

# Mobile & Wireless Communication (4351104) - Winter 2023 Solution

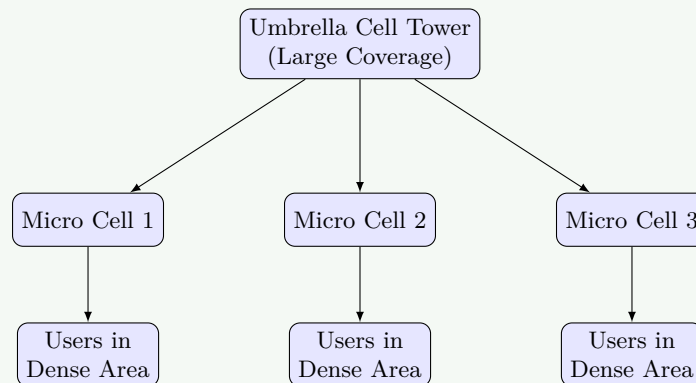
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December 12, 2023

## Question 1(a) [3 marks]

Draw & Explain umbrella cell.

### Solution



- **Umbrella Cell:** Large coverage cell overlaying smaller cells.
- **Purpose:** Handles overflow traffic from micro/pico cells.
- **Coverage:** Provides backup coverage for high-traffic areas.

### Mnemonic

"Under My Big Umbrella"

## Question 1(b) [4 marks]

Define full forms: (i) CCH (ii) TCH (iii) SCH (iv) BCCH

### Solution

| Acronym | Full Form                 | Function                    |
|---------|---------------------------|-----------------------------|
| CCH     | Control Channel           | Carries control information |
| TCH     | Traffic Channel           | Carries voice/data traffic  |
| SCH     | Synchronization Channel   | Provides timing sync        |
| BCCH    | Broadcast Control Channel | Broadcasts system info      |

### Mnemonic

"Control Traffic Sync Broadcast"

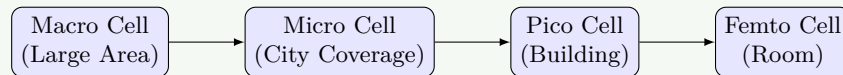
## Question 1(c) [7 marks]

What is cell? Explain different types of cells.

### Solution

**Cell** is the basic coverage area served by one base station in cellular communication.

| Cell Type  | Coverage | Power    | Usage           |
|------------|----------|----------|-----------------|
| Macro Cell | 1-30 km  | High     | Rural areas     |
| Micro Cell | 100m-2km | Medium   | Urban areas     |
| Pico Cell  | 10-100m  | Low      | Indoor coverage |
| Femto Cell | 10-30m   | Very Low | Home/office     |



- **Function:** Each cell provides wireless service to mobile users.
- **Frequency Reuse:** Same frequencies used in non-adjacent cells.
- **Handoff:** Users move between cells seamlessly.

### Mnemonic

“Many Mobile People Find coverage”

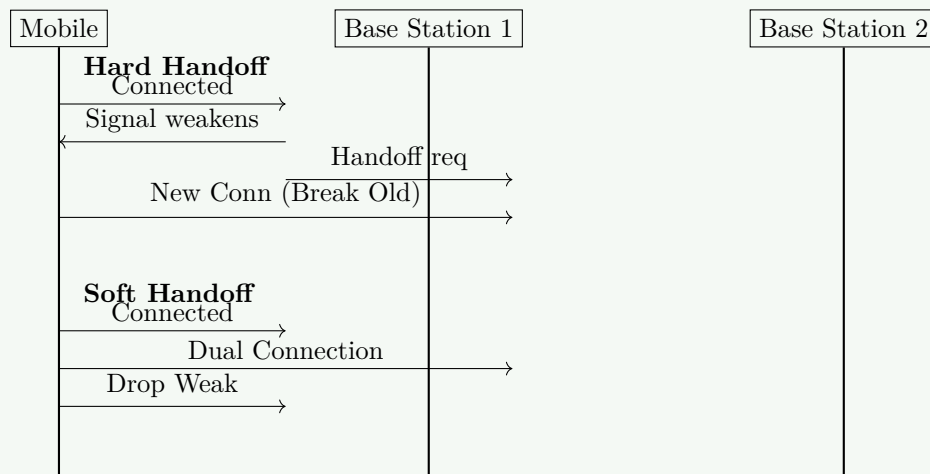
## Question 1(c) OR [7 marks]

What is handoff? Explain soft and hard handoffs.

