LECTURE NOTES ON MOBILE COMPUTING

PREPARED BY : NALINIKANTA MOHAPATRA

Introduction to Wireless and Mobile Networks: Historic Background

Introduction

A **Wireless Network** is a communication network in which data is transmitted between devices without using physical cables. It relies on electromagnetic waves such as radio waves, microwaves, and infrared signals.

A **Mobile Network** is a type of wireless network that allows users to communicate and access services while moving from one location to another. It provides mobility, enabling continuous communication through cellular infrastructure.

Wireless and mobile networks have transformed communication by enabling voice calls, messaging, internet access, multimedia services, and IoT applications anytime and anywhere.

Historic Background of Wireless and Mobile Networks

The evolution of wireless and mobile communication can be divided into several stages:

1. Early Wireless Communication (1860–1900)

- **1864:** James Clerk Maxwell proposed the theory of electromagnetic waves.
- **1887:** Heinrich Hertz experimentally proved the existence of electromagnetic waves.
- **1895:** Guglielmo Marconi developed the first practical wireless telegraph system using radio waves.
- Wireless communication was initially used for military and maritime communication.

2. Radio Communication Era (1900–1940)

- Rapid growth in radio broadcasting.
- Development of AM and FM radio systems.
- Wireless communication became common for ships, aviation, and military operations.
- Communication was mainly analog.

3. Mobile Radio Systems (1940–1970)

- Two-way mobile radio systems were introduced.
- Used by police, ambulance, fire services, and taxis.
- Large equipment with limited coverage.
- No automatic handoff between communication cells.

4. Cellular Communication Concept (1970s)

- Researchers at Bell Labs introduced the concept of dividing a service area into small geographic regions called **cells**.

- Each cell is served by a **base station**.
- Frequency reuse improved network capacity.
- This concept became the foundation of modern cellular networks.

5. First Generation (1G) – 1980s

- Analog cellular communication.
- Designed mainly for voice calls.
- Low voice quality and poor security.
- Examples:
    - AMPS (Advanced Mobile Phone System)
    - NMT (Nordic Mobile Telephone)

Features

- Analog transmission
- Voice only
- Low capacity
- Limited coverage

6. Second Generation (2G) – 1990s

- Digital cellular communication.
- Better voice quality.
- SMS (Short Message Service) introduced.
- Improved security through digital encryption.

Technologies

- GSM (Global System for Mobile Communications)
- CDMA (Code Division Multiple Access)

Features

- Digital voice
- SMS support
- Better battery life
- Improved security

7. Third Generation (3G) – 2000s

- High-speed mobile internet.
- Multimedia communication.
- Video calling and mobile web browsing.

Features

- Internet access
- Video calls
- Mobile TV
- Faster data transfer (up to several Mbps)

8. Fourth Generation (4G) – 2010s

- All-IP (Internet Protocol) network.
- High-speed broadband internet.
- HD video streaming.
- Online gaming.
- Voice over LTE (VoLTE).

Features

- High-speed internet
- Low latency
- HD multimedia
- Cloud services
- Mobile applications

9. Fifth Generation (5G) – Present

- Ultra-high-speed communication.
- Very low latency.
- Supports billions of connected devices.
- Enables smart cities, autonomous vehicles, and advanced IoT applications.

Features

- Multi-Gbps data rates
- Low latency (around 1 ms under ideal conditions)
- Massive IoT connectivity
- AI-enabled network management
- Enhanced reliability

Evolution of Mobile Network Generations

Generation	Period	Technology	Main Services
1G	1980s	Analog	Voice calls
2G	1990s	GSM, CDMA	Voice, SMS
3G	2000s	UMTS, CDMA2000	Internet, video calling
4G	2010s	LTE	HD streaming, VoLTE, broadband
5G	Present	NR (New Radio)	Ultra-fast internet, IoT, AI applications

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Advantages of Wireless and Mobile Networks

- Mobility and portability
- Easy installation and deployment
- Cost-effective for large areas
- Supports real-time communication
- Internet access from almost anywhere
- Enables IoT and smart devices

Applications

- Mobile communication
- Internet access
- Smart homes
- Smart cities
- Healthcare (telemedicine)
- Online education
- Banking and e-commerce
- Transportation and navigation
- Industrial automation
- Military communication

Conclusion

The evolution of wireless and mobile networks has progressed from early radio communication to today's high-speed **5G** networks. Each generation has improved speed, capacity, security, and service quality. These advancements have made wireless communication an essential part of modern life, supporting everything from voice calls to advanced IoT ecosystems.

