



# ST. ANNE'S COLLEGE OF ENGINEERING AND TECHNOLOGY

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## PART A- Two marks

### 1. What are the characteristics of first generation 1G?

1. 2.4 kbps speed enables voice calls in one nation.
2. Use an analogue signal.
3. Poor voice quality, insufficient battery life.
4. Large phone size limited capacity poor handoff dependability inadequate security
5. Spectrum efficiency was relatively low.

### 2. What are the characteristics of second generation 2G?

1. 2G stands for the Second Generation.
2. Data transmission rates of up to 64kbps were achieved through digital signals.
3. Enables services such as text messaging, picture messages, and MMS Multimedia message.
4. Incapable of dealing with complicated data such as videos.
5. Strong digital signals were required to enable mobile phones to function, digital signals will be weak if no network coverage in a particular area.

### 3. What are the characteristics of third generation 3G?

1. Speed 2 Mbps typically referred to as smartphones.
2. Broadband and data transfer rates have been increased to handle web-based applications and music and video files.
3. It allows for speedier communication.
4. Sending/receiving huge email messages.
5. High-speed web access, improved security, video conferencing, 3D gaming.

### 4. What are the characteristics of fourth generation 4G?

1. Ability to give speeds ranging from 10Mbps to 1Gbps, high quality streaming video, a combination of Wi-Fi and Wi-Max and increased security.
2. Provide any type of service at any time and from any location as needed by the user.
3. Expansion of multimedia services.
4. Low cost per bit, increased battery usage.
5. Implementation is complex, intricate technology is required, and expensive equipment is necessary to build a next-generation network.

### 5. List the features 5G.

The present 5G technology trend has the following feature.

1. 5G technology can provide connectivity speeds of up to 25 Mbps.
2. 5G technology provides cell phone users with high quality and bi-directional extensive bandwidth sharing.
3. 5G technology enables large-scale data transmission at gigabit speeds, with about 65,000 connections supported.
4. The uploading and downloading speeds of 5G technology have reached a new high.
5. Virtual private networks are also supported by 5G technology.

### 6. Define User Equipment (UE)

- In 2G, the handsets were called as mobile phones or cell phones, as they were predominantly used for making voice calls.
- However, in 3G, the handsets can support both voice and data services. Hence, the term User Equipment or UE is used to represent the end user device, which could be a mobile phone or a data terminal.

### 7. Define Radio Access Network (RAN)

- The RAN, also known as the UMTS Radio Access Network, UTRAN, is the equivalent of the previous Base Station Subsystem (BSS) in GSM.



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- RAN includes the NodeB function and the Radio Network Controller (RNC) function. The NodeB function provides the air interface. The RNC manages the air interface for the overall network.

## 8. Define Core Network.

The core network is the equivalent of Network Switching Subsystem or NSS in GSM and provides all the central processing and management for the system. Core network has both circuit switched and packet switched network elements.

## 9. Define Home Location register (HLR)

- HLR is a database that contains all information about the subscriber including their last known location.
- The HLR maintains a mapping between Mobile Station International Subscriber Directory Number (MSISDN) and International Mobile Subscriber Identity (IMSI). MSISDN is the mobile phone number used for making and receiving voice calls and SMS.

## 10. Define Equipment Identity Register (EIR)

- The EIR is the function that decides whether a user equipment is allowed onto the network or not. EIR is typically integrated with the HLR.
- EIR is used for blocking or monitoring calls from a stolen user equipment. Each user equipment is uniquely identified through a number known as the International Mobile Equipment Identity (IMEI).

## 11. Define Authentication Centre (AuC)

- AuC is used for storing a shared secret key, which gets generated and burned in the SIM card at the time of manufacturing.
- AuC function is typically co-located with the HLR function. AuC does not exchange the shared secret key, but would run an algorithm on the International Mobile Subscriber Identity (IMSI), to generate data for authentication of a subscriber / user equipment. Each IMSI is unique and gets mapped to a SIM card.

## 12. Define Mobile switching center (MSC)

- MSC is responsible for functions such as routing calls and SMS messages. It interfaces with the HLR for keeping track of subscriber location and does call handovers, when the mobile subscriber moves from one location to another.
- Gateway MSC (GMSC) is a function that is present either within or outside of the MSC. A GMSC interfaces with the external networks such as the Public Switched Telephone Network (PSTN), which is our legacy land line network.

## 13. Define Serving GPRS Support Node (SGSN)

- SGSN is responsible for mobility management and authentication of subscribers / mobile devices in a GPRS network.
- It performs a role which is similar to the role played by the MSC for voice calls. The SGSN and MSC are often co-located in the network.

## 14. Define Gateway GPRS Support Node (GGSN)

GGSN acts as a gateway to the Internet. It connects the GPRS network with the packet switched data network. GGSN receives data addressed to a given subscriber, checks if the subscriber is active and then forwards the data to the SGSN serving the particular subscriber.

## 15. Define Charging Gateway Function (CGF)

- CGF handles Call Detail Records (CDRs) generated by the GGSN in a GPRS network.
- There are different types of CDRs processed by the CGF, based on the network node that generates the CDR. For example, when a SGSN generates CDRs, it is called S-CDR.

## 16. Evolved Node B (eNB)

- eNodeB is the entity that supports air interface and performs radio resource management.
- It provides radio resource management functions such as IP header compression, user data encryption, and routing the user data to the Serving Gateway (SGW).