### Solution

**Handoff** is the process of transferring an ongoing call from one cell to another as mobile moves.

| Feature    | Hard Handoff       | Soft Handoff            |
|------------|--------------------|-------------------------|
| Connection | Break-before-make  | Make-before-break       |
| Channels   | One at a time      | Multiple simultaneously |
| Technology | GSM, TDMA          | CDMA                    |
| Quality    | Brief interruption | Seamless transition     |



- **Initiation:** Based on signal strength measurements.

- **MAHO:** Mobile Assisted Handoff improves decision accuracy.

### Mnemonic

“Hard Hurts, Soft Smooth”

## Question 2(a) [3 marks]

Define full forms: (i) SIM (ii) LTE (iii) WCDMA

### Solution

| Acronym | Full Form                              | Purpose             |
|---------|--|---------------------|
| SIM     | Subscriber Identity Module             | User authentication |
| LTE     | Long Term Evolution                    | 4G technology       |
| WCDMA   | Wideband Code Division Multiple Access | 3G standard         |

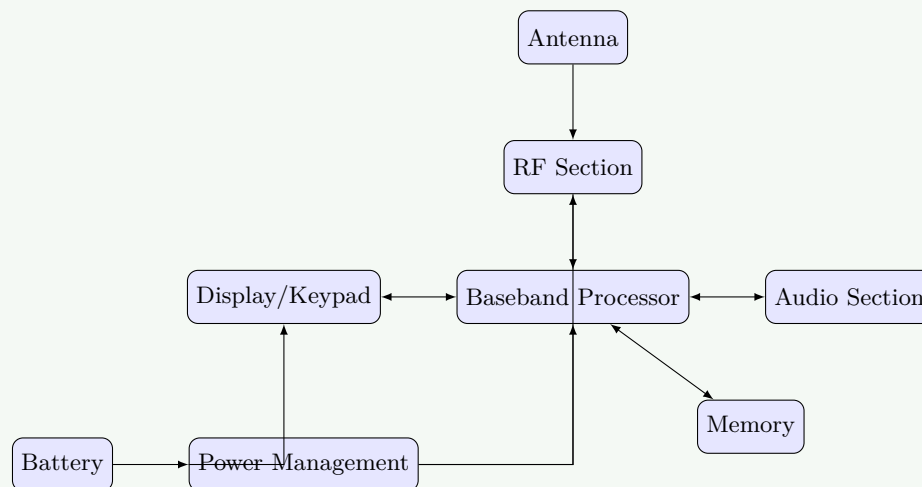
### Mnemonic

“Subscriber’s Long Wideband connection”

## Question 2(b) [4 marks]

Draw mobile handset block diagram.

### Solution



- **RF Section:** Transmits/receives radio signals.
- **Baseband:** Processes digital signals and protocols.
- **Audio:** Handles voice input/output.
- **Power Management:** Controls battery usage efficiently.

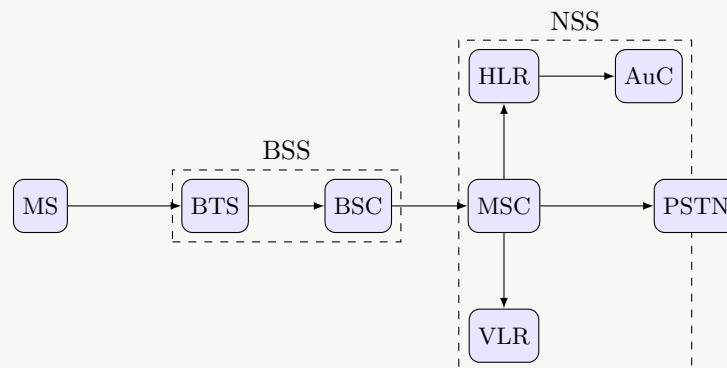
### Mnemonic

“Radio Baseband Audio Power”

## Question 2(c) [7 marks]

Explain GSM architecture with diagram.

