

Lecture 32: 4.1 Introduction to 4G technology

4G and 5G Networks

DI05011011: Mobile Communication

Agenda for Today

- 1. Evolution: 1G to 4G
- 2. What is 4G?
- 3. IMT-Advanced Requirements
- 4. Key Features of 4G
- 5. All-IP Network Architecture
- 6. Types of 4G Technologies
- 7. Summary and Preview

Evolution: From 1G to 4G

- - **1G:** Analog voice.
- - **2G:** Digital voice, SMS (GSM, CDMA).
- - **3G:** Mobile broadband, video calling, internet access (UMTS, CDMA2000).
- - **4G:** Ultra-broadband internet access, IP telephony, gaming, high-definition mobile TV.
- 4G represented a fundamental shift from circuit-switched to packet-switched networks for everything, including voice.

What is 4G?

- 4G is the fourth generation of broadband cellular network technology, succeeding 3G.
- It provides mobile ultra-broadband Internet access.
- Designed to offer higher data rates, improved quality of service (QoS), and lower latency.
- Provides a comprehensive and secure all-IP based mobile broadband solution to laptop computer wireless modems, smartphones, and other mobile devices.

- The ITU (International Telecommunication Union) defined 'True 4G' under the IMT-Advanced specification:
- - Data rates of **100 Mbps** for high mobility (e.g., in cars/trains).
- - Data rates of **1 Gbps** for low mobility (e.g., stationary or walking).
- - Scalable channel bandwidths of 5 to 20 MHz, optionally up to 40 MHz.
- - Seamless connectivity and global roaming across multiple networks.

Key Features of 4G Technology

- 1. **High Speed:** Supports peak data rates of 100 Mbps to 1 Gbps.
- 2. **High Capacity:** Can support more active users per cell.
- 3. **Low Latency:** Reduced delay in packet delivery (crucial for gaming and voice).
- 4. **All-IP Network:** Complete transition to packet switching (IPv6 support).
- 5. **High Spectral Efficiency:** Delivers more bits per hertz than 3G.

- Previous generations used Circuit Switching for voice and Packet Switching for data.
- **4G Paradigm:**
 - - Entirely Packet Switched.
 - - Voice is treated as just another data application (Voice over LTE or VoLTE).
 - - Uses IP (Internet Protocol) for all services: voice, data, and multimedia.
 - - Simplifies network architecture and reduces costs.

Improved Quality of Service (QoS)

- Because 4G is All-IP, managing different types of traffic is critical.
- - **QoS Mechanisms:** Ensure time-sensitive packets (like voice or live video) get priority over less sensitive ones (like file downloads).
- - End-to-end QoS support is a mandatory feature in 4G to guarantee user experience.
- - Prevents jitter and packet loss during critical communications.

- Achieving IMT-Advanced speeds requires advanced physical layer technologies:
- 1. **OFDM (Orthogonal Frequency Division Multiplexing)**: Deals efficiently with multipath interference.
- 2. **MIMO (Multiple Input Multiple Output)**: Uses multiple antennas to increase data rates and reliability.
- We will cover these in detail in upcoming lectures.

Types of 4G Technologies

- Two main candidate technologies competed for the 4G standard:
- 1. **WiMAX (IEEE 802.16m)**: Driven by the computer/IT industry.
- 2. **LTE-Advanced (Long-Term Evolution)**: Driven by the telecommunications industry (3GPP).

WiMAX (Worldwide Interoperability for Microwave Access)

- - Based on the IEEE 802.16 standard.
- - Designed primarily as a broadband wireless access technology (like long-range Wi-Fi).
- - Early versions offered fixed wireless, later adapted for mobile (Mobile WiMAX).
- - Deployed early in some markets but ultimately lost out to LTE due to lack of global ecosystem support.

LTE (Long-Term Evolution)

- - Developed by the 3GPP (3rd Generation Partnership Project).
- - Represents a smooth evolution path for existing GSM/UMTS networks.
- - Adopted globally as the de facto 4G standard.
- - LTE-Advanced (Release 10 onwards) formally met the IMT-Advanced 4G requirements.

Real-World Application: Streaming and Video Calls

- **Pre-4G Era:** Video streaming over cellular was heavily buffered, low-resolution, and unreliable.
- **4G Era:**
 - - Enabled HD Netflix/YouTube streaming on mobile.
 - - Made FaceTime and WhatsApp video calls seamless.
 - - Allowed real-time multiplayer mobile gaming (e.g., PUBG Mobile) due to low latency.
- 4G fundamentally changed how we consume media on the go.

- 4G networks provide ultra-broadband speeds and low latency.
- The ITU's IMT-Advanced defines true 4G as 100 Mbps (mobile) and 1 Gbps (stationary).
- 4G is an All-IP network, transitioning away from circuit-switched voice.
- Key enabling technologies are OFDM and MIMO.
- LTE-Advanced emerged as the global standard, defeating WiMAX.

- In the next lecture, we will dive deeper into **LTE and WiMAX**.
- We will explore:
 - 1. LTE Architecture (EPC and E-UTRAN)
 - 2. Detailed comparison of LTE and WiMAX
 - 3. How LTE handles handovers and mobility.