## 17. Define Serving Gateway (SGW)



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- SGW serves as the mobility anchor for the user plane. It takes care of inter-eNodeB handovers & User Equipment (UE) mobility between 3GPP networks.
- It is responsible for routing/forwarding data packets between the eNodeB & Packet Data Network Gateway (PDN GW).

## 18. Define Packet Data Network Gateway (PGW)

- PDN GW provides the UE with connectivity to the external packet data networks such as Internet.
- It serves as the anchor point for intra-3GPP network mobility, as well as mobility between 3GPP and non-3GPP networks.
- It takes care of Policy and Charging Enforcement Function (PCEF), which includes Quality of Service (QoS), online/offline flow-based charging data generation, deep-packet inspection, and lawful intercept.

## 19. Define Mobility Management Entity (MME)

MME manages mobility, UE identities and security parameters. It operates in the Control plane and provides functions such as managing session states, authentication, mobility with 3GPP 2G/3G nodes, and roaming.

## 20. Define Policy and Charging Rules Function (PCRF)

Policy and Charging Rules Function (PCRF) maintains the policy and charging related controls for all the subscribers. For example, a subscriber's quality of service policy is stored in the PCRF server.

## 21. What is Circuit Switched Fall-Back (CSFB)?

- When LTE is just used for data transfer, voice calls are handled through the legacy circuit switched mechanisms - by falling back to a 3G or 2G network.
- Circuit Switched Fall- Back (CSFB) works only when the area covered by an LTE network is also covered by the 3G network.

## 22. Define Voice over LTE (VoLTE)

- Voice over LTE is relatively a new concept, to support voice calls over the 4G network.
- While CSFB helped the service providers during the migration from 2G/3G to 4G networks, VoLTE runs completely on the 4G network.
- In case of VoLTE, the user equipment / mobile should be capable of initiating a VoLTE call and the network should support VoLTE.

## 23. How do setting up a VoLTE?

Setting up a VoLTE is a two-step process:

1. At first, the UE sets up a dedicated bearer/tunnel for IMS APN (Access Point Name).
2. Once the bearer is established, the UE sets up a Session Initiation Protocol (SIP) connection with the IMS Core. SIP is a popular protocol used for Voice over IP (VOIP) communications, over the Internet.

## 24. What is Radio Access Network (RAN)?

The Radio Access Network (RAN) architecture has evolved across the different generations of the wireless network, to support the bandwidth and scalability requirements. RAN has two distinct units the Remote Radio Head (RRH) and the Baseband Unit (BBU).

## 25. Draw the table for evolution of RAN.

Generation	Architecture / Technology	Base Station
2G	GSM	Base Transceiver Station (BTS)
3G	UMTS	NodeB
4G	LTE	Evolved NodeB (eNodeB)
5G	NR	Next Generation NodeB (gNodeB)



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## 26. State the need for 5G. (Nov/Dec 23)

- Internet of Things (IOT) will require an infrastructure that can handle several billions of network devices connecting to the wireless network, and at the same time energy efficient.
- 3D video and Ultra High Definition Video streaming applications are hungry for additional bandwidth.
- Virtual Reality and Augmented Reality enabled gaming, video streaming and industrial applications require sub- millisecond latencies.

## 27. Define Next Generation Core (NG-core)

- NG-Core for 5G is the equivalent of Evolved Packet Core (EPC) in a 4G network.
- 5G NG-Core architecture supports virtualization and allows the user plane functions to be deployed separately, from the control plane functions.
- In addition, the user plane and control plane functions can be scaled independently.

## 28. State the functions of 5G NG –Core.

1. Authentication Server Function (AUSF)
2. Access and Mobility Management Function (AMF)
3. Data Network (DN)
4. Network Exposure Function (NEF)
5. Network Repository Function (NRF)

## 29. Define Authentication Server Function (AUSF)

AUSF acts as an authentication server, performing UE authentication using Extensible Authentication Protocol (EAP). EAP is a popular protocol used in Wi-Fi networks for authenticating Wi-Fi clients. In the 4G network, AUSF function was part of the Home Subscriber Server (HSS) function.

## 30. Define Access and Mobility Management Function (AMF)

- Responsible for connection management, registration management and mobility management (handling of reachability and idle/active mode mobility state).
- It also takes care of access authentication and authorization. AMF also supports Lawful intercept function for AMF events. In the 4G network, this function was part of the Mobility Management Entity (MME).

## 31. Define Data Network (DN)

DN offers operator services, internet access and third party services.

## 32. Define Network Exposure Function (NEF)

NEF is a proxy or API aggregation point for the core network and provides security when services or external application functions access the 5G Core nodes. This is a new function introduced in 5G architecture.

## 33. Define Network Repository Function (NRF)

NRF supports service discovery, and maintains/provides profiles network function instances. This is a new function introduced in 5G architecture.

## 34. Define Network Slice Selection Function (NSSF)

NSSF supports the selection of network slice instances to serve the User Equipment (UE), based on the Network Slice Selection Assignment Information (NSSAIs) configured or allowed for a given UE. This is a new function introduced in 5G architecture.

## 35. What is Policy Control Function (PCF)?

PCF provides a unified policy framework and shares policy rules to control plane functions, to enforce them. It also accesses subscription information relevant for policy decisions from the Unified Data Repository (UDR). PCF was part of the PCRF function in the 4G network.