### Solution



| Component | Function                  |
|-----------|---------------------------|
| MS        | Mobile Station (handset)  |
| BTS       | Base Transceiver Station  |
| BSC       | Base Station Controller   |
| MSC       | Mobile Switching Center   |
| HLR       | Home Location Register    |
| VLR       | Visitor Location Register |

- **BSS:** Base Station Subsystem handles radio interface.
- **NSS:** Network Switching Subsystem manages calls.
- **Authentication:** AuC verifies subscriber identity.

### Mnemonic

“Mobile Base Network calls Home”

## Question 2(a) OR [3 marks]

Define full forms: (i) RSSI (ii) MAHO (iii) NCHO

### Solution

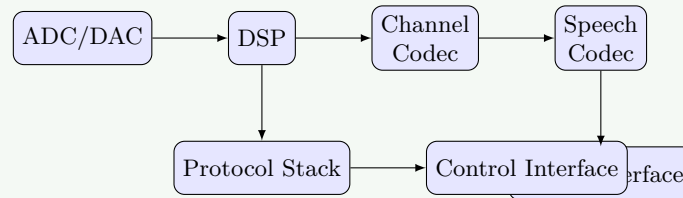
| Acronym | Full Form                          | Function                      |
|---------|------------------------------------|-------------------------------|
| RSSI    | Received Signal Strength Indicator | Signal quality measurement    |
| MAHO    | Mobile Assisted Handoff            | Mobile helps handoff decision |
| NCHO    | Network Controlled Handoff         | Network decides handoff       |

### Mnemonic

“Received Mobile Network signals”

## Question 2(b) OR [4 marks]

Draw baseband section block diagram.

**Solution**

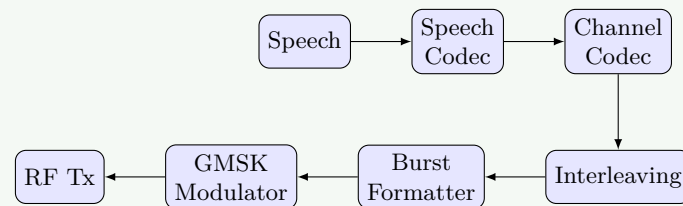
- **ADC/DAC:** Analog to Digital conversion.
- **DSP:** Digital Signal Processor.
- **Channel Codec:** Error correction coding.
- **Speech Codec:** Voice compression/decompression.

**Mnemonic**

“Analog Digital Speech Protocol”

**Question 2(c) OR [7 marks]**

Explain GSM signal processing with diagram.

**Solution**

| Stage                | Function                  | Purpose              |
|----------------------|---------------------------|----------------------|
| <b>Speech Codec</b>  | Compress voice to 13 kbps | Bandwidth efficiency |
| <b>Channel Codec</b> | Add error correction      | Signal reliability   |
| <b>Interleaving</b>  | Distribute burst errors   | Error protection     |
| <b>GMSK</b>          | Gaussian MSK modulation   | Spectral efficiency  |

- **Processing Rate:** 270.833 kbps gross bit rate.
- **Frame Structure:** 8 time slots per TDMA frame.
- **Frequency Hopping:** 217 hops per second.

**Mnemonic**

“Speech Channel Interleaves Modulated Radio”

**Question 3(a) [3 marks]**

Explain cell splitting.

**Solution**

Cell splitting divides congested cells into smaller cells to increase capacity.

- **Process:** Replace high-power cell with multiple low-power cells.
- **Benefit:** Increases system capacity by frequency reuse.

- **Implementation:** Reduce antenna height and transmit power.

