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MATRIC NO.: 15/ENG04/033

COURSE CODE: EEE 512

ASSIGNMENT

1. (i) Working principle of 3G

   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.

   Circuit switched elements

   The circuit switched elements of the UMTS core network architecture include the following network entities:

   - Mobile switching centre (MSC): This is essentially the same as that within GSM, and it manages the circuit switched calls under way.
   - Gateway MSC (GMSC): This is effectively the interface to the external networks.

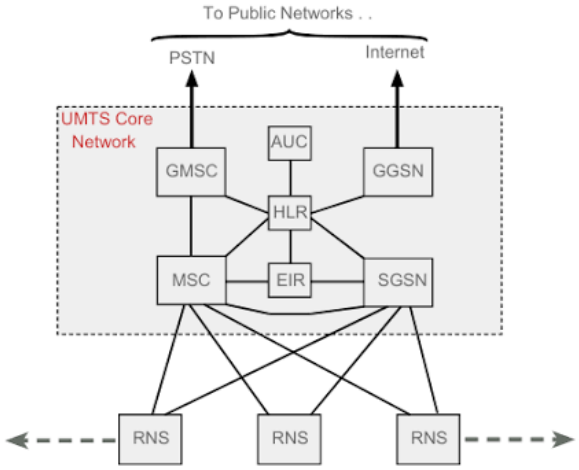
   Packet switched elements

   The packet switched elements of the 3G UMTS core network architecture include the following network entities:

   - Serving GPRS Support Node (SGSN): As the name implies, this entity was first developed when GPRS was introduced, and its use has been carried over into the UMTS network architecture. The SGSN provides a number of functions within the UMTS network architecture.
   - Gateway GPRS Support Node (GGSN): Like the SGSN, this entity was also first introduced into the GPRS network. The Gateway GPRS Support Node (GGSN) is the central element within the UMTS packet switched network. It handles inter-working between the UMTS packet switched network and external packet switched networks, and can be considered as a very sophisticated router. In operation, when the GGSN

receives data addressed to a specific user, it checks if the user is active and then forwards the data to the SGSN serving the particular UE.

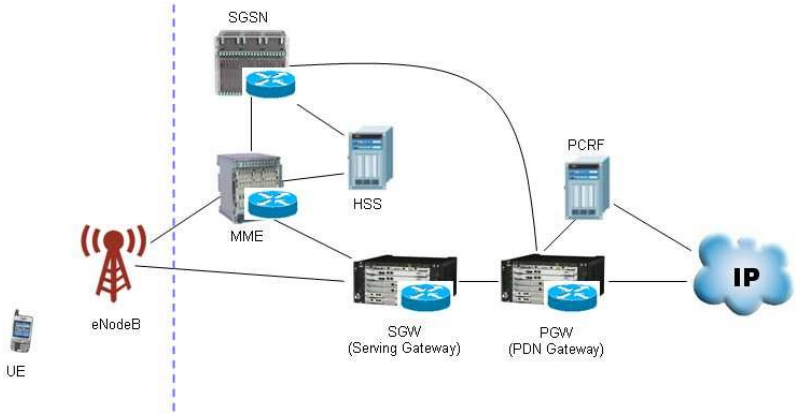
- Home location register (HLR): This database contains all the administrative information about each subscriber along with their last known location. In this way, the UMTS network is able to route calls to the relevant RNC / Node B. When a user switches on their UE, it registers with the network and from this it is possible to determine which Node B it communicates with so that incoming calls can be routed appropriately. Even when the UE is not active (but switched on) it re-registers periodically to ensure that the network (HLR) is aware of its latest position with their current or last known location on the network.
- Equipment identity register (EIR): The EIR is the entity that decides whether a given UE equipment may be allowed onto the network. Each UE equipment has a number known as the International Mobile Equipment Identity. This number, as mentioned above, is installed in the equipment and is checked by the network during registration.
- Authentication centre (AuC) : The AuC is a protected database that contains the secret key also contained in the user's USIM card.



Working principle of 4G network

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 below presents the 4G-network architecture. The idea is to use Session Initiation Protocol (SIP). 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).