## 36. What is Session Management Function (SMF)?

SMF provides session management, UE IP address allocation & management and DHCP functions. It also provides traffic steering configuration for User Plane Function (UPF) for proper traffic routing. SMF function was split between the MME and Packet Gateway (PGW) function in 4G network.



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## 37. What is Unified Data Management (UDM)?

UDM provides Authentication and Key Agreement (AKA) credentials, user identification handling, access authorization and subscription management functions. UDM was part of the HSS functionality in the 4G architecture.

## 38. What is User Plane Function (UPF)?

- UPF provides packet routing and forwarding functions. In addition, it also handles QoS services. UPF function was split between Serving Gateway (SGW) and PGW in the 4G architecture.
- Separating the user plane from the control plane in both SGW/PGW, enables the service providers to deploy the UPF closer to the network edge.

## 39. What is Application Function (AF)?

AF function is similar to the AF function in the 4G network. It interacts with the 5G core to provide services such as application influence on traffic routing, accessing Network Exposure Function (NEF) and interacting with policy framework for policy control.

## 40. What is CUPS in 4G architecture?

- CUPS was originally introduced in the 4G Evolved Packet Core (EPC) architecture. EPC with CUPS support separates the control plane function from the user plane function in the network.
- Network functions within 4G EPC such as Packet Gateway (PGW), Serving Gateway (SGW) and Traffic Detection Function (TDF), were split into control plane and user plane functions.

## Part B

1. Explain various Networks evolution: 2G, 3G, and 4G.
2. Explain Evolution of Radio access networks/ What is RAN? And its functions (Nov/Dec 23)
3. Discuss the Need for 5G.
4. Discuss 4G versus 5G.
5. Explain Next Generation Core (NG-Core) (Nov/Dec 23)
6. Explain visualized Evolved Packet Core (vEPC)
7. Explain CUPS in 4G architecture

## Unit-2

### Part-A

#### Part – A Two marks

## 1. What are the drivers for 5G? /List the use cases enabled by 5G (Nov/Dec 23)

- (1) Business case demands from a broader set of economic actors, including industrial companies driving new use cases,
- (2) New technologies for delivering core network components creating expectations of more efficient and flexible operations, and
- (3) Shifts in how business, society and environmental needs are balanced to deliver services in a new way.

## 2. List the new technologies have driven the development of 5G.

- (1) Virtualization,
- (2) Cloud native,
- (3) Containers,
- (4) Microservices



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(5) Automation

### 3. Define virtualization.

- Traditionally Mobile core network element functional designs are distributed applications which scale horizontally and run on dedicated hardware such as processor blades in a chassis.
- The network element architecture is distributed internally onto specific types of blades that perform specific tasks.
- The first major step of virtualization was to migrate those application-specific blades to virtualized resources such as virtual machines (VMs) and later containers.

### 4. Define cloud native.

Cloud Native architectures have gained a lot of interest over the past years and service operators attempt to emulate the efficiencies captured by so-called hyperscalers (e.g., Facebook, Google, Amazon) has led to a much heightened interest in this area.

### 5. What are several cloud-native design principles?

- ✓ Infrastructure Agnostic
- ✓ Software decomposition and life cycle management
- ✓ Resiliency
- ✓ State-optimized design
- ✓ Orchestration and automation

### 6. What is infrastructure agnostic?

Cloud-native applications are independent and agnostic of any underlying infrastructure and resources.

### 7. What is Software decomposition and life cycle management?

Software is decomposed into smaller, more manageable pieces, utilizing microservice architectures. Each piece can be individually deployed, scaled, and upgraded using a CaaS (Container as a Service) environment.

### 8. Define Resiliency.

In legacy applications, the MTBF (Mean Time between Failures) of hard-ware has been the base metric for resiliency. In the cloud, we instead rely on distribution and independence of software components that utilize auto-scaling and healing. This means that failures within an application should cause only temporary capacity loss and never escalate to a full restart and loss of service.

### 9. Define State-optimized design.

How we manage state depends on the type of state/data and the context of the state. Therefore, there is no “one size fits all” way of handling state and data, but there should be a balance between performance, resiliency, and flexibility.

### 10. What is Orchestration and automation?

A huge benefit of cloud-native applications is increased automation through, for example, a Kubernetes-based CaaS layer. A CaaS enables auto-scaling of microservices, auto-healing of



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failing containers, and software upgrades including canary testing (small-scale testing) before larger deployments.

## 11. Define container.

- From a simplistic perspective, system-level virtualization allows instances of an Operating System (OS) to run simultaneously on a single-server on top of something called a hypervisor.
- A hypervisor is a piece of computer software that creates and runs virtual machines. System-level virtualization allows multiple instances of OS on a single server on top of a hypervisor.

## 12. What is microservices?

Microservices are an architectural and organizational approach to software development where rather than be developed in a monolithic fashion, software is composed of small independent services that communicate over well-defined APIs.

## 13. What are the benefits of microservices?

- Microservice instances have a much smaller scope of functionality and therefore changes can be developed more quickly.
- An individual feature is expected to apply to a small set of microservices rather than to the entire packet and 5GC function.
- Microservice instances can be added/removed on demand to increase/decrease the scalability of their functions. Microservices can have independent software upgrade cycles.