#### Mnemonic

“Split Small Cells”

### Question 3(b) [4 marks]

Explain Li-Ion type batteries used in mobile handset with its advantages and disadvantages.

#### Solution

| Advantages          | Disadvantages         |
|---------------------|-----------------------|
| High energy density | Safety concerns       |
| No memory effect    | Degradation over time |
| Low self-discharge  | Temperature sensitive |
| Lightweight         | Expensive             |

- **Chemistry:** Lithium ions move between electrodes.
- **Voltage:** 3.7V nominal per cell.
- **Capacity:** Measured in mAh (milliampere-hours).

#### Mnemonic

“Light Ion Energy Safety”

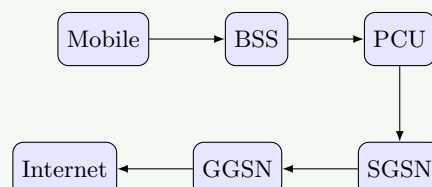
### Question 3(c) [7 marks]

Explain GPRS.

#### Solution

**GPRS** (General Packet Radio Service) provides packet-switched data service over GSM.

| Feature    | Specification            |
|------------|--------------------------|
| Data Rate  | Up to 171.2 kbps         |
| Technology | Packet switching         |
| Channels   | Uses multiple time slots |
| Billing    | Based on data volume     |



- **PCU:** Packet Control Unit manages packet data.
- **SGSN:** Serving GPRS Support Node.
- **GGSN:** Gateway GPRS Support Node.
- **Classes:** Class 1-12 with different speed/slot combinations.

**Mnemonic**

“General Packet Radio Service”

**Question 3(a) OR [3 marks]**

Explain cell sectoring.

**Solution**

Cell sectoring divides omnidirectional cell into sectors using directional antennas.

- **Common:** 3-sector (120°) or 6-sector (60°) configurations.
- **Benefit:** Reduces co-channel interference.
- **Implementation:** Directional antennas at same site.

**Mnemonic**

“Sector Reduces Interference”

**Question 3(b) OR [4 marks]**

Explain Li-Po type batteries used in mobile handset with its advantages and disadvantages.

**Solution**

| Advantages        | Disadvantages        |
|-------------------|----------------------|
| Flexible shape    | Lower energy density |
| Ultra-thin design | Shorter lifespan     |
| Lightweight       | Safety risks         |
| No memory effect  | Higher cost          |

- **Technology:** Lithium Polymer electrolyte.
- **Form Factor:** Can be molded into various shapes.
- **Voltage:** 3.7V nominal per cell.

**Mnemonic**

“Polymer Flexible Thin Light”

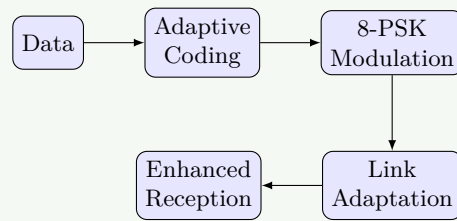
**Question 3(c) OR [7 marks]**

Explain EDGE.

**Solution**

**EDGE** (Enhanced Data rates for GSM Evolution) improves GSM data rates.

| Parameter        | GSM         | EDGE           |
|------------------|-------------|----------------|
| Modulation       | GMSK        | 8-PSK          |
| Data Rate        | 9.6 kbps    | Up to 384 kbps |
| Error Correction | Basic       | Advanced       |
| Spectrum         | Same as GSM | Same as GSM    |



- **8-PSK:** 8-Phase Shift Keying provides 3 bits per symbol.
- **Link Adaptation:** Adjusts coding scheme based on channel quality.
- **Incremental Redundancy:** Improves error correction efficiency.

