

Extra Notes 2

WiFi header: Takes up a significant portion of the packet, increasing the number of devices increases the amount of overhead caused by MAC headers. It's not very efficient with the amount of information it can carry, besides even being a fixed size. To address this problem:

- header compression by eliminating unnecessary redundant info, wifi 6 using MIMO to improve efficiency.

TDD vs FDD: FDD → uplink and downlink use different channels, which means different frequencies. This allows for simultaneous communication in both directions for more efficient use of the spectrum, also greater distances, but doesn't allow multiple antennas, MIMO.

TDD → uses the same frequency separated in time, having dynamic allocation of time slots. Supports longer distances and transmissions are not continuous.

1G: First cellular networks for mobile voice communication. Operates between 800 - 900 MHz. Problems: limited channel capacity, low-quality voice, large cell sizes, no data services and no security.

2G (GSM): Improved capacity, improved voice quality, smaller cell sizes meant that coverage area was improved. Data services were implemented, such as messaging (SMS) with SIM.

2.5G (GPRS): Faster data rate, improved capacity, always-on

connectivity, QoS features and built-in security features. Takes use of PDP (packet data protocol) and GTP (GPRS tunnel protocol). **PDP** → protocol used to establish and manage data connections in GPRS network. Responsible for creating and maintaining logical links between a mobile device and network and controlling the flow between them.

GTP → tunneling protocol used to transfer data over the GPRS network, creating logical tunnel between mobile device and network, where data goes encapsulated in GTP packets (efficient and secure).

SGSN → uses the PDP, maintains location of device, managing connections and security.

GGSN → acts as gateway between GPRS networks and other networks, routing those data packets.

3G (UMTS): High speed data, improved capacity, wider coverage, advanced services and better security. IMS is an important technology used for advanced multimedia services such as VoIP, video conferencing, instant messaging.

IMS → based on client-server architecture (server in IMS core which is a set of network elements responsible for managing and delivering multimedia services). Also provides QoS, security and mobile management. It has CSCF (call session control function), MGCF (media gateway control function) and HSS (Home subscriber server).

4G (LTE): high-speed data, more coverage, improved connectivity, advanced services and better security. (5G)

capacity, advanced services

is a technology that supports voice and messaging in 4G using 2G/3G services. VoLTE, on the other hand, the call is made through the 4G network. SGW is responsible for managing the mobility of the device, routing to the PGW and manage connections, controlling access and data flow and security. PGW acts as gateway between LTE network and other networks, managing QoS, auth, bill and security policies.

5G: Fundamental aspects:

- high-speed data (up to 10 Gbps) enabling ultra-low latency, high-definition video streaming, etc.
 - High-bandwidth: Larger bandwidth available for data transfer, allows more users.
 - Low-latency: much lower latency (even $< 1\text{ms}$) which is important for virtual reality or self-driving cars.
 - Improved capacity: Massive MIMO, beamforming as network scaling to increase the number of users.
- 5G slicing** divides the network into multiple virtual networks, each with its own set of resources and characteristics to improve performance and reliability. Each user can connect up to 8 slices.
- Advanced services: industry 4.0, IoT, smart cities
 - Security with built in encryption and more.

Turning off GSM for LTE:

GSM networks have been deployed for many years and have a larger coverage area than LTE, specially in rural areas. This can create a gap in coverage where users will lose the service.

Devices that only support GSM will have to be replaced, having significant cost.

Infrastructure is also a problem where the physical infrastructure differs from GSM to LTE (different frequencies) which can lead to more cost upgrading/uplacing by the operators.

Lastly, network planning and managing for the new capacity and QoS that comes with a lot of new users.