# Module - 5

Total - 25m

* 1) Explain mobile IP optimisation (5m/10m)

2) Write short note on IP-V6 (5m)

* 3) Explain different approches used in macro mobility (MIPv6, FMIPv6) (2m/5m/10m)

* 4) Explain different approaches used in micro mobility (Cellular IP, HAWAII, HMIPv6) (2m/10m)

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Date

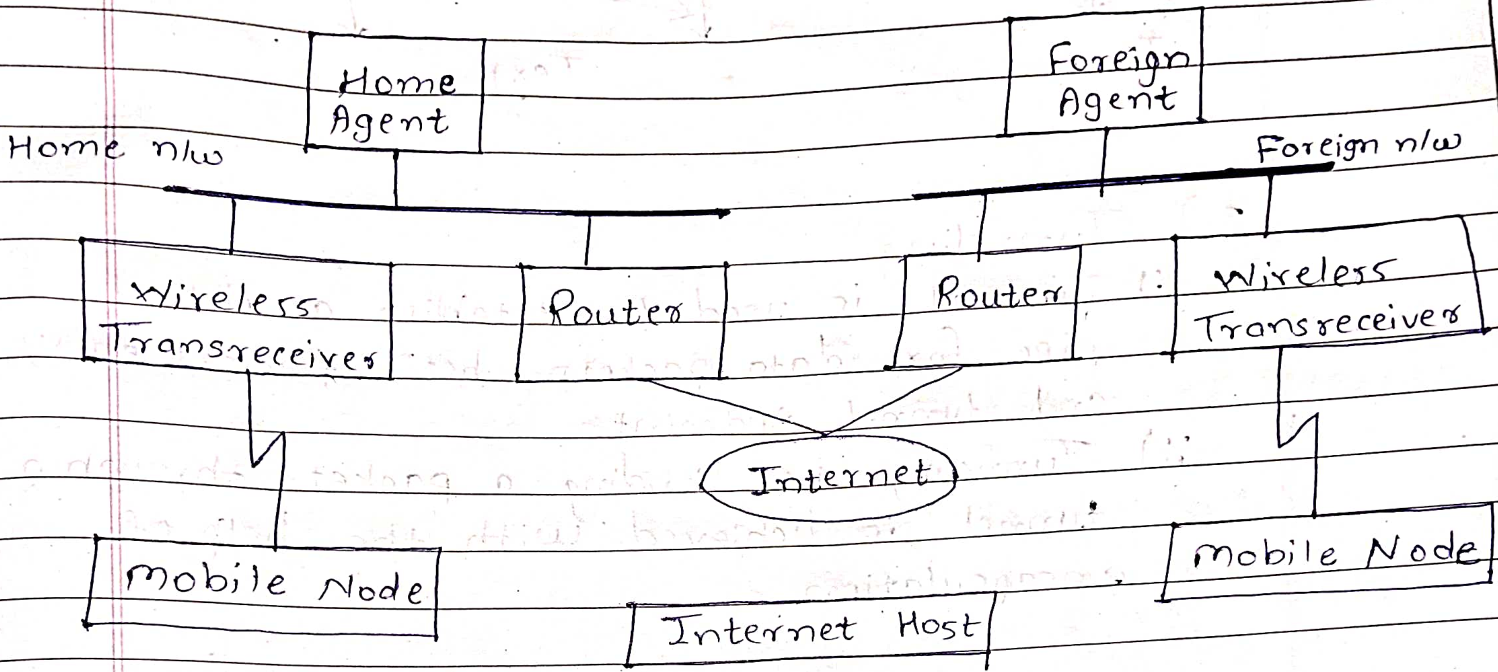
Module - 6

Total - 10m

Q] Explain * i) LTE 5m
* ii) VOLTE 2m/5m
* iii) SAE architecture 5m/10m
iv) 2G, 3G, 4G, 5G 5m/10m

3) What is mobile IP and explain its process

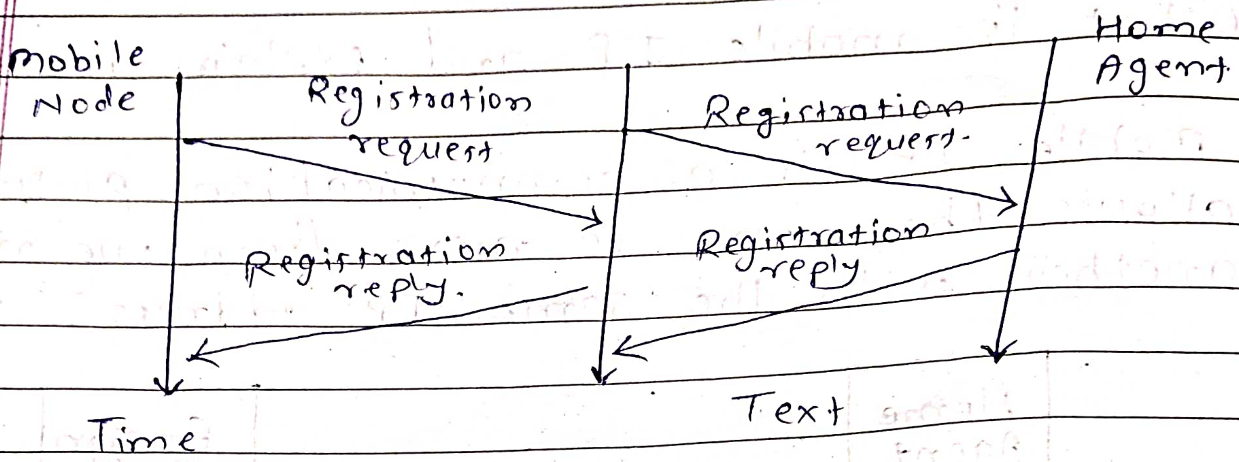
→ Mobile IP is a communication protocol that allows the users to move from one n/w to another with the same IP address.