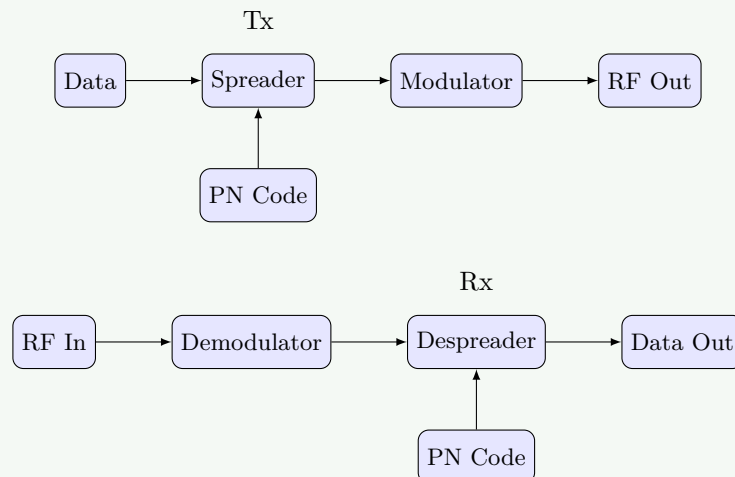
### Mnemonic

“Enhanced Data GSM Evolution”

## Question 4(a) [3 marks]

Draw DSSS transmitter and receiver block diagram.

### Solution



- **Spreader:** Multiplies data with PN sequence.
- **Despreader:** Correlates received signal with same PN code.
- **Processing Gain:** Ratio of spread to original bandwidth.

### Mnemonic

“Direct Sequence Spread Spectrum”

## Question 4(b) [4 marks]

Compare CDMA and GSM.



**Solution**

| Parameter          | CDMA                   | GSM            |
|--------------------|------------------------|----------------|
| Multiple Access    | Code Division          | Time Division  |
| Capacity           | Higher (soft capacity) | Fixed capacity |
| Handoff            | Soft handoff           | Hard handoff   |
| Power Control      | Critical               | Less critical  |
| Frequency Planning | Not required           | Required       |
| Voice Quality      | Better                 | Good           |

**Mnemonic**

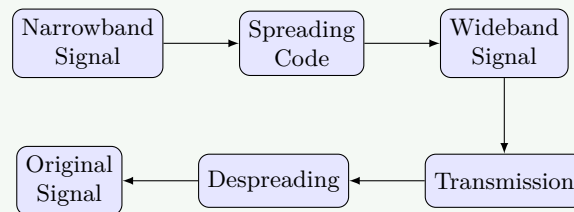
“Code Division vs Time Division”

**Question 4(c) [7 marks]**

Explain concept of spread spectrum with applications.

**Solution**

**Spread Spectrum** spreads signal bandwidth much wider than required for data transmission.



| Type | Method                     | Application |
|------|----------------------------|-------------|
| DSSS | PN sequence multiplication | CDMA, WiFi  |
| FHSS | Frequency hopping          | Bluetooth   |
| THSS | Time hopping               | UWB systems |

**Benefits:**

- **Anti-jamming:** Resistant to interference.
- **Low Power Density:** Difficult to detect.
- **Multiple Access:** Many users share spectrum.
- **Multipath Resistance:** Resolves delayed signals.

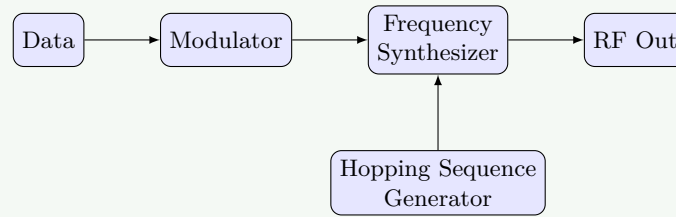
**Applications:** GPS, WiFi, Bluetooth, Military communications.

**Mnemonic**

“Spread Signal Spectrum Security”

**Question 4(a) OR [3 marks]**

Draw FHSS transmitter block diagram.

**Solution**

- **Frequency Synthesizer:** Changes carrier frequency rapidly.
- **Hopping Sequence:** Pseudo-random frequency pattern.
- **Dwell Time:** Time spent on each frequency.

**Mnemonic**

“Frequency Hopping Spread Spectrum”

**Question 4(b) OR [4 marks]**

Explain call processing in CDMA.

