Module 6

Q. Compare all Mobile Generations i.e. 1G, 2G, 3G, 4G, and 5G in a table
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Feature	1G	2G	3G	4G	5G
Time Period	1980s	1990s	2000s	2010s	2020s onward
Technology	Analog	Digital (GSM, CDMA)	WCDMA, UMTS, HSPA	LTE, LTE-Advanced	NR (New Radio), mmWave, Massive MIMO
Data Speed	~2.4 Kbps	Up to 64 Kbps	384 Kbps to few Mbps	100 Mbps to 1 Gbps+	1–10 Gbps
Bandwidth	30 KHz	200 KHz	1.25 MHz to 20 MHz	20 MHz to 100 MHz	Up to 1 GHz
Services	Voice only	Voice + SMS	Voice + SMS + Data	HD Video, VoIP, Mobile Web	UHD Streaming, VR, IoT, AI integration
Latency	High (300+ ms)	~300 ms	~100–150 ms	~30–50 ms	1–10 ms
Security	Poor	Basic encryption (GSM)	Improved (128-bit encryption)	Strong (AES, IPsec)	Advanced (5G-AKA, unified authentication)
Switching Type	Circuit Switching	Circuit + Packet Switching	Packet Switching (mostly)	Fully Packet Switched (All IP)	Fully Packet Switched with slicing
Main Limitation	Poor voice quality, no data	Low data speed, limited services	Limited bandwidth for heavy data	Network congestion, not IoT-optimized	High cost, infrastructure dependency
Examples	AMPS	GSM, CDMA	UMTS, HSPA	LTE, WiMAX	5G NR (SA/NSA modes)

Q. What is a Self Organizing Network (SON)?

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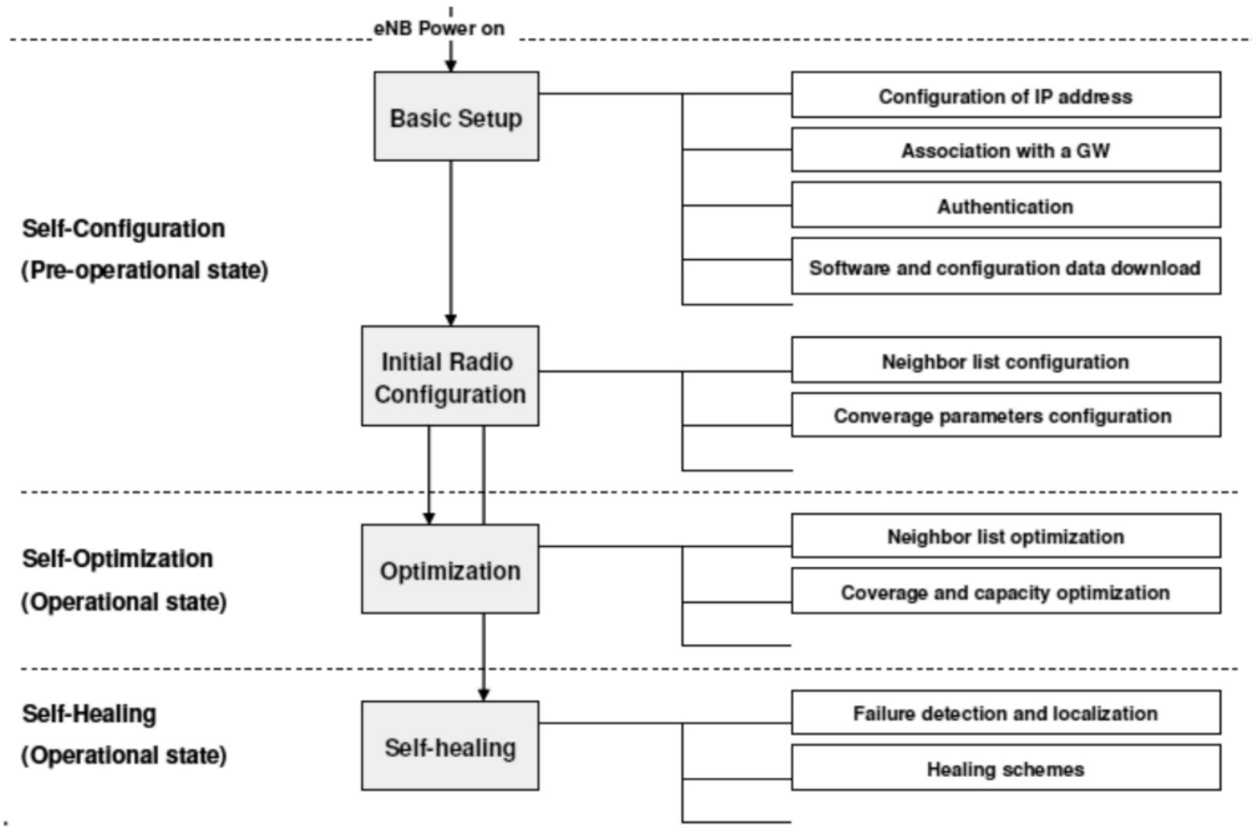
A **Self Organizing Network (SON)** is a concept in modern mobile communication (mainly LTE and 5G) where the network can manage and optimize itself **without human involvement**.