Process of Mobile IP :-

1) Agent Discovery -
During the agent discovery phase the HA and FA advertise their service on the network.
Two methods -
i) Agent advertisement
ii) Agent Solicitation

2) Registration -
Main purpose of registration is to inform the home agent of current location for correct forwarding of packets.




3) Tunneling

i) Tunnel is used to establish a virtual pipe for data packets betn tunnel entry and tunnel endpoint.

ii) Tunneling i.e Sending a packet through a tunnel is achieved with the help of encapsulation.

# * IPV6 –

→ Mobile IPV6 is intended to enable IPV6 nodes to move from one IP subnet to another.

→ While a mobile node is away from home:

i> It sends information about its current location to a home agent.

ii> The home agent intercepts packets addressed to the mobile node & tunnels them to the mobile nodes present location.

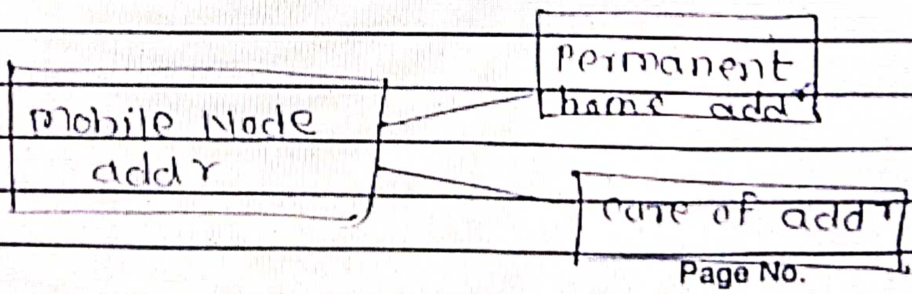
## Features of IPV6 –

1) Address auto configuration –
- stateless auto configuration.
- stateful auto configuration.

2) Neighbor discovery –
- Discovery each others presence & find routers
- determine each other link layer addr.
- maintain reachability information.

3) Extension headers –
- Routing header.
- destn option header.