Advantages and Disadvantages of Mobile Systems

Introduction

A **mobile system** is a wireless communication system that enables users to communicate, access the internet, and use various digital services while moving from one place to another. Mobile systems are widely used in personal, business, healthcare, education, and industrial applications.

Advantages of Mobile Systems

1. Mobility

- Users can communicate from almost anywhere while on the move.
- Supports seamless connectivity across different locations.

2. Wireless Communication

- No physical cables are required.
- Easy to install and use.

3. Easy Internet Access

- Provides access to email, websites, cloud services, and online applications.
- Supports remote work and online learning.

4. Instant Communication

- Enables voice calls, video calls, SMS, instant messaging, and email.
- Facilitates real-time communication.

5. Cost-Effective

- Reduces the need for wired infrastructure.
- Affordable mobile devices and data plans are widely available.

6. Emergency Services

- Allows users to quickly contact emergency services.
- GPS helps locate users during emergencies.

7. Supports Business Operations

- Enables mobile banking, online shopping, remote meetings, and digital payments.
- Improves productivity through remote access.

8. Entertainment

- Supports music streaming, video streaming, gaming, and social media.

9. Location-Based Services

- GPS navigation, ride-hailing, food delivery, and location tracking are possible.

10. IoT Connectivity

- Connects smart devices such as smart homes, wearable devices, and industrial sensors.

Disadvantages of Mobile Systems

1. Security Risks

- Vulnerable to hacking, malware, phishing, and data theft.
- Personal information may be compromised.

2. Limited Battery Life

- Mobile devices require frequent charging, especially during heavy usage.

3. Network Coverage Issues

- Signal strength may be weak in rural, remote, or underground areas.
- Network congestion can reduce performance.

4. Limited Bandwidth

- During peak hours, users may experience slower internet speeds.

5. Health Concerns

- Long-term exposure to radio-frequency (RF) radiation is still being studied.
- Excessive mobile use may contribute to eye strain and poor posture.

6. Distraction

- Frequent notifications and excessive mobile use can reduce concentration.
- Using mobile phones while driving increases accident risk.

7. Privacy Issues

- Apps may collect personal data and location information.
- Unauthorized access can lead to privacy breaches.

8. Dependence on Network Availability

- Communication depends on network coverage and service provider reliability.

9. Device Cost

- Advanced smartphones and accessories can be expensive.
- Repair and maintenance costs may also be high.

10. Environmental Impact

- Electronic waste (e-waste) and battery disposal can harm the environment if not managed properly.

Comparison Table

Advantages	Disadvantages
Mobility and portability	Security and privacy risks
Wireless connectivity	Limited battery life
Easy internet access	Network coverage issues
Instant communication	Bandwidth limitations
Supports business and education	Device and maintenance costs
GPS and location services	Distraction and addiction
Emergency communication	Dependence on network availability
Entertainment services	Environmental impact (e-waste)
Supports IoT applications	Possible health concerns
Easy installation	Risk of data loss and cyberattacks

Applications of Mobile Systems

- Voice and video communication
- Mobile banking and digital payments
- Online education
- Telemedicine
- GPS navigation
- E-commerce
- Social networking
- Smart homes and IoT
- Business collaboration
- Emergency response services

Conclusion

Mobile systems have revolutionized communication by providing **mobility, convenience, and instant access to information and services**. They support numerous applications in daily life and business. However, they also present challenges such as **security threats, privacy concerns, battery limitations, and dependence on network coverage**. Proper security practices, responsible usage, and ongoing technological improvements help maximize the benefits while minimizing the drawbacks.