It means if you install a new base station (eNodeB), it will **automatically configure itself**, connect with the rest of the network, and start operating without needing manual setup or tuning.

SON works just like "Plug and Play" in computers—when you plug in a new device (like a keyboard or printer), it starts working automatically.



Why SON is Needed

Traditionally, setting up a mobile network involves multiple steps:

1. **Network planning**
2. **Hardware installation**
3. **Basic configuration**
4. **Parameter optimization**
5. **Ongoing monitoring and tuning**

SON tries to **automate step 4 and 5**, and partially automate step 3. This saves time, reduces errors, and makes the network more efficient

Architecture of SON

The SON architecture includes three major functional blocks:

1. Self-Configuration

- New elements like base stations (eNodeBs) configure themselves automatically when powered on.
- This includes setting frequencies, power levels, and connecting to the core network.

2. Self-Optimization

- The network monitors itself and adjusts parameters such as:
  - Handover settings
  - Transmission power
  - Load balancing between cells
  - Interference control
- It ensures better performance and resource use.

3. Self-Healing

- SON can detect failures in the network like a cell outage or performance drop.
- It automatically takes actions to fix or compensate for these issues, like rerouting traffic to nearby cells.

Goals of SON

1. **Provide Optimal Coverage**

Ensure users can connect to the network from anywhere with stable and good-quality service.

2. **Provide Optimal Capacity**

Support as many users as possible while maintaining good performance, even during peak usage.

Advantages of SON

1. **Better Network Performance**

Improves speed, reliability, and coverage by automatically adjusting to traffic and user behavior.

2. **Lower Operating Costs**

Reduces manual work like site visits and parameter tuning.

3. **Faster and Easier Deployment**

Helps in quick installation of new sites, small cells, and upgrades.

Disadvantages of SON

1. **Complexity and Compatibility Issues**

Different vendors and technologies may not work smoothly together, making SON harder to implement.

2. **Security and Privacy Concerns**

SON collects a lot of user and network data, which needs to be protected properly.

3. **Less Human Control**

Too much automation may reduce transparency and make it harder to monitor or debug the system.

Q. Compare LTE and LTE advanced

Feature	LTE (Long Term Evolution)	LTE-Advanced
Release	3GPP Release 8	3GPP Release 10 and beyond
Maximum Downlink Speed	Up to 100 Mbps	Up to 1 Gbps
Maximum Uplink Speed	Up to 50 Mbps	Up to 500 Mbps
Carrier Aggregation	Not supported	Supported (up to 5 carriers, 100 MHz total)
MIMO Support	Up to 4x4 MIMO	Up to 8x8 MIMO
Peak Spectrum Efficiency	Lower (16 bps/Hz)	Higher (30 bps/Hz)
Latency	Around 10 ms	Reduced latency (less than 5 ms)
Cell Edge Performance	Moderate	Improved through coordinated multipoint (CoMP)
Relay Nodes Support	Not available	Supported (for improved coverage)
Backward Compatibility	Compatible with 3G and 2G	Fully backward compatible with LTE
Target Use	Basic mobile broadband	Advanced broadband + high-speed multimedia use

