Section-A

1. What do you mean by Doppler Spread?

- Doppler Spread is the broadening of the frequency spectrum of a signal due to the relative motion between the transmitter and receiver.
- It is caused when either the user or surrounding objects are moving, leading to a Doppler shift in the frequency.
- High Doppler spread results in **fast fading**, affecting the data rate and signal quality.
- It is a major concern in mobile communication as it causes signal distortion and loss of synchronization.

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2. What do you mean by Pure and Slotted ALOHA?

Pure ALOHA:

- Transmitter sends data anytime without checking if the channel is free.
- If data collides, it waits for a random time and retransmits.
- **Throughput** is very low (~18%).

Slotted ALOHA:

- Time is divided into slots and data is sent only at the beginning of a slot.
- Reduces chances of collision.
- **Throughput** is better than Pure ALOHA (~36%).

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3. What do you mean by Channel Modeling?

- Channel modeling is the **mathematical representation** of a communication channel.
- It helps in understanding how the signal behaves in different environments (like urban, rural, etc.).
- Models consider effects like **path loss, shadowing, fading**, and **noise**.

- Important types: Free-space model, Rayleigh fading model, Rician model, etc.

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4. Write the services provided by GSM.

- **Voice Services**: High-quality mobile voice calls.
- **SMS (Short Message Service)**: Sending and receiving text messages.
- **MMS (Multimedia Messaging Service)**: Sending pictures, videos, and audio.
- **Data Services**: Internet access, GPRS, EDGE.
- **Supplementary Services**:
    - Call waiting
    - Call forwarding
    - Caller ID
    - Conference calling

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5. What do you mean by Cell Splitting?

- Cell Splitting is the process of dividing a large coverage area (macrocell) into smaller cells (microcells or picocells).
- Done to increase **network capacity** and handle **more users**.
- Smaller cells reuse frequencies more efficiently, improving quality.
- Helps in reducing **co-channel interference** and **improving signal strength**.

Section-B

6. What do you mean by Fading? Explain in detail.

Fading refers to the variation in the strength of the received signal due to:

- Multipath propagation (signals taking different paths to reach receiver).

- Obstructions like buildings, trees, etc.
- Movement of transmitter/receiver.

Types of Fading:

1. **Small-Scale Fading:**
    - Caused by **multipath interference**.
    - Rapid changes in signal amplitude.
    - Types: Rayleigh fading, Rician fading.
2. **Large-Scale Fading:**
    - Caused by **shadowing** from buildings or hills.
    - Results in slow variations in signal strength.
3. **Flat Fading**: All frequency components fade equally.
4. **Frequency-selective Fading**: Some frequencies fade more than others.

Effects:

- Signal loss, distortion, data errors.
- Requires techniques like **diversity, equalization, and coding** to minimize.

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8. Explain the Diversity Technique in Detail.

Diversity is used to **reduce the effects of fading** and improve signal reliability. It works by receiving the same signal through **different paths** or methods.

Types of Diversity:

1. **Time Diversity**:
    - Transmit the same data at **different times**.
    - Used in error correction and retransmission methods.
2. **Frequency Diversity**:
    - Transmit the signal over **multiple frequencies**.
    - If one frequency fades, others may not.
3. **Space Diversity** (Antenna Diversity):

- Use **multiple antennas** at the transmitter/receiver.
- Signals are combined to get a stronger signal.

4. **Polarization Diversity**:
   - Use signals with **different polarizations** (vertical & horizontal).

Benefits:

- Improves signal strength and quality.
- Reduces the chance of complete signal loss.
- Commonly used in **MIMO systems** in 4G and 5G.

Section-C

Q9: Write a short note on:

(a) Bluetooth and ZigBee (6 marks)

🔹 **Bluetooth:**

1. **Definition:**
   Bluetooth is a **wireless communication technology** used for short-range data exchange between devices.
2. **Frequency:**
   Operates on **2.4 GHz ISM band**.
3. **Range:**
   Usually up to **10 meters**, extendable up to 100 meters.
4. **Speed:**
   Data rate up to **2 Mbps** in classic Bluetooth, higher in newer versions.
5. **Application:**
   - Wireless earphones, mouse, keyboard
   - File transfer between mobiles
   - Smart home and IoT

6. **Network Type:**
   Forms a **Piconet** (1 master + 7 slaves).

- **ZigBee:**

1. **Definition:**
   ZigBee is a **low-power, low-data rate** wireless communication standard mainly for **IoT and automation**.
2. **Frequency:**
   Operates on **2.4 GHz**, also supports 868 MHz (Europe), 915 MHz (USA).
3. **Range:**
   Around **10–100 meters**, can be extended using mesh networking.
4. **Speed:**
   Data rate up to **250 kbps**.
5. **Application:**
   - Home automation
   - Smart lighting
   - Industrial control systems
6. **Power Usage:**
   Very low power, ideal for battery-operated devices.

(b) 4G and 5G Mobile Techniques (6 marks)

- **4G (Fourth Generation):**

1. **Technology:**
   Based on **LTE (Long Term Evolution)**.
2. **Speed:**
   Up to **100 Mbps** (mobile) and **1 Gbps** (stationary).
3. **Latency:**
   Around **30-50 ms**.

4. **Key Features:**
    - HD video streaming
    - Online gaming
    - VoIP calling (Voice over LTE)
5. **Application:**
    - Mobile internet
    - Video conferencing
    - Cloud services
6. **Drawback:**
    - Cannot handle large-scale **IoT** demands.

🔹 **5G (Fifth Generation):**

1. **Technology:**
   Based on **millimeter wave**, **Massive MIMO**, and **beamforming**.
2. **Speed:**
   Up to **10 Gbps** or more.
3. **Latency:**
   As low as **1 ms** — very fast!
4. **Key Features:**
    - Ultra-fast download/upload
    - Real-time communication
    - Supports **massive IoT**, **AR/VR**, **autonomous cars**
5. **Application:**
    - Smart cities
    - Remote surgery
    - Industry 4.0
6. **Advantage:**

- **High capacity**, **low delay**, and **reliable** connections.