## 14. What is the key principle of 3GPP 5G Core architecture?

One key principle with the design of the 3GPP 5G Core architecture was not providing backwards compatibility for the previous generations of radio access networks, i.e., GSM, WCDMA and LTE.

## 15. List the options of 3GPP 5G architecture.

- To specify LTE support for the new 5G architecture
- To specify support for combinations of LTE and NR access
- To specify an alternative 5G architecture based on an evolution of LTE/EPC

## 16. Mention the ways that LTE or NR can be deployed.

In summary, there are four ways that LTE and/or NR can be deployed:

- Only LTE for all signalling and data traffic
- Only NR for all signalling and data traffic
- A combination of LTE and NR where LTE has the larger coverage and is used for signalling while both LTE and NR are used for data traffic
- A combination of LTE and NR where NR has the larger coverage and is used for signalling while both LTE and NR are used for data traffic.



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### 17. What is AMF?

The AMF is the “Access and Mobility Management Function”. It interacts with the radio network and the devices through signalling over the N2 and N1 interfaces respectively.

### 18. What is SMF?

The SMF is the “Session Management Function”, meaning as the name suggests that the SMF manages the end user (or actually device) sessions.

### 19. What is UPF?

The “User Plane Function” (UPF) has as the main task to process and forward user data. The functionality of the UPF is controlled from the SMF.

It connects with external IP networks and acts as a stable IP anchor point for the devices towards external networks, hiding the mobility.

### 20. What is UDM?

The UDM is the “Unified Data Management Function”. It acts as a front-end for the user subscription data stored in the UDR (more on that further down) and executes several functions on request from the AMF.

### 21. What is UDR?

The UDR—the “Unified Data Repository”—is the database where various types of data is stored. Important data is of course the subscription data and data defining various types of network or user policies.

### 22. What is AUSF?

The functionality of the “Authentication Server Function” (AUSF) is quite limited but very important. It provides the service of authenticating a specific device, in that process utilizing the authentication credentials created by the UDM. In addition, the AUSF provides services for generating cryptographical material to allow for secure updates of roaming information and other parameters in the device.

### 23. What is Beamforming?

Beamforming: 5G NR supports a large number of multiple input multiple output (MIMO) antennas, which would allow it to work in a high interference environment through a technique called “beamforming”. It enables 5G radios to provide both coverage and capacity.

### 24. What are two types of NR-U implementations?

The types of NR-U implementations are

1. Licensed Assisted Access (LAA) NR-U
2. Standalone NR-U

### 25. What is MIMO?

MIMO stands for Multiple Input and Multiple Output, where several small antennas are grouped together at the transmitter and at the receiver.



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### 26. What is Coordinated Multipoint (CoMP)?

- Coordinated Multipoint (CoMP) is a technique used to improve radio performance, at cell edges by utilising the capability of more than one base station to enable the communication .
- Using CoMP, radio access nodes dynamically coordinate the transmission and reception of signals from the UE to multiple base stations.

### 27. List the advantages of Coordinated Multipoint (CoMP)

- ❖ Helps the service provider to improve the utilization of network resources. For example, data can be passed through a base station which is not loaded.
- ❖ User notices lesser call drops, as several cell sites come together to provide service to the user.
- ❖ User notices higher bandwidth, as multiple base stations serve the user, at a given time. The impact of the interference gets reduced and interference is used constructively.

### 28. What is Microcells?

Microcells are designed for providing wireless coverage to a large geographic area and suited for providing network coverage to outdoor applications such as smart communities. Microcells provide coverage for a distance between 500 meters and 2.5 kilometers. Microcells can support nearly 200 users at a time.

### 29. What are the benefits of 5G to cloud-hosted solutions?

- ✓ Faster Transfer of Data
- ✓ Uninterrupted Storage
- ✓ Reliability with Large Data
- ✓ Enhanced Productivity

### 30. What is RAN?

The radio access network (RAN) and aggregated backhauled support the capabilities of data transport, radio transmission and reception.

### 31. What is SCMA?

SCMA (Sparse Code Multiple Access) is introduced as a new multiple access scheme. In SCMA, different incoming data streams are directly mapped to code words of different multi-dimensional codebooks, where each code word represents a spread transmission layer.

### 32. What is NOMA?

In non-orthogonal multiple access (NOMA) with advanced receiver, multiple users can use the same time and frequency resource.

### 33. What are the key baseline functions for the EPC?

The key baseline functions for the EPC based system include support of multiple 3GPP RATs (i.e., GERAN, UTRAN, and E-UTRAN), support for non-3GPP accesses such as W-LAN, and support of fixed wireline access.

### 34. What are the functionality of the HSS (Home Subscription Server)?

- User security support
- Mobility management
- User identification handling



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- Access authorization
- Service authorization support
- Service provision support

### 35. What is policy control charging (PCC)?

Policy control is a very generic term and in a network there are many different policies that can be implemented, for example, policies related to security, mobility, use of access technologies, etc.

### 36. What is (Enhanced) Dedicated Core Networks ((e)DECOR)?

(e)DECOR was inspired by the desire and flexibility for the operators to deploy within an operator's network (designated by PLMN ID(s)) multiple core networks and directing users towards specific core networks and thus allowing partitioning off the full core networks.

### 37. What is virtualized evolved packet core? (Nov/Dec 23)

DECOR and CUPS are two key enablers for the base core network architecture that enhances EPC for 5G based on EN-DC due to the flexibility and versatility they provide for the operators for deployment of differentiated core networks towards specific targeted users.