**Solution**

| Phase         | Process            | Description             |
|---------------|--------------------|-------------------------|
| System Access | Power control      | Mobile adjusts power    |
| Call Setup    | Channel assignment | Assign Walsh code       |
| Traffic       | Soft handoff       | Multiple base stations  |
| Call Release  | Power down         | Gradual power reduction |

- **Rake Receiver:** Combines multipath signals.
- **Power Control:** 800 times per second.
- **Soft Capacity:** Degrades gracefully with load.

**Mnemonic**

“Code Division Multiple Access”

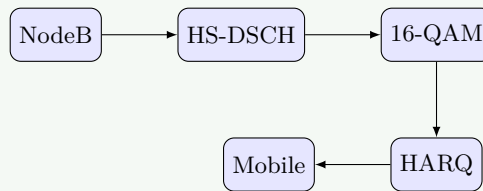
**Question 4(c) OR [7 marks]**

Explain HSDPA.

**Solution**

**HSDPA** (High Speed Downlink Packet Access) enhances WCDMA downlink data rates.

| Feature         | Enhancement     |
|-----------------|-----------------|
| Data Rate       | Up to 14.4 Mbps |
| Modulation      | 16-QAM          |
| HARQ            | Hybrid ARQ      |
| Fast Scheduling | 2ms TTI         |



- **HS-DSCH:** High Speed Downlink Shared Channel.
- **AMC:** Adaptive Modulation and Coding.
- **Fast Cell Selection:** Improves cell edge performance.
- **MIMO:** Multiple antenna configurations possible.

#### Mnemonic

“High Speed Downlink Packet Access”

### Question 5(a) [3 marks]

List LTE specifications.

#### Solution

| Parameter           | Specification           |
|---------------------|-------------------------|
| Peak Data Rate      | 300 Mbps DL, 75 Mbps UL |
| Bandwidth           | 1.4 to 20 MHz           |
| Latency             | <10ms user plane        |
| Mobility            | Up to 350 km/h          |
| Spectrum Efficiency | 3-4x better than 3G     |

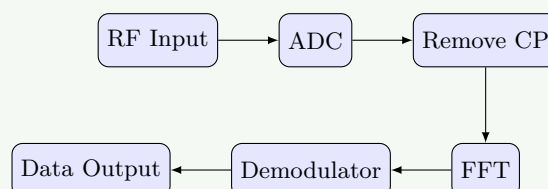
#### Mnemonic

“Long Term Evolution specifications”

### Question 5(b) [4 marks]

Draw OFDM receiver and explain its working.

#### Solution



- **FFT:** Fast Fourier Transform converts time to frequency domain.
- **Cyclic Prefix:** Guards against inter-symbol interference.
- **Subcarriers:** Parallel transmission on multiple frequencies.
- **Demodulation:** QPSK/16QAM/64QAM per subcarrier.

**Mnemonic**

“Orthogonal Frequency Division Multiplexing”

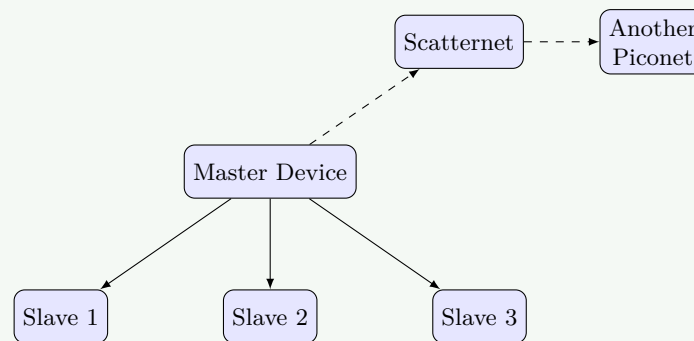
**Question 5(c) [7 marks]**

Explain Bluetooth Technology & list its applications.