Cell Concept in Mobile Communication

Introduction

The **Cell Concept** is the fundamental principle of modern cellular mobile communication. Instead of using one powerful transmitter to cover a large area, the service area is divided into many small regions called **cells**. Each cell is served by its own **Base Station (BS)** with a low-power transmitter. This improves coverage, increases network capacity, and allows users to move freely while staying connected.

Definition

A **cell** is the smallest geographical area in a cellular network covered by a base station. The entire service area is divided into several interconnected cells to provide uninterrupted mobile communication.

Cell Structure

- Each cell is ideally represented by a **hexagonal shape**.
- A **Base Station (BS)** is located at the center (or sometimes at a corner) of each cell.
- Mobile users communicate with the nearest base station.
- Adjacent cells are connected through a **Mobile Switching Center (MSC)**.

Why is a Hexagonal Shape Used?

Although radio coverage is circular, a **hexagon** is used for network planning because:

- It covers an area without leaving gaps.
- It avoids overlapping between neighboring cells.
- It provides six neighboring cells, simplifying frequency planning.
- It closely approximates circular coverage.

Components of the Cell Concept

1. Cell

- The basic coverage area of a cellular network.
- Served by one base station.

2. Base Station (BS)

- Communicates directly with mobile users.
- Handles radio transmission and reception within the cell.

3. Mobile Station (MS)

- A user's mobile device (smartphone, tablet, etc.).
- Communicates with the nearest base station.

4. Mobile Switching Center (MSC)

- Controls multiple base stations.
- Performs call routing, switching, authentication, and mobility management.

Working of the Cell Concept

1. The service area is divided into many small cells.
2. Each cell has a dedicated base station.
3. Mobile users connect to the nearest base station.
4. As a user moves from one cell to another, the network transfers the connection to the new base station through a process called **handoff (handover)**.
5. Frequencies are reused in non-adjacent cells to increase capacity.

Frequency Reuse

Frequency reuse means the same radio frequencies can be assigned to cells that are far enough apart to avoid interference.

Advantages

- Efficient use of the available spectrum.
- Increased network capacity.
- Reduced operating cost.
- Supports more simultaneous users.

Handoff (Handover)

Handoff is the process of transferring an ongoing call or data session from one base station to another as the user moves between cells.

Types of Handoff

- **Hard Handoff:** The connection with the old base station is released before connecting to the new one ("break before make").
- **Soft Handoff:** The mobile device is connected to both the old and new base stations simultaneously for a short period ("make before break").

Types of Cells

Cell Type	Coverage Area	Typical Application
Macro Cell	Large (1–20 km)	Cities, highways, rural areas
Micro Cell	Small (500 m–2 km)	Urban streets, dense city areas
Pico Cell	Very Small (10–200 m)	Offices, malls, airports
Femto Cell	Home or small office	Indoor residential and business use

Advantages of the Cell Concept

- Efficient utilization of radio frequencies.
- Increased network capacity through frequency reuse.
- Supports user mobility with seamless handoff.
- Better coverage over large geographical areas.
- Lower transmission power requirements.
- Easier network expansion by adding more cells.

- Reduced interference compared to a single high-power transmitter.

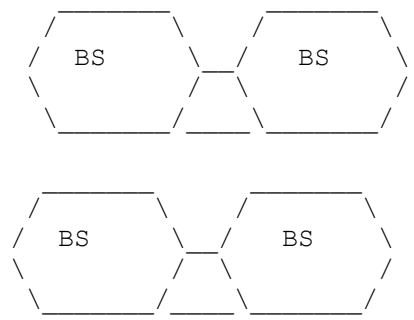
Disadvantages of the Cell Concept

- Network design and planning are complex.
- Frequent handoffs can increase signaling overhead.
- Infrastructure cost is high due to many base stations.
- Interference may occur if frequency reuse is not planned properly.
- Requires continuous monitoring and maintenance.