## Operational Principle –

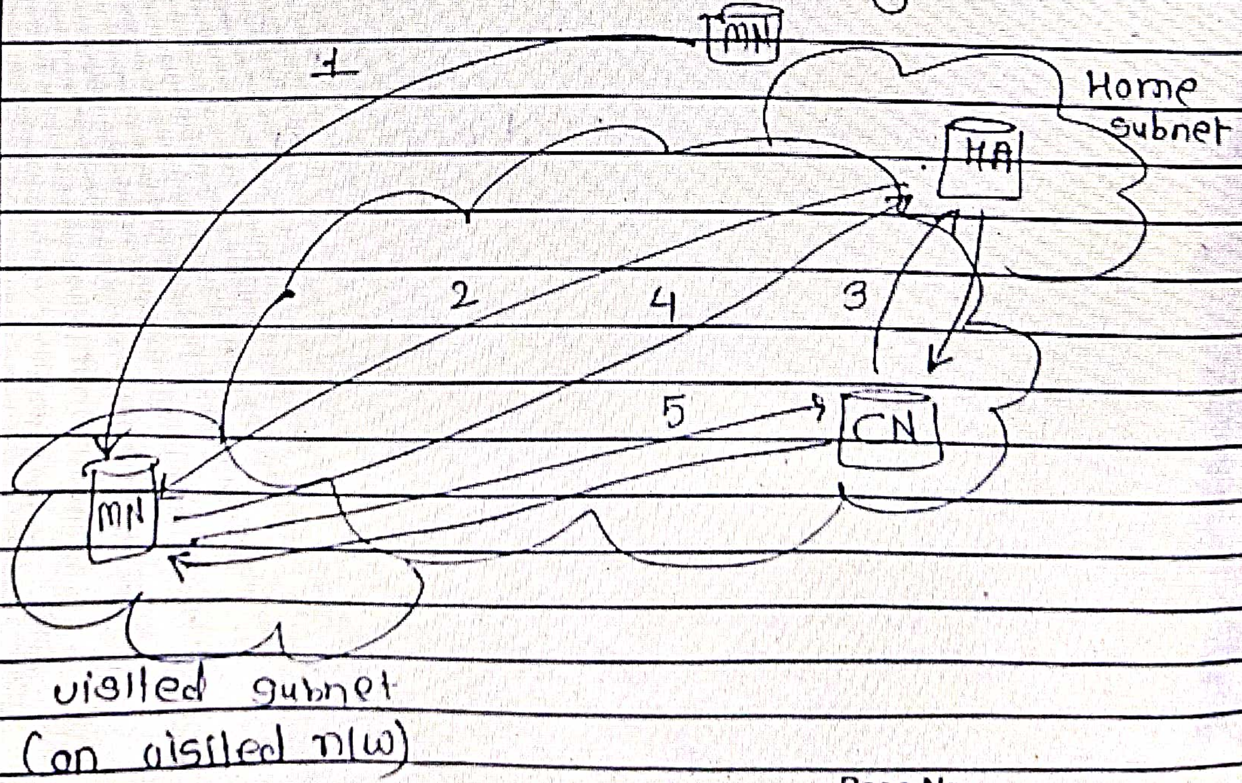


→ The goal of IP mobility is to maintain the TCP connⁿ betⁿ a mobile host & a static host while reducing the effects of location changes while the mobile host is moving around, without having to change the underlying TCP/IP.

* Two kinds of entities comprise a mobile IP implementation.

→ A Home agent (HA) stores information about mobile nodes whose permanent home addr is in the home agent's n/w.

→ A foreign agent (FA) stores information about mobile nodes visiting its n/w. Foreign agent also advertise care-of-addresses, which are used by mobile IP.



Advantages & disadvantages of IPV6.

* Advantages –

i) Support for security using (IPsec) internet protocol security.

ii) more powerful internet.

iii) Address allocation is done by the device itself.

* Disadvantages –

i) It will be much harder to remember IP addr.

ii) IPV6 is not available to m/c that run IPV4

iii) Time to convert over to IPV6.

Appln of IPV6 –

1) FTP Client

2) Telnet client

3) Internet explore.

* Macro mobility – i.e. mobile nodes movement betn different domains, to which inter domain mobility management schemes can be employed; acting as a global mobility soln with the advantages of flexibility, robustness, & scalability.

i) MIPV6 (Mobile IPV6) –

→ Mobile IP support of both MIPV6 but IPV4 has a couple of drawbacks. The main drawback of IPV4 is addr exhaustion, making MIPV6 the future option for mobility protocol in IP n/w.

→ Mobile IPV6 is a protocol developed as a subset of IPV6 to support mobility.

→ MIPV6 is an update of the mobile IP standard designed to authenticate mobile devices using IPV6 addr.

→ In traditional IP routing, IP addr represent a topology. Routing mechanisms rely on the assumption that each n/w node will always have the same point of attachment to the Internet & that each nodes IP addr identifies the n/w link where it is connected.

→ In this routing scheme, if you disconnect a mobile device from the internet & want to reconnect through a diff n/w, you have to configure the device with new IP addr & the appropriate netmask & default router.

→ Mobile IPV6 allows a mobile node to transparently maintain connection while moving from one subnet to another.

FMIPV6 (Fast Hand over for Mobile IPV6) :-

→ Mobile IPV6 (MIPV6) enables a mobile node (MN) to maintain its connectivity to the internet when moving from one access point to another. This process is referred to as 'handover'.

→ During handover, there is a period during which the mobile node is unable to send or receive packets. This period is called 'Hand over latency'.

→ Hand over latency results from the standards' handover procedure such as movement detection new care of addr configuration, binding updates.

→ This Hand over latency is often unacceptable to real-time traffic such as Voice over IP (VoIP)

→ The fast handover for mobile IPV6 (FMIPV6) aims at reducing the long handover latency in mobile IPV6 by fast movement detection & fast binding update.

→ It uses anticipation based on layer 2 trigger information of the mobile node (MN) to obtain a new care-of-addr at the new link while still connected to the previous link, thus reducing handover delay.

→ Furthermore, it also reduces packet loss by buffering before the real link layer handover take place.

* Micro mobility -

→ Mobile IP exhibits several problems regarding the duration of handover & the scalability of the regi procedure.

→ Assuming a large no. of mobile devices changing n/w quite frequently, a high load on the home agents as well as on the n/w is generated by regi & binding update message.

→ IP micro-mobility protocol can complement mobile IP by offering fast & almost seamless handover control in limited geographical areas.