Working principle of 5G network

5G is effectively a dynamic, coherent and flexible framework of multiple advanced technologies supporting a variety of applications. 5G utilizes a more intelligent architecture, with Radio Access Networks (RANs) no longer constrained by base station proximity or complex infrastructure. 5G leads the way towards disaggregated, flexible and virtual RAN with new interfaces creating additional data access points.

5G Spectrum and Frequency

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.

MEC

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.

NFV and 5G

Network function virtualization (NFV) decouples software from hardware by replacing various network functions such as firewalls, load balancers and routers with virtualized instances running as software. This eliminates the need to invest in many expensive hardware elements and can also accelerate installation times, thereby providing revenue generating services to the customer faster.

NFV enables the 5G infrastructure by virtualizing appliances within the 5G network. This includes the network slicing technology that enables multiple virtual networks

to run simultaneously. NFV can address other 5G challenges through virtualized computing, storage, and network resources that are customized based on the applications and customer segments.

5G RAN Architecture

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.

eCPRI

Network dis-aggregation with the functional split also brings other cost benefits particularly with the introduction of new interfaces such as eCPRI. RF interfaces are not cost effective when testing large numbers of 5G carriers as the RF costs rapidly increase. The introduction of eCPRI interfaces presents a more cost-effective solution as fewer interfaces can be used to test multiple 5G carriers. eCPRI is aimed to be a standardized interface for 5G used for instance in the O-RAN front haul interface such as the DU. CPRI in contrast to eCPRI was developed for 4G, however in many cases was vendor specific making it problematic for operators.

Network Slicing

Perhaps the key ingredient enabling the full potential of 5G architecture to be realized is network slicing. This technology adds an extra dimension to the NFV domain by allowing multiple logical networks to simultaneously run on top of a shared physical network infrastructure. This becomes integral to 5G architecture by creating end-to-end virtual networks that include both networking and storage functions.

Operators can effectively manage diverse 5G use cases with differing throughput, latency and availability demands by partitioning network resources to multiple users or “tenants”.

Network slicing becomes extremely useful for applications like the IoT where the number of users may be extremely high, but the overall bandwidth demand is low. Each 5G vertical will have its own requirements, so network slicing becomes an important design consideration for 5G network architecture. Costs, resource management and flexibility of network configurations can all be optimized with this level of customization now possible. In addition, network slicing enables expedited trials for potential new 5G services and quicker time-to-market.

Beamforming

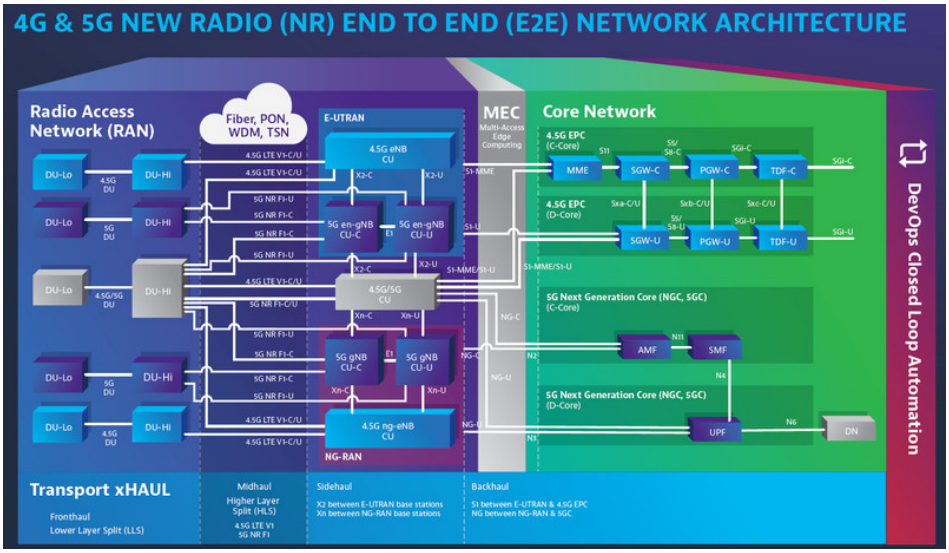
Another breakthrough technology integral to the success of 5G is beamforming. Conventional base stations have transmitted signals in multiple directions without regard to the position of targeted users or devices. Through the use of multiple-input, multiple-output (MIMO) arrays featuring dozens of small antennas combined in a single formation, signal processing algorithms can be used to determine the most efficient transmission path to each user while individual packets can be sent in multiple directions then choreographed to reach the end user in a predetermined sequence.

