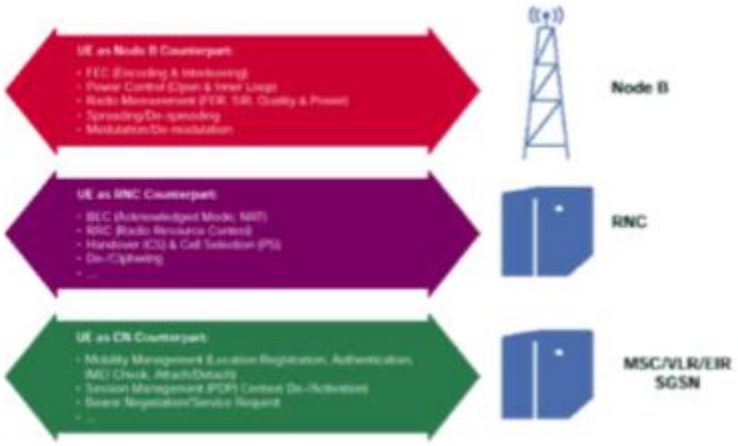


Node B (Source:www.iec.org)

The main task of Node B is the conversion to and from the Uu radio interface, including forward error correction (FEC), rate adaptation, W-CDMA spreading/dispreading, and quadrature phase shift keying (QPSK) modulation on the air interface. It measures quality and strength of the connection and determines the frame error rate (FER), transmitting these data to the RNC as a the FDD softer Handover. This micro diversity combining is carried out independently, eliminating the need for additional transmission capacity in the Iub. The Node B also participates in power control, as it enables the UE to adjust its power using down-link (DL) transmission power control (TPC) commands via the inner-loop power control on the basis of uplink (UL) TPC information. The predefined values for inner-loop power control are derived from the RNC via outer-loop power control.

UE

The UMTS UE is based on the same principles as the GSM MS-the separation between mobile equipment (ME) and the UMTS subscriber identity module (SIM) card (USIM). Figure below shows the user equipment functions. The UE is the counterpart to the various network elements in many functions and procedures.



UMTS UE (Source:www.iec.org)

UMTS Open Service Architecture

One of the important features of UMTS is Open Service Architecture (OSA). OSA is a framework which aims at building various kinds of services on the top of UMTS core Network. The OSA will provide APIs to access the network functions like authentication and authorization of the user. The APIs are guaranteed to be secure, independent of vendor specific solutions and also independent of programming language by use of Object Oriented techniques like CORBA, SOAP etc. Various services like VPN, conferencing and many more unknown services can be implemented with the help of these APIs.

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)

ARCHITECTURE OF 4G

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:

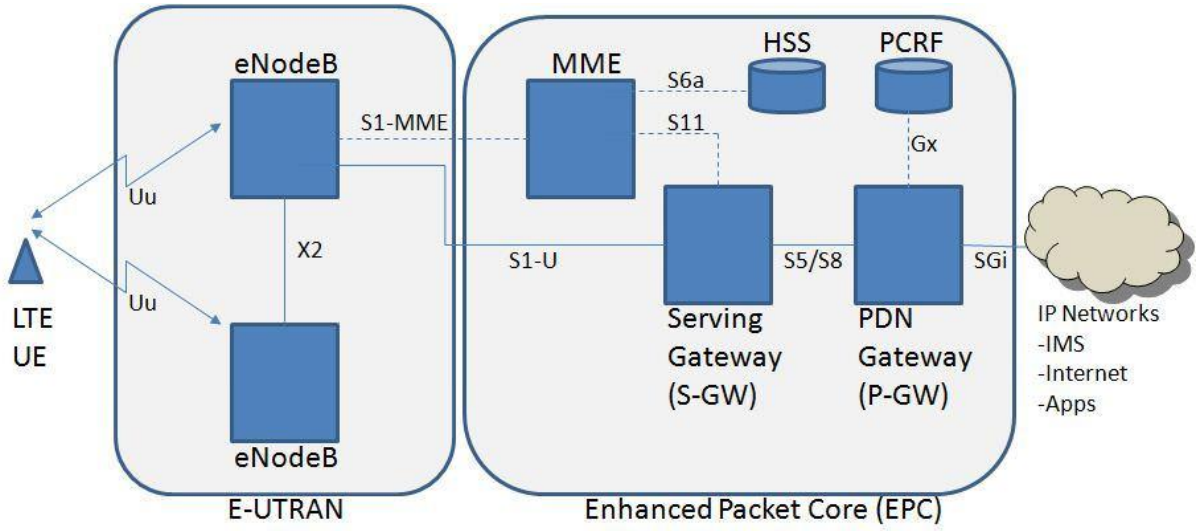
1. SDR stands for Software Defined Radio.
2. It is the form of open wireless architecture.