## Part-B

1. Discuss the fundamentals of 5G technologies.
2. What is NVF? Explain its need and architecture (Nov/Dec 23)
3. Explain overview of 5G core network architecture.
4. Discuss the Service-based architecture (SBA)
5. Explain new Radio and Cloud Technologies (Nov/Dec 23)
6. Explain overview of Information on Cloud technologies
7. Explain overview of RAN Virtualization
8. Explain Radio Access Technologies (RATs).
9. Discuss EPC for 5G.
10. Briefly explain the Information on modulation or coding scheme
11. Discuss EPC for 5G
12. What are the key EPC functions? (Nov/Dec 23)

## Unit-3

### Part-A

#### Part – A Two marks

#### 1. What is network slicing?

A Network Slice is realizing a complete network for any type of access and is an enabler for providing services. The used physical or virtual infrastructure resources may be dedicated to the Network Slice or shared with other Network Slices.

#### 2. List the benefits of network slicing.

- ✓ Better customer experience by per customer adaptations and optimizations
- ✓ Shorter time-to-market and time-to-customer
- ✓ Simpler resource management



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- ✓ Increased automation
- ✓ Flexibility and agility
- ✓ Reduced risks by separation of concerns.

### 3. What are the different requirements to be addressed by a Network Slice?

- ✓ Traffic capacity requirements per geographical area
- ✓ Charging requirement
- ✓ Coverage area requirement
- ✓ Degree of isolation requirement
- ✓ End-to-end latency requirement
- ✓ Mobility requirement
- ✓ Overall user density requirement
- ✓ Priority requirement and etc.

### 4. What is Management and orchestration?

During the preparation and whole Lifecycle management process, the customer is able to provide its requirements using APIs from which the customer gets information of how the Network Slices perform, and is able to modify its requirements as to adapt to the needs of the customer. It provides a high-level view of the process in the preparation and the Lifecycle management of a network Slice Instance (NSI).

### 5. What is network slice preparation?

Network Slice “blueprints” or “templates” are used to simplify the process. If a Network Slice template exists that meets the customer requirements, then the preparation process can be shortened, as either the customer may be able to use an existing NSI.

### 6. What is network slice commissioning?

NSI provisioning in the commissioning phase includes creation of the NSI. During NSI creation all needed resources are allocated and configured to satisfy the Network Slice requirements.

### 7. What is network slice decommissioning?

NSI provisioning in the decommissioning phase includes decommissioning of non-shared resources if required and removing the NSI specific configuration from the shared resources. After the decommissioning phase, the NSI is terminated and does not exist anymore.

### 8. What is Multi-access Edge Computing (MEC)?

Multi-Access Edge Computing (MEC) is an integral part of the 5G ecosystem. MEC helps service providers to bring application oriented capabilities closer to the users and support several latency sensitive use cases from the edge.

### 9. What are the needs for MEC?

- ✓ Growth in the number of mobile devices connecting to the network (with IOT, it is expected to explode even further)
- ✓ Growth in the volume of data generated by the Over the Top (OTT) applications such as social media, video streaming and online gaming.



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- ✓ Need for distributing the infrastructure where the application services are hosted in a service provider network, to improve the application performance and the user experience etc.

### 10. What are the MEC architecture functions?

- ❖ MEC Orchestrator
- ❖ MEC Platform
- ❖ MEC Platform Manager
- ❖ Virtualization Infrastructure
- ❖ MEC Application Services

### 11. What is the use of Virtualization Infrastructure?

Virtualized infrastructure provides shared compute, storage and networking resources for hosting MEC related applications or Virtual Network Functions (VNFs).

### 12. What MEC Breakout mode?

The session connection is redirected to a MEC application which is either hosted locally on the MEC platform or on a remote server. Some examples of breakout applications are local Content Deliver Network (CDN) caches (for ex., Akamai caches), gaming services and media delivery services (for ex., Netflix streaming). Normally, you achieve this by defining forwarding policies

### 13. What is MEC In-line mode ?

MEC is deployed transparently, in an in-line mode. The session connection is maintained with the original server, while all the traffic traverses and goes through the application running in the MEC. Examples of in-line MEC applications are transparent content caching and security applications.

### 14. What is MEC Tap mode?

In Tap mode, data exchanged in a session is selectively duplicated and forwarded to the tap MEC application. Some examples of tap mode applications are virtual network probes, monitoring and security applications.

15. **What is MEC Independent mode** - MEC application and services run independently, but still the MEC application is registered in the MEC platform and will receive other MEC services, such as DNS and radio network information (for ex., radio bearer statistics). Steering the traffic to the MEC is achieved by configuring local DNS or MEC host's data plane.

### 16. What is meant by service continuity?

In any telecom technology one of the key feature requirement is data session and service continuity to ensure the uninterrupted service experience to the users irrespective of any change of UE IP address or change in Core network anchor point.

### 17. Give the types of SSC modes?

- SSC mode 1
- SSC mode 2
- SSC mode 3



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### 18. List the advantages of 5G SA network deployment.

To make better use of the competence of 5G, we just need to upgrade the existing EPC to complete the interconnection between EPC and 5GC with this solution.

### 19. List the advantages of 5G NSA network deployment.

There is no need to deploy 5GC in early period of 5G deployment. By implementing this network architecture, the control interface of S1 is only provided to LTE eNodeB, while the user plane interface of S1 can be provided to eNodeB and NR gNodeB at the same time.

