

Lecture 1: 1.1 Evolution of Cellular communication (1G to 5G)

Fundamental of Cellular Communication

DI05011011: Mobile Communication

Agenda for Today

- 1. Introduction to Mobile Communication
- 2. The First Generation (1G): Analog Voice
- 3. The Second Generation (2G): Digital Voice & SMS
- 4. Transition (2.5G & 2.75G): GPRS and EDGE
- 5. The Third Generation (3G): Mobile Broadband
- 6. The Fourth Generation (4G): IP-Based High Speed
- 7. The Fifth Generation (5G): IoT and Ultra-Low Latency
- 8. Summary of Generations

Introduction to Mobile Communication

- Mobile communication allows transmission of voice and data to users on the move.
- It relies on electromagnetic waves to transmit signals without physical wires.
- Generations of mobile communication are denoted by 'G' (Generation).
- Each generation introduces significant improvements in data speed, capacity, and technology.

1G: The Analog Era (1980s)

- Introduced in the early 1980s.
- **Technology:** Analog signal transmission.
- **Primary Use:** Voice calls only.
- **Key Standard:** AMPS (Advanced Mobile Phone System).
- **Limitations:**
 - - Poor voice quality and high background noise.
 - - No data or text messaging capabilities.
 - - Very poor security (easily tapped).
 - - Large, bulky phones with short battery life.

2G: The Digital Revolution (Early 1990s)

- Introduced in the early 1990s.
- **Technology:** Digital signal transmission (Circuit Switching).
- **Primary Use:** High-quality voice, SMS (Short Message Service), and MMS.
- **Key Standards:** GSM (Global System for Mobile Communications) and CDMA.
- **Improvements over 1G:**
 - - Digital encryption (improved security).
 - - Better voice clarity and less static.
 - - Introduction of the SIM card (in GSM).
 - - Lower power consumption.

The Bridge: 2.5G and 2.75G

- Before jumping to 3G, the network needed interim data upgrades.
- **2.5G (GPRS - General Packet Radio Service):**
 - - Introduced Packet Switching alongside Circuit Switching.
 - - Speeds up to 114 Kbps.
 - - Enabled basic web browsing (WAP) and email.
- **2.75G (EDGE - Enhanced Data rates for GSM Evolution):**
 - - Pushed 2G technology to its limits.
 - - Speeds up to 384 Kbps.
 - - Allowed better multimedia transmission.

3G: Mobile Broadband (Early 2000s)

- Introduced around 2001.
- **Technology:** UMTS (Universal Mobile Telecommunications System), WCDMA.
- **Primary Use:** High-speed internet, video calling, mobile TV.
- **Speeds:** 2 Mbps to 21 Mbps (with HSPA).
- **Key Features:**
 - - True mobile broadband experience.
 - - Always-on data connection.
 - - Rise of smartphones (early iPhones and Androids).
 - - Heavier focus on data rather than just voice.

4G: The IP Era and LTE (2010s)

- Introduced around 2010.
- **Technology:** LTE (Long Term Evolution) and WiMAX.
- **Architecture:** Entirely IP-based (Packet Switched only).
- **Primary Use:** HD video streaming, online gaming, fast browsing.
- **Speeds:** 100 Mbps to 1 Gbps.
- **Key Features:**
 - - Voice over LTE (VoLTE) - Voice calls sent as data packets.
 - - Dramatically reduced latency.
 - - High spectral efficiency and capacity.

5G: The Era of IoT and Ultra-Low Latency (2020s)

- Currently rolling out globally.
- **Technology:** NR (New Radio), Massive MIMO, Millimeter Wave.
- **Speeds:** Up to 10 Gbps (100x faster than 4G).
- **Key Pillars of 5G:**
 - - **eMBB (Enhanced Mobile Broadband):** Blazing fast speeds for VR/AR.
 - - **URLLC (Ultra-Reliable Low Latency Comms):** 1ms latency for remote surgery, autonomous cars.
 - - **mMTC (Massive Machine Type Comms):** Connecting millions of IoT devices per sq km.

Speed and Capability Comparison

- **Downloading a 2-Hour HD Movie (approx. 2GB):**
- - **1G:** Impossible (No data).
- - **2G (GPRS):** ~20 days.
- - **3G:** ~2 hours.
- - **4G:** ~5 to 10 minutes.
- - **5G:** ~10 to 20 seconds.

Summary of Network Architectures

- - **1G**: Analog, Circuit Switched (Voice).
- - **2G**: Digital, Circuit Switched (Voice + SMS).
- - **3G**: Digital, Circuit Switched (Voice) + Packet Switched (Data).
- - **4G**: Digital, All-IP Packet Switched (Data and Voice over IP).
- - **5G**: Digital, All-IP, Cloud-native, Network Slicing.

- The evolution of mobile communication happens roughly every 10 years.
- **1G:** Analog voice.
- **2G:** Digital voice and text (GSM, CDMA).
- **3G:** Mobile broadband and video calling.
- **4G:** All-IP networks, LTE, and HD streaming.
- **5G:** IoT, autonomous systems, and ultra-low latency.

- Now that we know the history, how do these networks actually cover large areas?
- In the next lecture, we will cover:
- **1.2 Basic Cellular Concept and Cellular System**
- - Why do we use 'cells' ?
- - How frequency allocation works.
- - The basic architecture of a cellular system.