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

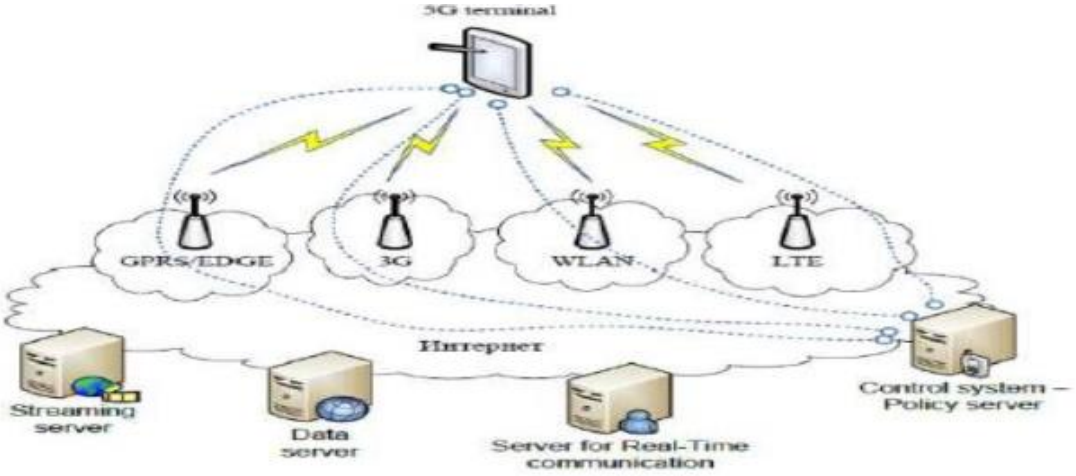
It provide quality of service and charging