→ The following section presents three of the most commonly used approaches :-

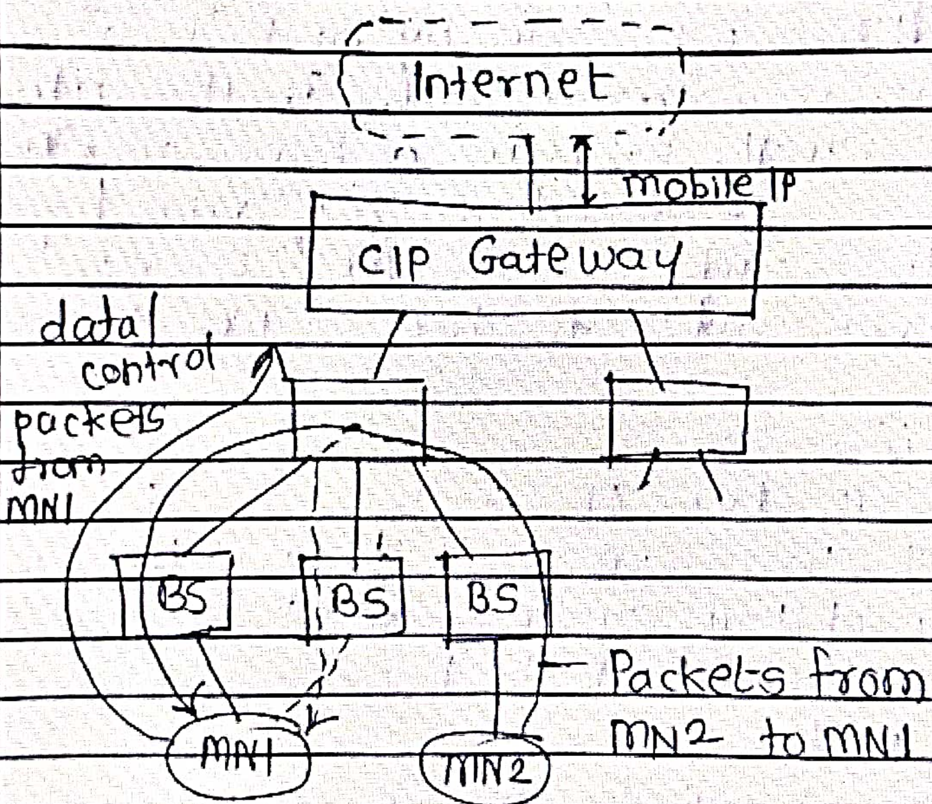
1) cellular IP
2) Hawaii
3) Hierarchical mobile IPv6 (HMIPv6)

1) Cellular IP -

→ cellular IP provides local handovers without renewed regi by instaling a single cellular IP gateway (CIPGW) for each domain, which acts to the outside world as a foreign agent.

→ Inside the cellular IP domain, all nodes collect routing information for accessing MNs based on the origin of packets sent by the MNs towards the CIPGW.

→ Soft handover are achieved by allowing simultaneous forwarding of packets destined for a mobile node along multiple paths.
→ A mobile node moving betn adjacent cell will temporarily be able to receive packets via both old & new base station (BS) if this is supported by the lower protocol layers:




Advantage –

1) Manageability – cellular IP is mostly self-configuring & integration of the CIPGW into a firewall would facilitate administration of mobility-related functionality. This is however not explicitly specified.

2) cheap passive connectivity.

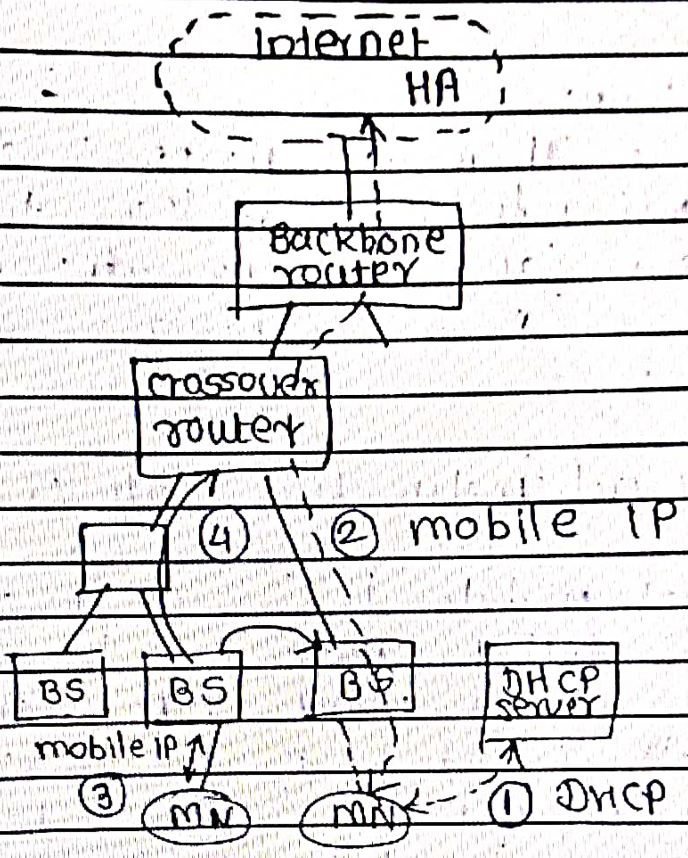
3) Flexible Handoff
4) simple memory less mobile host.