### 20. List the advantages of 5G NR network deployment.

With the requirement of 5G NR providing continuous coverage, the control plane always set in 5G NR to fully achieve massive and strong function for users. The rapid rising of 5GC has become an irresistible tendency.

### 21. What edge computing?

Edge computing is about bringing the services closer to the location where they are to be delivered. Services here includes computing power and memory needed for e.g. running a requested application.

### 22. Mention the 5G protocols.

- 5G NAS
- NGAP
- GTP-U
- IPSec
- GRE

### 23. What is 5G mobility management?

5GMM procedures are used to keep track of the whereabouts of the UE, to authenticate the UE and control integrity protection and ciphering. The 5GMM procedures also allow the network to assign new temporary identities to the UE (5G-GUTI) and also request identity information (SUCI and PEI) from the UE.

### 24. What are the basic 5GMM procedures?

- Registration
- Deregistration
- Authentication
- Security mode control
- Service request
- Notification

### 25. What are the set of security services provided by IPsec?

- Access control
- Data origin authentication
- Connection-less integrity
- Detection and rejection of replays



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- Confidentiality
- Limited traffic flow confidentiality.

### 26. Give an overview of GRE Protocol aspects. (Nov/Dec 23)

The GRE is a protocol designed for performing tunnelling of a network layer protocol over another network layer protocol.

It is generic in the sense that it provides encapsulation of one arbitrary network layer protocol (e.g., IP or MPLS) over another arbitrary network layer protocol.

### 27. Write the main functions of the 5G non-access stratum (NAS)? (Nov/Dec 23)

Handling of UE registration and mobility, including generic functionality for access control such as connection management, authentication, NAS security handling, UE identification and UE configuration

## Part-B

1. Discuss about Network slicing/ What is network slicing? Explain its requirements, architecture, benefits and management. Discuss same with 100 users ( Nov/Dec 23)
  2. Explain Multi access edge computing (MEC) (Nov/Dec 23)
  3. Explain 5G end-to-end system architecture
  4. Discuss about 5G service continuity
  5. Explain the relation to EPC.
  6. How does core network evolve to 5GC from EPC ?
  7. Explain the Maturity of 5G NR deployment
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8. Explain edge computing
  9. Explain 5G protocols: 5G NAS
  10. Explain NG application protocol (NGAP)
  11. Explain GPRS tunnelling protocol for the User Plane (GTP-U)
  12. Explain IP security (IPSec) Protocol (Nov/Dec 23)
  13. Explain Generic routing encapsulation (GRE)

## Unit-4

## Part-A

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### Part – A Two marks

#### 1. What is mobility management?

The mobility is a core feature of 5GS. Mobility Management is required to ensure the following:

- That the network can “reach” the user, for example to notify the user about incoming messages and calls,



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- That a user can initiate communication toward other users or services such as Internet access, and that connectivity and ongoing sessions can be maintained as the user moves, within or between access technologies.
- 2. What are the mobility management functions?**
    - Service Area Restriction
    - Local Area Data Network (LADN)
      - Mobile Initiated Connection Only (MICO)
  - 3. What is Service Area Restriction?**

Mobility with session continuity is controlled at UE level at certain areas
  - 4. Local Area Data Network (LADN)?**

Mobility with session continuity is controlled at PDU Session level making communication available at certain areas
  - 5. Mobile Initiated Connection Only (MICO)?**

Paging capability (as part of the mobility service) is optional.
  - 6. What are the 5G Mobility Management (5GMM) related procedures?**
    - ✓ Common procedures
    - ✓ Specific procedures
    - ✓ Connection management procedures
  - 7. What is Registration and Mobility?**

Radio networks are built by cells that range in size from tens and hundreds of meters to tens of kilometers and the UE updates the network about its location on a regular basis.
  - 8. What is paging?**

Paging is sending message and it is used to search for Idle UEs and establish a signalling connection. Paging is, for example, triggered by downlink packets arriving to the UPF.
  - 9. What is Mobile Initiated Connection Only (MICO) mode?**

Mobile Initiated Connection Only (MICO) mode was introduced to allow paging resources to be saved for UEs that don't need to be available for Mobile Terminating communication. When the UE is in MICO mode, the AMF considers the UE as unreachable when the UE is in CM-IDLE state.
  - 10. What is RRC Inactive?**

It includes support for efficient communication with minimal signalling by using a concept called RRC Inactive which affects the UE, NG-RAN and 5GC. RRC Inactive is a state where a UE remains in CM-CONNECTED state (i.e. at NAS level) and can move within an area configured by NG-RAN (the RAN Notification Area – RNA) without notifying the network.
  - 11. How are the 5GC assistance information divided?**
    - ✓ Core Network assisted RAN parameters tuning.
    - ✓ Core Network assisted RAN paging information.
    - ✓ RRC Inactive Assistance Information.
  - 12. What is Service Area and Mobility Restrictions?**

Mobility Restrictions enables the network, mainly via subscriptions, to control the Mobility Management of the UE as well as how the UE accesses the network. Similar logic as used in EPS is applied in 5GS, but with some new functionality added as well.



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### 13. What is RAT restriction?