eNode B-evolved Node B

It is used as radio resources management and radio bearer control

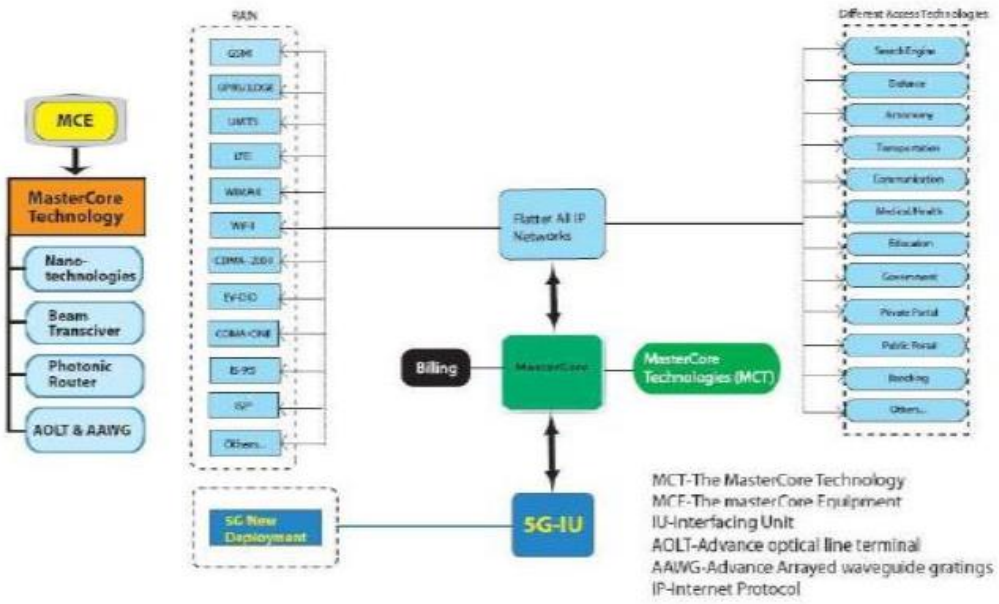
ARCHITECTURE OF 5G

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.
- 3G used the new IP (Internet Protocol) connectivity for data services which is packet based
- Support multimedia applications such as video and photography.
- The major drawback of 1G and 2G "interoperability" has finally been allowed in 3G networks
- 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.
- Compared to the previous generation Power consumption is high due to more complex modulation/demodulation and also with the wide use of data the power consumption significantly increases.
- 3G requires closer base stations which is expensive.

Advantages of 4G:

- Quickly download files over a wireless network
- Ultra-fast downlink and uplink speeds
- Extremely high voice quality

- Ease of access and less latency
- Easily access Internet, IM, social networks, streaming media, video calling
- 4G is 10 times faster than 3G
- Higher bandwidth when compared to 3G

Disadvantages of 4G:

- New frequencies mean 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.
- 5G network can easily be incorporated with previous generation 3G and 4G networks to ensure availability to voice and data.
- Increased Bandwidth for All Users
- More Bandwidth Means Faster Speed
- Most likely, will provide a huge broadcasting data (in Gigabit), which will support more than Most likely, will provide a huge broadcasting data (in Gigabit), which will support more than 60,000 connections
- New Technology Options May Become Available on a 5G Network
- 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.
- Technology is still under process and research on its viability is going on
- 5G network Technology will take more time for security and privacy issues.
- An Increased Bandwidth will mean Less Coverage
- 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 pedestrian, 2Mbps indoors	ITU's IMT advanced requirements include ability to operate in up to 40 MHz radio channels and with very high spectral efficiency.	At Least 1GB/s or more data rates to support ultra-high 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 smoothl
Standards	GSM, GPRS, EDGE ETC.	WCDMA, CDMA 2000	All access convergence including; OFMDA, MC-CDMA network-LMP	CDMA AND BDMA
Multiple access	TDMA CDMA	CDMA	CDMA	CDMA BDMA
Starts from	1990	2001	2010	2015
Switching	Circuit Packet	Circuit Packet	Packet	All Packet
Frequency	1.6-2.5GHz	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)

There is no correlation between the 5G and Corona virus. There is no credible evidence, or any logical or scientific proof that shows that the 5G is link to the spread of the corona virus.

COVID-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 can cause symptoms very similar to the flu – fever and a dry cough (the two most common symptoms), fatigue, aches and pains, and nasal congestion.

The virus is primarily spread between people during close contact, often via small droplets produced by coughing, sneezing, or talking. The droplets usually fall to the ground or onto surfaces rather than remaining in the air over long distances. People may also become infected by touching a contaminated surface and then touching their face. In experimental settings, the virus may survive on surfaces for up to 72 hours.

It all can be traced back to a strange, baseless theory that emerged in February: that 5G wireless networks caused the Covid-19 pandemic. If not that, then that 5G mysteriously hastens the transmission of the virus such theory was initially debunked but later went main stream after being spread by influential people all over the world from politicians, celebrities e.tc.

Wuhan China turned on its 5G Network around October 2019 and the COVID-19 pandemic which started in a market in Wuhan China, started around December 2019. With the time difference of COVID 19 taking 14 days to show up, how can there not be a case in 2 months

5G Poses No Risk to Public Health

What is true is that 5G uses higher frequency waves than 3G or 4G to provide faster data transmission to more users. Because 5G waves don't travel as far in built-up areas, mast towers need relatively more 5G transmitters. But having more transmitters means 5G can run at lower power levels than 4G, which also decreases the radiation they emit.

Radio frequency cannot cause viruses or microorganisms to spread neither that the component used to build this 5G technologies are organic which can cause the corona virus to reproduce sustaining life for a long period of time.

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”.