Disadvantages -
1) efficiency - Additional n/w load is induced by forwarding packets on multiple path.
2) Transparency - changes to MNs are required.
3) security - Routing tables are changed based on msg sent by mobile nodes. additionally, all system in the n/w can easily obtain a copy of all packets destined for an MN by sending packets with the MNs source addr to the CIPGW.

(2) Hawaii -
→ Hawaii (Handoff-Aware Wireless Access Internet Infrastructure) tries to keep micro-mobility support as transparent as possible for both home agent & mobile nodes.
→ It's concrete goals are performance & reliability improvements & support for quality of service mechanisms.

→ On entering an HAWAII domain, a mobile node obtain a co-located COA (step 1)
→ Registers with the HA (step 2)
→ Additionally, when moving to another cell inside the foreign domain, the MN

sends a registration request to the new base station as to a foreign agent (step 3)




→ Thus mixing the concept of co-located COA & foreign agent COA.
The base station intercepts the registration request & sends out a handoff update message, which reconfigures all routers on the path from the old & new base station to the so-called cross over router (step 4).

Advantages –

1) security – challenge - response extension are mandatory. In contrast to cellular IP routing changes are always initiated by

the foreign domain's infrastructure.

2) Transparency – HAWAII is mostly transparent to mobile nodes.

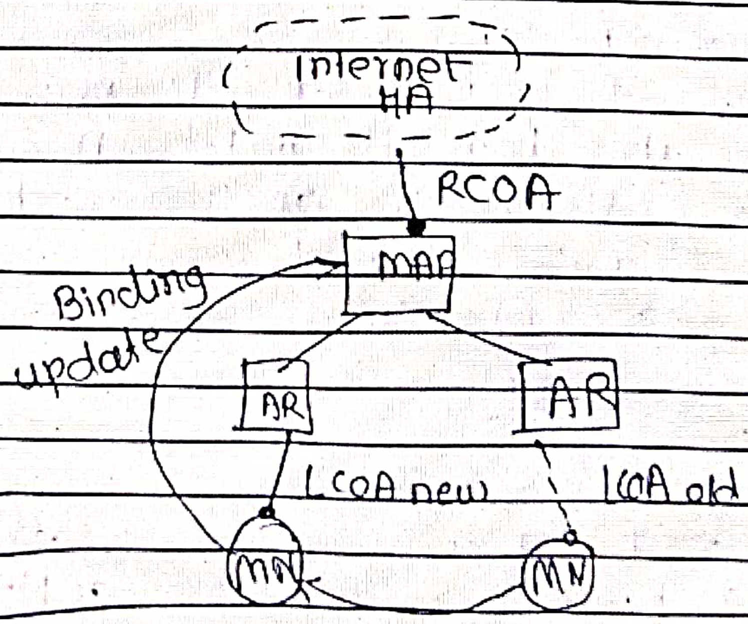
Disadvantages –

1) Security – There are no provisions regarding the setup of IPsec tunnels.

2) Implementation :- No private addr support is possible becoz of co-located COAs.

Hierarchical mobile IPV6 (HMIPV6)

→ Hierarchical mobile IPV6 (HMIPV6) provides micro-mobility support by installing a mobility anchor point (MAP). MAP is an entity which is responsible for a certain domain & act as a local HA within for this domain for visiting MNs.



→ The MAP receives all packets on ~~de~~ behalf of the MN, encapsulates & forwards them directly to the MN's current addr LCoA (link CoA).

Advantages -

i) security - MNs can have location privacy bcoz LCoAs can be hidden.

2) Efficiency - direct routing betn CNs sharing the same link is possible.

disadvantages -

1) Transparency - additional infrastructure component (MAP)

2) security - Routing table are changed based on msg sent by mobile nodes. This requires strong authentication & protection against denial of service attacks.

## 6.1 Long Term Evolution : Overview

### 6.1.1 LTE System Overview

- 3GPP stands for Third Generation Partnership Project.
- Under 3GPP, widely used 3G standards UMTS WCDMA/HSPA were developed.
- LTE (Long Term Evolution) is the 4G successor to the 3G UMTS system.
- LTE Provides much higher data speeds, low latency and greatly improved performance as well as lower operating costs.
- LTE came into market around in 2010. Initial deployments gave little improvement over 3G HSPA and were sometimes treated as 3.5G or 3.99G.
- Later the full capability of LTE was realized. It provided a full 4G level of performance.
- The first deployments were simply known as LTE, but later deployments were designated 4G LTE Advanced.

## 6.3 Voice over LTE (VoLTE)

**Q. Explain in short voice over LTE.**

- VoLTE stands for **V**oice **O**ver **L**ong **T**erm **E**volution.
- It is a digital packet voice service that is delivered over IP via an LTE access network.