Defines the 3GPP Radio Access Technologies a UE is not allowed to access in a PLMN and may be provided by the 5GC to the NG-RAN as part of the Mobility Restrictions. The RAT restriction is enforced by the NG-RAN at connected mode mobility.

### 14. What is Forbidden Area?

A Forbidden Area is an area in which the UE is not permitted to initiate any communication with the network for the PLMN.

### 15. What is Core Network type restriction?

Defines whether UE is allowed to access to 5GC, EPC or both for the PLMN.

### 16. What is Service Area Restriction?

Defines areas controlling whether the UE is allowed to initiate communication for services.

### 17. What is Allowed Area?

In an Allowed Area, the UE is permitted to initiate communication with the network as allowed by the subscription.

### 18. What is Non-Allowed Area?

In a Non-Allowed Area a UE is “service area restricted” meaning that neither the UE nor the network is allowed to initiate signalling to obtain user services (both in CM-IDLE and in CM-CONNECTED states).

### 19. What is control overhead?

5GS supports the ability to control the amount of load UEs produce toward the 5GS through different mechanisms. Mechanisms for 5GC to balance load across NFs and also to scale the amount of resources consumed for the NFs are often enough to handle normal fluctuations of load impacting the 5GC.

### 20. What are the mechanisms used to control overload in 5G?

- ✓ Congestion in control channel resources
- ✓ Congestion in random access channel (RACH) resources
- ✓ Release/reject UE RRC connection

### 21. What is Congestion in control channel resources?

5QI-based scheduling controls cases when e.g. the number of users awaiting scheduling exceeds the number of users that can be admitted such that the random access procedure fails.

### 22. What is Congestion in random access channel (RACH) resources?

Random access back-off. This pushes some UEs into a longer back-off. This is when there are so many access attempts on the RACH that the UE provided preambles cannot be detected anymore.

### 23. What is Release/reject UE RRC connection?

If there are not enough resources to process RRC connection requests, Releasing RRC connection or rejecting RRC connection attempts can be used.



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### 24. What is Unified Access Control?

EPS supports multiple variants of access barring mechanisms as they were developed in different releases to address different needs for congestion control. The 5GS supports one mechanism called Unified Access Control (UAC) which is extensible, flexible (e.g. each operator can define their own category when to apply access control) and supports a variety of scenarios.

### 25. What are the Interworking with EPC using 3GPP access options?

- ✓ In single-registration mode
- ✓ In dual-registration mode

### 26. What is Command and Control Method?

The conventional method for allocating spectrum is known as “Command and Control Method. There are some countries following this technique of spectrum allocation. In this method radio spectrum is divided into different spectrum bands that are allowed to specific radio communication services such as satellite services, mobile, broadcast on an exclusive basis.

### 27. What is Spectrum Sharing?

It is sharing of available spectrum. The demand for multimedia content and information processing, services such as e-education and e-health, mobile broadcasting, enormous increase in the electronic gadgets necessitate efficient use of all available and usable frequency spectrum.

### 28. What is Spectrum Trading?

Spectrum trading is a case of spectrum sharing with the involvement of commercial activities. Spectrum trading is found to be a more economical way of efficient use of spectrum. It is an option through which flexibility can be increased and spectrum assigned to a particular service, and can be easily transferred for other usage.

### 29. List the merits of spectrum trading?

- Improves efficient spectrum usage
- Facilitates the evaluation of spectrum licenses, and gaining knowledge of market value of spectrum
- Quicker process, with better and faster decision-making by those with information
- Removes barriers to entry by allowing small operators and start-ups to acquire spectrum rights of use more readily, thereby facilitating the development of market competition
- There is an opportunity for more rapid redeployment and faster access for spectrum

### 30. Define Cognitive Radio.( Nov/Dec 23)

IEEE approved definition of cognitive radio (CR) is a radio in which communication systems are aware of their environment and internal state, and can make decisions about their radio operation based on that information and predefined objectives.

### 31. What are the self-organizing features of Cognitive radios?

- ✓ Spectrum resource management
- ✓ Security management



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- ✓ Mobility and connection management

### 32. What is Spectrum Handover?

The phenomenon of frequency changing dynamically is said to be spectrum handover. A secondary user changes its frequency on appearance of a primary user or due to transmission degradation. This necessitates designing a handover scheme.

### 33. Define Millimeter (MM) Wave (Nov/Dec 23)

Millimeter wave (MM wave), also known as millimeter band, is the band of spectrum with wavelengths between 10 millimeters (30 GHz) and 1 millimeter (300 GHz). It is also known as the extremely high frequency (EHF) band by the International Telecommunication Union (ITU).

### 34. List the Advantages of millimeter (MM) wave

Millimeter wave is a band of electromagnetic spectrum that can be used in a broad range of products and services, such as high-speed, point-to-point wireless local area networks (WLANs) and broadband access. In telecommunications, millimeter wave is used for a variety of services on mobile and wireless networks, as it enables higher data rates than at lower frequencies, such as those used for Wi-Fi and current cellular networks.