**Solution**

**Bluetooth** is short-range wireless communication technology for personal area networks.

| Parameter | Specification       |
|-----------|---------------------|
| Range     | 10m (Class 2)       |
| Frequency | 2.4 GHz ISM band    |
| Data Rate | Up to 3 Mbps        |
| Topology  | Piconet (8 devices) |

**Protocol Stack:**

- **RF Layer:** Physical radio interface.
- **Baseband:** Medium access control.
- **L2CAP:** Logical Link Control.
- **Applications:** Various profiles (A2DP, HID, etc.).

**Applications:**

- Audio devices (headphones, speakers)
- File transfer between devices
- Input devices (keyboard, mouse)
- Health monitoring devices
- Smart home automation

**Mnemonic**

“Blue Tooth Personal Area Network”

**Question 5(a) OR [3 marks]**

List advantages of 5G Technology.

**Solution**

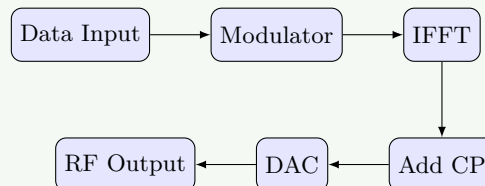
| Advantage            | Benefit                    |
|----------------------|----------------------------|
| Ultra-low latency    | <1ms response time         |
| High data rates      | Up to 10 Gbps              |
| Massive connectivity | 1M devices/km <sup>2</sup> |
| Network slicing      | Customized services        |
| Energy efficiency    | 90% more efficient         |

**Mnemonic**

“Fifth Generation advantages”

**Question 5(b) OR [4 marks]**

Draw OFDM transmitter and explain its working.

**Solution**

- **Modulation:** Maps bits to symbols (QPSK/QAM).
- **IFFT:** Inverse FFT converts frequency to time domain.
- **Cyclic Prefix:** Copies end samples to beginning.
- **DAC:** Digital to Analog Converter for transmission.

**Mnemonic**

“Orthogonal Frequency Division Multiplexing Transmitter”

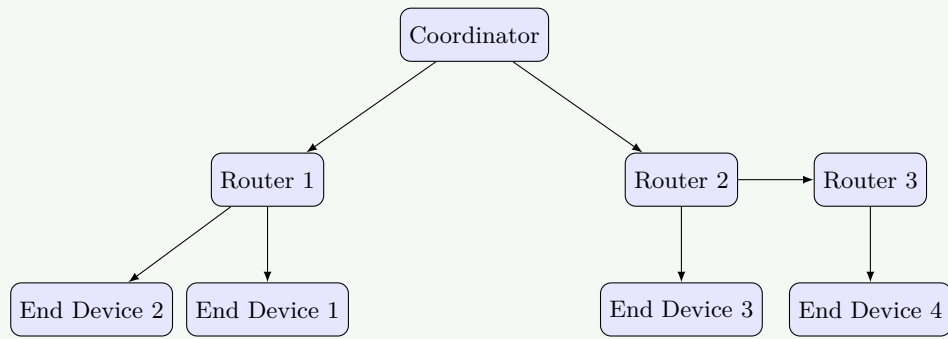
**Question 5(c) OR [7 marks]**

Explain Zigbee Technology & list its applications.

**Solution**

**Zigbee** is low-power wireless mesh networking standard based on IEEE 802.15.4.

| Parameter | Specification            |
|-----------|--------------------------|
| Range     | 10-100m                  |
| Data Rate | 250 kbps                 |
| Power     | Very low (battery years) |
| Topology  | Mesh network             |
| Frequency | 2.4 GHz globally         |

**Network Roles:**

- **Coordinator:** Network manager.
- **Router:** Forwards messages.
- **End Device:** Simple sensors/actuators.

**Applications:**

- Home automation (lights, thermostats)
- Industrial monitoring
- Smart grid systems
- Healthcare monitoring
- Agricultural sensors
- Building management systems

**Features:**

- **Self-healing:** Automatic route discovery.
- **Low cost:** Simple implementation.
- **Secure:** AES encryption.
- **Reliable:** Mesh redundancy.

**Mnemonic**

“Zigbee Mesh Network Applications”