- When 3GPP started designing the LTE system, prime focus was to create a system which can achieve **high data throughput with low latency.**
- LTE is an all IP network and the ability to carry voice was not given much importance. Therefore, for LTE networks to carry traditional circuit switched voice calls, a different solution was required.
- This solution to carry voice over IP in LTE networks is commonly known as "VoLTE". Basically VoLTE systems covert voice into data stream, which is then transmitted using the data connection.
- VoLTE is based on the IMS(IP multimedia system).
- IMS is an architectural framework for delivering multimedia communications services such as voice, video and text messaging over IP networks.

### Voice over LTE - VoLTE basics

- VoLTE, Voice over LTE is an IMS (IP multimedia System) based technique.
- VoLTE enables the system to be integrated with the suite of other applications for LTE.
- To make implementation of VoLTE easy and cost effective to operators, cut down version of IMS network was defined. This not only reduced the number of entities required in the IMS network, but it also simplified the interconnectivity.
- This considerably reduced the costs for network operators as this had been a major issue for acceptance of IMS. The reduced IMS network for LTE has been shown in Fig. 6.3.1.

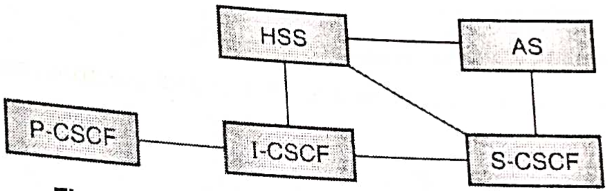



**Fig. 6.3.1 : Reduced IMS network for VoLTE**

The entities within the reduced IMS network used for VoLTE are explained below :

(i) **IP-CAN IP, Connectivity Access Network :** This consists of the EUTRAN and the MME.

(ii) **P-CSCF, Proxy Call State Control Function :** The P-CSCF is the user to network proxy. All SIP signaling to and from the user runs via the P-CSCF whether in the home or a visited network.

(iii) **I-CSCF, Interrogating Call State Control Function :** The I-CSCF is used for forwarding an initial SIP request to the S-CSCF. When the initiator does not know which S-CSCF should receive the request.

(iv) **S-CSCF, Serving Call State Control Function :** The S-CSCF performs a variety of actions within the overall system, and it has a number of interfaces to enable it to communicate with other entities within the overall system.

(v) **AS, Application Server :** It is the application server that handles the voice as an application.

(vi) **HSS, Home Subscriber Server :** The IMS HSS or home subscriber server is the main subscriber database used within IMS. The IMS HSS provides details of the subscribers to the other entities within the IMS network, enabling users to be granted access or not dependent upon their status.

The IMS calls for VoLTE are processed by the subscriber's S-CSCF in the home network. The connection to the S-CSCF is via the P-CSCF.

### Benefits of VoLTE

The implementation of VoLTE offers many benefits, both in terms of cost and operation.

VoLTE provides following benefits :

- Provides a more efficient use of spectrum than traditional voice;
- Meets the rising demand for richer, more reliable services;

- Eliminates the need to have voice on one network and data on another;
- Can be deployed in parallel with video calls over LTE and multimedia services, including video share, multimedia messaging, chat and file transfer;
- Ensures that video services are fully interoperable across the operator community, just as voice services are,
- Increases handset battery life by 40 % (compared with VoIP);
- Provides rapid call establishment time.

### 6.2.2 SAE Architecture

**MU - Dec. 19**

**Q. Explain different components used in LTE architecture with diagram.** **(Dec. 19, 10 Marks)**

- System Architecture Evolution (SAE) is a new network architecture designed to simplify LTE networks. It establish a flat architecture similar to other IP based communications networks.
- SAE uses an eNB and Access Gateway (aGW) and removes the RNC and SGSN from the equivalent 3G network architecture. This allows the network to be built with an "All-IP" based network architecture.
- SAE also includes entities to allow full inter-working with other related wireless technology (WCDMA, WiMAX, WLAN, etc.). These entities can specifically manage and permit the non-3GPP technologies to interface directly with the network.
- The high-level network architecture of LTE is comprised of following three main components :
  (i) The User Equipment (UE)
  (ii) The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN)
  (iii) The Evolved Packet Core (EPC)

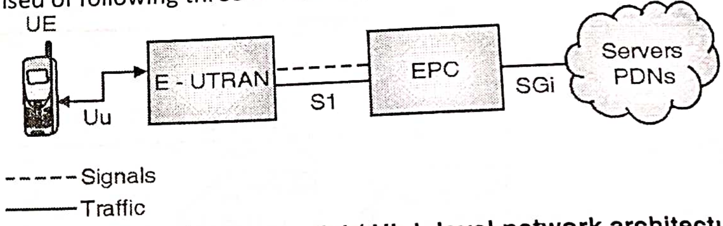



**Fig. 6.2.1 : LTE reference model ( High level network architecture)**

- The evolved packet core (EPC) provides the means to communicate with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem.
- Between EU and E-UTRAN there is **Uu** interface,
- EPC is connected to E-UTRAN via **S1** interface and to the outside world via **SGi** interface.