## Part-B

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1. Explain Mobility management. (Nov/Dec 23)
  2. Explain Interworking with EPC
  3. Explain Interworking with EPC using 3GPP access
  4. Explain interworking using the N26 interface
  5. Explain command and control.
  6. Explain spectrum sharing and trading/ Dynamic spectrum sharing and its advantages (Nov/Dec 23)
  7. Explain the Spectrum Using SDR and Cognitive Radio – Dynamic Sharing
  8. Explain Spectrum Trading
  9. Explain Cognitive radio based on 5G.
  10. Discuss about Millimeter Waves
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## **Unit-5**

### **Part- A**

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#### **1. List the Security features in 5G network or need for security in 5G network**

**(Nov/Dec 23)**

1. 5G uses licensed spectrum, which prevents hackers from eavesdropping into the network and getting access to sensitive data that gets exchanged over the network.
2. 5G Network slicing ensures that data exchanged by one customer or a service does not get shared with other customers or services riding on the network.
3. 5G supports “**Home Control**” features for preventing network spoofing attacks. Home Control feature authenticates the device location in roaming scenarios.

#### **2. What is Extensible Authentication Protocol (EAP)?**

5G provides native support for Extensible Authentication Protocol (EAP). It allows new authentication methods to be plugged into the network, by the service provider. It also homogenizes the authentication method for 3GPP and non-3GPP systems (for example, 5G and WiFi systems).

#### **3. What is Security Anchor Function (SEAF)?**

Security Anchor Function (SEAF) in 5G, allows for re-authentication of the device, when the device moves between different access networks without having to run the full authentication process. SEAF is now part of the Access and Mobility Management Function (AMF), in the 5G core.

#### **4. What is PLMN?**

In telecommunication, a public land mobile network (PLMN) is a combination of wireless communication services offered by a specific operator in a specific country. A PLMN typically consists of several cellular technologies like GSM/2G, UMTS/3G, LTE/4G, offered by a single operator within a given country, often referred to as a cellular network.

#### **5. What is SEPP?**

The Security Edge Protection Proxy (SEPP) enables secure interconnect between 5G networks. The SEPP ensures end-to-end confidentiality and/or integrity between source and destination network for all 5G interconnect roaming messages.

#### **6. What is SUCI?**

Subscription Concealed Identifier (SUCI) .This is a temporary identifier used to conceal the subscriber's permanent identity (SUPI) in a 5G network. It is used for authentication and authorization purposes and provides improved security and privacy features compared to the IMSI used in 4G networks.

#### **7. Define User domain security**

User domain security includes the set of security features that secure the user access to the mobile device. The most common security feature in this user domain context is the secure access to the USIM. Access to the USIM will be blocked until the USIM has authenticated the user. Authentication is in this case based on a shared secret (the PIN code) that is stored inside the USIM.



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### **8. What are the primary different primary authentication and key agreement protocols in the 5G network?**

In the 5G network, three different primary authentication and key agreement protocols are defined in the related 3rd generation partnership project (3GPP) specifications, including the 5G AKA (authentication and key agreement) protocol, the EAP-AKA' protocol, and the 5G EAP-TLS protocol.

### **9. What is Flow based QoS framework?**

The QFI is carried in an (GTP-U) encapsulation header on N3 (and N9) i.e. without any changes to the end-to-end packet header. Data packets marked with the same QFI receives the same traffic forwarding treatment (e.g. scheduling, admission threshold). The QoS Flows can be GBR QoS Flows i.e. that require guaranteed flow bit rate, or QoS Flows that do not require guaranteed flow bit rate (Non-GBR QoS Flows).

### **10. Define Service Data Adaptation Protocol (SDAP).**

Service Data Adaptation Protocol (SDAP).specified in 3GPP TS 37.324, is used to enable multiplexing if more than one QoS Flow is sent on a DRB, i.e. if the NG-RAN decides to setup a DRB per QFI then the SDAP layer is not needed.

### **11. How to Protect the MEC infrastructure?**

The risk can be minimized by deploying endpoint protection software in the MEC host. MEC applications and services can be protected and secured by configuring and enforcing application or service specific policies. For example, configuring role-based access control for administrators managing the MEC applications and services. In addition, implement monitoring to provide enhanced visibility of the MEC applications, MEC services and the MEC infrastructure components.

### **12. How to Protect the Virtualized Infrastructure?**

5G brings-in additional complexity to the operations teams, in deploying, managing and securing the network infrastructure - as several 5G components are deployed in a virtualized infrastructure. In order to protect, the Virtualized Network Functions (VNFs), service providers have to turn-on DNS level security features to block bad domains and bad talkers from accessing the network.

### **13. How to Protect the CPE and Small Cell devices?**

In 5G, several equipment such as the Customer Premise Equipment (CPE) and Small Cells are deployed closer to the user or at the user premise. In such cases, encryption of sensitive data stored in non-secure physical locations is a must. All the CPE or Small Cell devices connecting to the service provider's 5G network should validate firmware and software packages cryptographically at the time of booting.

### **14. Distinguish between Network Access Security and Network Domain Security. (Nov/Dec 23)**

User domain security includes the set of security features that secure the user access to the mobile device. The most common security feature in this user domain context is the secure access to the USIM. Similarly Network domain security includes the set of features for its access.



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## Part-B

1. Discuss about Security features in 5G networks.  
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2. Explain network domain security.
3. Explain in detail Security aspects of Service Based interfaces
4. Explain user domain security  
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5. Discuss about flow based QoS framework. (Nov/Dec 23)
6. Discuss about mitigating the threats in 5G. (Nov/Dec 23)
7. Discuss about 5G AKA based primary authentication  
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8. Explain in detail Network Domain Security for IP based communication
9. Discuss about Service Based interfaces between PLMNs in roaming  
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