5G Beamforming

With 5G data transmission occupying the millimeter wave, free space propagation loss, proportional to the smaller antenna size, and diffraction loss, inherent to higher frequencies and lack of wall penetration, are significantly greater. On the other hand, the smaller antenna size also enables much larger arrays to occupy the same physical space. With each of these smaller antennas potentially reassigning beam direction several times per millisecond, massive beamforming to support the challenges of 5G bandwidth becomes more feasible. With a larger antenna density in the same physical space, narrower beams can be achieved with massive MIMO, thereby providing a means to achieve high throughput with more effective user tracking.

5G Core Architecture

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.



(ii)

NETWORK	ADVANTAGE	DISADVANTAGE
3G	Faster data rates. Increased capability. High speed mobile internet access.	Requires 3G compatible phones. Cost of upgrading is expensive. Power consumption is high.
4G	Extreme high voice quality. Higher bandwidth. 4G is 10 times faster than 3G.	Higher data price for consumers. Requires 4G compatible device. New frequency means new component in cell towers.
5G	Increased bandwidth. Faster internet speed.	Increased bandwidth means less coverage. Radio frequency problem.

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

TECHNOLOGY	2G	3G	4G	5G
Bandwidth	14-16kbps	2mbps	200mbps	>1gbps
Handoff	Horizontal	Horizontal	Horizontal & Vertical	Horizontal & Vertical
Switching	Circuit	Packet except for air interface	All packet	All packet
Core network	PSTN	Packet network	Internet	Internet

3. (i) NO

(ii) A lot of people are pushing a conspiracy theory claiming that 5G (which is used in mobile phone networks and relies on signals carried by radio waves) is somehow responsible for coronavirus. Some of these theories suggest that the coronavirus can be transmitted through 5G or that 5G suppresses the immune system. Both are untrue. To understand why 5G and the virus aren't linked, you have to understand why 5G radio waves aren't powerful enough to damage the cells in your body alone or transmit a virus.

The immune system can be affected by a lot of things such as being tired one day, or not having a good diet. These fluctuations can make a person more susceptible to catching viruses or being sick. It is known that very strong radio waves can cause heating and 5G is not strong enough to heat people up enough to have any meaningful effect or weaken the immune system. Radio waves can disrupt a person's physiology as they heat the person up, meaning the immune system can't function. But the energy levels from 5G radio waves are tiny and they are not strong enough to affect the immune system. There have been lots of studies on this. The radio waves involved in 5G and other mobile phone technology sit on the low frequency end of the electromagnetic spectrum. Less powerful than visible light, they are not strong enough to damage cells, unlike radiation at the higher frequency end of the spectrum which includes the sun's rays and medical x-rays. Likewise, radio waves and viruses aren't transmitted in the same way. Viruses invade human or animal cells and use them to reproduce, which is what causes infection. Viruses cannot live very long outside a living thing, so they have to find a way in - usually via droplets of liquid from coughs or sneezes. The present epidemic is caused by a virus that is passed from one infected person to another. The coronavirus spreads from one person to another, typically through tiny droplets of saliva produced when a sick person coughs, sneezes, or breathes. The only types of viruses you can transmit via radio waves are ones that affect computers, not humans. Viruses and electromagnetic waves that make mobile phones and internet connections work are different things. I believe that this is a conspiracy theory which was spread through social media networks such as Facebook, Nextdoor, and Instagram. The virus is spreading in countries without access to 5G. The pandemic has hit counties like Iran, India, and Japan where 5G isn't even in use yet. Iran has only just reportedly finalized its regulations on 5G, with plans to roll out the technology later this year. Iran currently has more than 66,000 confirmed cases of COVID-19. Japan only just started rolling out 5G services in the past week, and India's 5G launch may even be delayed because of the pandemic. At the same time, South Korea has had 5G towers in place for a year now, and it only began seeing COVID-19 cases after the Wuhan outbreak. 5G and COVID-19 are both global phenomena happening at roughly the same time.