### 6.2.2(A) Evolved Packet System (EPS)

- EPS refers to the architecture of the LTE mobile standard.
- It includes the Evolved Packet Core (EPC), the Radio Networks (E-UTRAN), the End User Equipment (UE) and the Services.
- EPS is based entirely on packet switching unlike legacy UMTS and GSM technologies that still use circuit switching .

### 6.2.2(B) The User Equipment (UE)

- UE is nothing but the mobile equipment.
- The internal architecture of the UE for LTE is identical to the one used by UMTS and GSM.
- The mobile equipment comprised of the following important modules :
  - o **Mobile Termination (MT) :** This handles all the communication functions.
  - o **Terminal Equipment (TE) :** This terminates the data streams.
  - o **Universal Integrated Circuit Card (UICC) :** This is also known as the SIM card for LTE equipment. It runs an application known as the Universal Subscriber Identity Module (USIM).
- A **USIM** stores user-specific data very similar to 3G SIM card. This keeps information about the user's phone number, home network identity and security keys etc.

### 6.2.2(C) The E-UTRAN

**Q. Explain various nodes present in E-UTRAN architecture.** **MU - Dec.19** **(Dec. 19, 10 Marks)**

The architecture of evolved UMTS Terrestrial Radio Access Network (E-UTRAN) has been illustrated in Fig. 6.2.2.

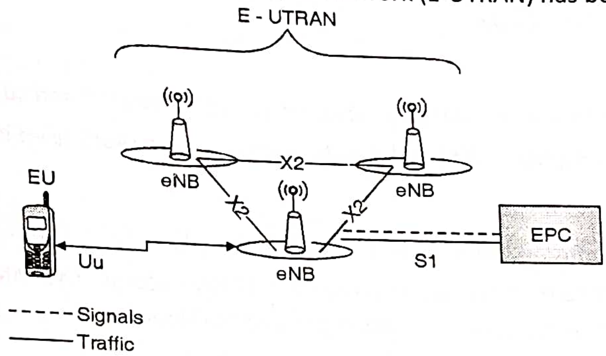



**Fig. 6.2.2 : Architecture of E-UTRAN**

- The E-UTRAN handles the radio communications between the mobile equipment (ME) and the evolved packet core (EPC). It contains only one component, the evolved base stations, called **eNodeB** or **eNB**.
- Each eNB is a base station that controls the mobiles in one or more cells.
- The base station that is currently communicating with a mobile is known as its serving eNB.
- Each eBN connects with the EPC by means of the S1 interface.
- Two nearby base stations can be connected via the X2 interface, which is mainly used for signaling and packet forwarding during handover.

### 6.2.2 (D) Evolved Packet Core (EPC) (The core network)

The architecture of Evolved Packet Core (EPC) is fully IP based has been illustrated in Fig. 6.2.3.

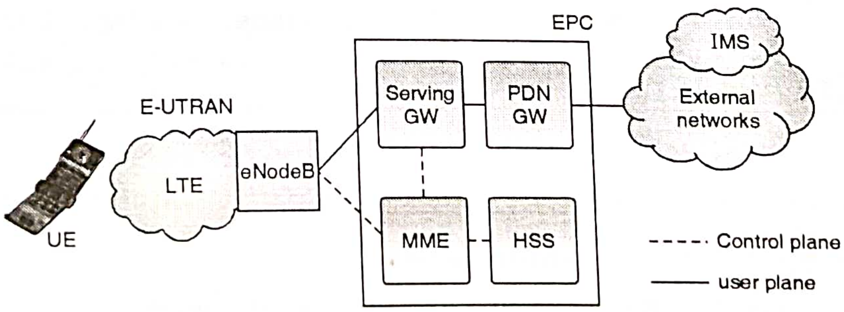



**Fig. 6.2.3 : Basic EPS architecture**

**Evolved Packet Core (EPC) components**

It contains following important components :

1. **Serving GW**

- The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.
- It is also responsible for inter-eNB handovers in the U-plane.
- It provides mobility between LTE and other types of networks (such as between 2G/3G and P-GW).
- The SGW keeps context information such as parameters of the IP bearer and routing information, and stores the UE contexts when paging happens.
- It is also responsible for replicating user traffic for lawful interception.

2. **PDN GW**

The PDN GW is the point of interconnect between the EPC and the external IP networks. PDN GW routes packets to and from the PDNs. The functions of the PGW include :

(i) Policy enforcement (ii) Packet filtering (iii) Charging support

(iv) Lawful interception (v) Packet screening

3. **HSS**

- The HSS (for Home Subscriber Server) is a database that contains user-related and subscriber-related information.
- It is similar to - Home Location Register (HLR) and Authentication Centre (AuC) used in 3G networks.