Applications

- Mobile telephone networks (2G, 3G, 4G, and 5G)
- Wireless internet services
- Public safety communication systems
- Smart cities and IoT networks
- Vehicle communication systems

Simple Diagram of the Cell Concept



BS = Base Station

Wireless Network

Introduction

A **Wireless Network** is a communication network in which data is transmitted between devices **without using physical cables or wires**. It uses **electromagnetic waves** such as radio waves, microwaves, infrared, or satellite signals to transfer information. Wireless networks provide flexibility, mobility, and easy access to communication and internet services.

Definition

A **Wireless Network** is a network that connects computers, mobile devices, and other electronic equipment through wireless communication technologies instead of wired connections.

Features of Wireless Networks

- No physical cables are required.
- Provides mobility and portability.
- Easy to install and expand.

- Supports communication over short and long distances.
- Enables internet access from multiple devices.
- Can be integrated with wired networks.

Types of Wireless Networks

1. Wireless Personal Area Network (WPAN)

- Covers a very short distance (up to 10 meters).
- Used for communication between personal devices.

Examples:

- Bluetooth
- ZigBee
- NFC (Near Field Communication)

Applications:

- Wireless keyboard and mouse
- Smartwatches
- Wireless headphones

2. Wireless Local Area Network (WLAN)

- Covers homes, offices, schools, and campuses.
- Based on **Wi-Fi (IEEE 802.11)** technology.

Applications:

- Home internet
- Office networking
- Educational institutions
- Public Wi-Fi hotspots

3. Wireless Metropolitan Area Network (WMAN)

- Covers an entire city or metropolitan area.
- Often based on **WiMAX (IEEE 802.16)**.

Applications:

- City-wide internet access
- Broadband services

4. Wireless Wide Area Network (WWAN)

- Covers very large geographical areas such as countries or continents.
- Uses cellular networks and satellite communication.

Examples:

- 4G LTE
- 5G
- Satellite communication

Applications:

- Mobile internet
- Long-distance communication
- Rural connectivity

Components of a Wireless Network

1. **Wireless Devices**
    - Smartphones
    - Laptops
    - Tablets
    - IoT devices
2. **Access Point (AP)**
    - Connects wireless devices to a wired network.
    - Acts as a central communication point.
3. **Wireless Router**
    - Provides internet access and manages network traffic.
    - Combines routing and wireless access functions.
4. **Network Interface Card (NIC)**
    - Enables a device to communicate wirelessly.
    - Built into most modern laptops and smartphones.
5. **Transmission Medium**
    - Radio waves
    - Microwaves
    - Infrared
    - Satellite signals

Working of a Wireless Network

1. A wireless router or access point transmits radio signals.
2. Wireless devices receive these signals using their wireless adapters.
3. Devices exchange data with the access point.
4. The access point connects to the internet or a wired network.
5. Data is transmitted and received without physical cables.

Advantages of Wireless Networks

- Easy installation without wiring.
- Mobility and freedom of movement.
- Easy network expansion.
- Cost-effective for large areas.
- Supports multiple devices simultaneously.
- Convenient internet access.
- Suitable for temporary and remote installations.

Disadvantages of Wireless Networks

- Lower security compared to wired networks if not properly protected.
- Signal interference from walls, electronic devices, or other wireless networks.
- Limited range depending on the technology used.
- Slower speeds than wired networks in some situations.
- Network congestion when many users connect simultaneously.
- Performance may be affected by weather (especially satellite communication).

Applications of Wireless Networks

- Mobile communication
- Wi-Fi internet access
- Smart homes
- Smart cities
- Healthcare (telemedicine)
- Online education
- Industrial automation
- Military communication
- Banking and e-commerce
- Internet of Things (IoT)

Comparison: Wired vs Wireless Network

Wired Network	Wireless Network
Uses cables	Uses radio waves and other wireless signals
Higher speed	Generally lower speed than wired (depending on technology)
More secure	More vulnerable to security threats if unsecured
Limited mobility	High mobility
Difficult installation	Easy installation
Less interference	More prone to interference