Q. SAE / LTE Architecture

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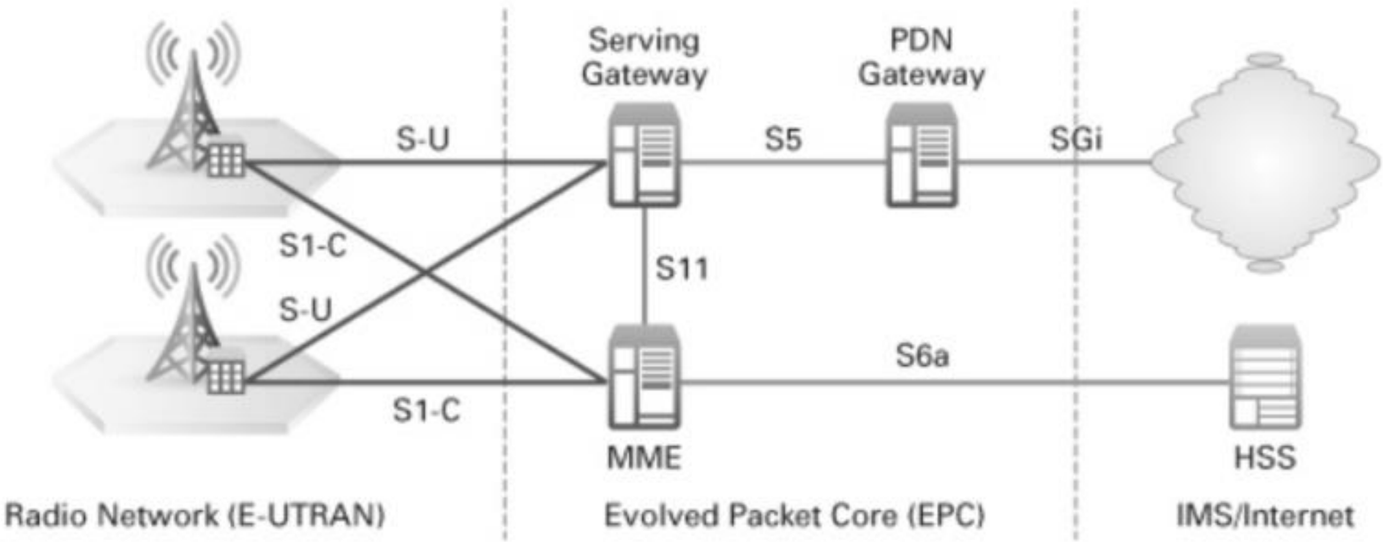
1. Introduction to SAE:

- **SAE (System Architecture Evolution)** is a flat, all-IP-based core network architecture designed to simplify LTE networks.
- It removes older 3G components like **RNC (Radio Network Controller)** and **SGSN (Serving GPRS Support Node)**, and uses only **eNB (Evolved Node B)** and the **Evolved Packet Core (EPC)**.



2. Goals of SAE:

- Provide **high-speed data** with **low latency**.
- Enable seamless **handover** and **interworking** with other networks (like WCDMA, WiMAX, WLAN).
- Improve **network scalability** and simplify deployment.

3. Components of SAE/LTE Architecture:

A. Evolved Node B (eNB):

- Directly connects to the mobile device (UE).
- Handles radio transmission, reception, and radio resource management.
- Communicates with EPC via the S1 interface.

B. Evolved Packet Core (EPC):

The EPC consists of the following major elements:

i. MME (Mobility Management Entity):

- Controls **signaling and mobility management** functions.
- Key responsibilities:
  - UE **authentication** (via HSS).
  - **Paging and tracking** of idle UEs.
  - **Bearer management** (activation/deactivation).
  - **Security**: NAS ciphering/integrity protection.
  - Manages **handover** and **roaming** procedures.
  - Controls mobility between LTE and legacy networks via the S3 interface.

ii. SGW (Serving Gateway):

- Acts as a **data router** for user plane traffic.
- Key responsibilities:
  - **Forwarding** user data packets between eNB and PGW.
  - **Mobility anchor** during handovers between eNBs.
  - Stores **UE context** and triggers paging when downlink data arrives.
  - Supports **lawful interception** of user traffic.

iii. PGW (Packet Data Network Gateway):

- Connects the EPC to **external networks** (e.g., the Internet).
- Key responsibilities:
  - Provides **IP address** to UEs.
  - Performs **QoS enforcement**, **deep packet inspection**, and **charging**.
  - **Filters packets**, **applies policies**, and **screens data**.
  - Supports **access to multiple PDNs** for a UE.

Voice over LTE

- Voice over LTE's full form is Voice Over Long Term Evolution

- VoLTE is a digital packet voice service that is delivered over IP via an LTE access network.

- When the LTE system was being desired by the 3GPP, its prime focus was on creating 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. And hence for the LTE networks a different solution was required to carry traditional circuit switch voice calls.

- VoLTE is this solution to carry voice over IP in LTE networks. Voice into data stream is converted by VoLTE, which is then using the data connection transmitted.

- IMS(IP multimedia System) is the basis of VoLTE.

- IP multimedia System is an architectural framework for delivering multimedia communications services such as voice, video, text messaging over IP network.

Benefits of VoLTE

- If we compare with traditional voice VOLTE provides more efficient use of spectrum.

- ~~It~~ Rapid call establishment time is provided by VOLTE

- Headset battery life is increased by 40% as compared to VOIP.

- It eliminates the need to have date on one network and voice on other.

- It ensures that video services are fully interoperable across the operator community, just as voice service are.