4. **MME**

- The MME (for Mobility Management Entity) deals with the control plane.
- It handles the signaling related to mobility and security for E-UTRAN access. The MME is responsible for the tracking and the paging of UE in idle-mode. It is the termination point of the Non-Access Stratum (NAS).
- Fig. 6.2.4 shows the entire SAE architecture.

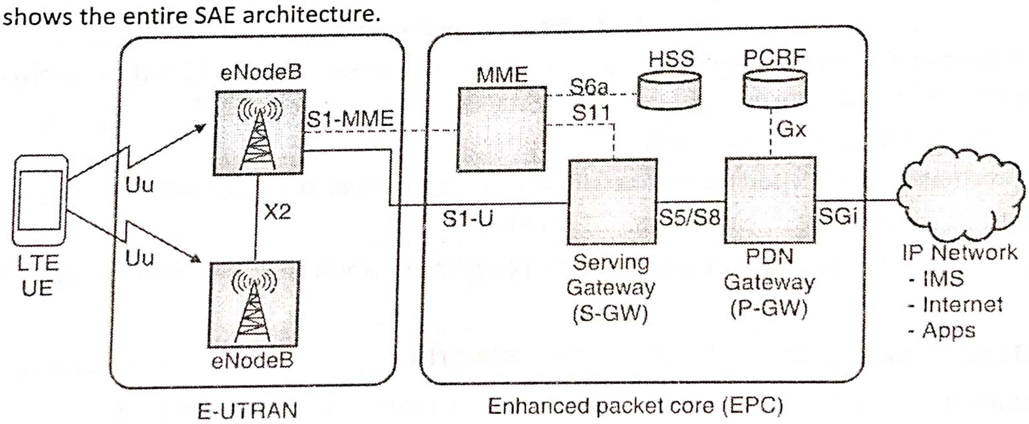



**Fig. 6.2.4 : LTE/SAE Architecture**

Difference between 1G, 2G, 2.5G, 3G, 4G

| | Basic Terms | 1G | 2G | 2.5G | 3G | 4G |
|---|---|---|---|---|---|---|
| 1) | Full form | 1st generation | Second genⁿ | Second & Half genⁿ | Third genⁿ | Fourth genⁿ |
| 2) | Year | 1980s | 1990s (1991) | 2001 - 2003 | 2005 | released in 2008 working fully upto 2009 |
| 3) | Support | voice only | sms, picture msg & mms | WAP, MMS, SMS, mobile games & search & directory | digital GPS, video on demand video conferencing | voice, video call mail VOIP internet, Video Streaming |
| 4) | Speed | 2.4 kbps | 40 - 50 kbps 500 kbps - 1 mbps | 20 - 40 kbps 236.8 kbps - 384 | 2 mbps for non moving devices & 384 kbps in moving vehicles | 50 mbps - 100 mbps |
| 5) | Dropped calls | Yes | Yes | Yes | Improvements | much better |
| 6) | Voice | Yes | Yes | Yes | Yes | Yes |

| | Basic Term | 1G | 2G | 2.5G | 3G | 4G |
|---|---|---|---|---|---|---|
| 7) | Video | No | No | No | Yes | Yes |
| 8) | Signals | Analog | Digital | Digital | Digital | Digital |
| 9) | Technologies | AMPS, NMT TACS | GSM | TDMA, CDMA | W-CDMA UMTS | LTE, LTE advanced |
| 10) | Multiple address access system | FDMA | TDMA, CDMA | TDMA CDMA | CDMA | CDMA |
| 11) | Switching type | Circuit switching | circuit switching for voice & packet switching for data | Circuit switching for voice & packet switching for data | Packet switching except for air interface | packet switching |
| 12) | Internet service | No internet | Narrow-band | Narrow-band | Broadband | Ultra broadband |
| 13) | bandwidth | Analog | 25 MHZ | 25 MHZ | 25 MHZ | 100 MHZ |
| 14) | Special chkt | 1st wireless commⁿ | digital version of 1G Technology | Upgrade version of 2G Technology | digital broadband | Very high speeds. All IP |

difference betn 4G & 5G

| specification | 4G | 5G |
|---|---|---|
| 1) Peak data rate | 1 Gbps | 10 Gbps |
| 2) Data band-width | 2 Mbps to 1 Gbps | 1 Gbps & higher as per need |
| 3) Spectral efficiency | 30 b/s/Hz | 120 b/s/Hz |
| 4) TTI (Transmission time interval) | 1 ms | Varying (100 µs (min) to 4 ms (max)) |
| 5) Latency | 10 ms (radio) | < 1 ms (radio) |
| 6) Mobility | 350 kmph | 500 kmph |
| 7) Connn density | 1000/km2 | 1000000/km2 |
| 8) frequency band | 2 to 8 GHz | 3 to 300 GHz |
| 9) Standards | AI access convergence including OFDMA, MC-CDMA, n/w - LMPS | CDMA & BDMA (beam division multiple access) |