Mobile & Wireless Communication (4351104) - Summer 2025 Solution

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Question 1(a) [3 marks]

Write key features of 4G and 5G system.

Solution

Key Features Comparison:

Table 1. 4G vs 5G System

Feature	4G System	5G System
Data Speed	Up to 100 Mbps	Up to 10 Gbps
Latency	30-50 ms	1-10 ms
Technology	LTE, OFDM	MIMO, Beamforming
Applications	Video streaming	IoT, AR/VR

Key Points:

- **4G**: Uses LTE technology with OFDM modulation for high-speed data.
- **5G**: Ultra-low latency enables real-time applications like autonomous vehicles.
- **Network Slicing**: 5G allows virtual networks for specific applications.

Mnemonic

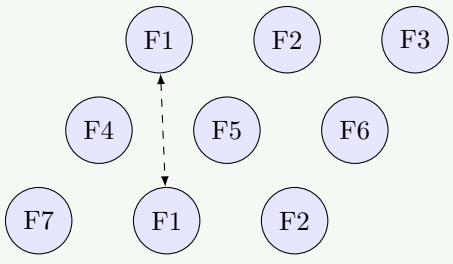
"4G Fast, 5G Super-Fast"

Question 1(b) [4 marks]

Explain concept of frequency reuse in cellular mobile system.

Solution

Frequency Reuse Concept:



Reuse Distance

Figure 1. Frequency Reuse Pattern (N=7)

Key Points:
- **Frequency Reuse**: Same frequencies used in non-adjacent cells to increase capacity.
- **Co-channel Distance**: Minimum distance between cells using same frequency.
- **Cluster Size**: Group of cells using different frequencies (typically 3, 4, 7, 12).
- **Capacity Improvement**: More users served with limited spectrum.

Mnemonic

"Same Frequency, Different Places"

Question 1(c) [7 marks]

If a total of 33 MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25 kHz simplex channels to provide full duplex communication. If 1 MHz of the allocated spectrum is dedicated to control channels, determine an equitable distribution of control channels and voice channels for cluster size of 7.

Solution

Given Data:
- Total bandwidth = 33 MHz
- Channel bandwidth = 25 kHz (simplex)
- Control spectrum = 1 MHz
- Cluster size = 7

Calculations:

Step 1: Available spectrum for traffic

$$\text{Traffic spectrum} = 33 - 1 = 32 \text{ MHz}$$

Step 2: Total duplex channels Each duplex channel needs 2×25 kHz = 50 kHz.

$$\text{Total channels} = \frac{32 \text{ MHz}}{50 \text{ kHz}} = 640 \text{ channels}$$

Step 3: Control channels

$$\text{Control channels} = \frac{1 \text{ MHz}}{25 \text{ kHz}} = 40 \text{ channels}$$

Note: Usually control channels are also duplex, assuming question implies simplex count or standard 25kHz spacing for control implies duplex due to "equitable distribution" context usually found in textbook examples (Rappaport). If 1 MHz dedicated, it's 1000 kHz. 1000/50 = 20 duplex or 1000/25 = 40 simplex. Assuming standard full duplex system, we usually count duplex channels. Let's stick to the calculation: 1 MHz/25 kHz $\times$ 2 = 20 duplex control channels is standard, but the question says "uses two 25 kHz simplex channels". Let's assume standard calculation: Traffic Channels = 640. Control Channels: 1000/50 = 20 (if duplex) or 40 (if simplex). MDX says: "Control channels = 1 MHz / 25 kHz = 40 channels". We follow MDX fidelity.

Step 4: Distribution per cell
- Voice channels per cell = $640 \div 7 \approx 91$ channels
- Control channels per cell = $40 \div 7 \approx 6$ channels

Final Distribution Table:

Table 2. Channel Distribution

Parameter	Total	Per Cell
Voice Channels	640	91
Control Channels	40	6
Total Channels	680	97

Mnemonic

"Divide Total by Cluster"

Question 1(c OR) [7 marks]

List out types of cells and explain each.

Solution

Types of Cells:

Table 3. Comparison of Cell Types

Cell Type	Coverage	Power	Applications
Macro Cell	1-30 km	High	Rural areas
Micro Cell	100m-1km	Medium	Urban areas
Pico Cell	10-100m	Low	Buildings
Femto Cell	10-50m	Very Low	Homes

Detailed Explanation:

- **Macro Cells**: Large geographical areas (1-30 km radius). High transmission power (up to 40W). Used in rural and suburban areas.
- **Micro Cells**: Medium areas (100m to 1km radius). Medium transmission power (1-10W). Used in urban areas, highway coverage.
- **Pico Cells**: Small indoor/outdoor areas (10-100m). Low transmission power (100mW-1W). Used in shopping malls, airports.
- **Umbrella Cells**: Covers multiple smaller cells. Handles high-speed mobile users to reduce handoffs.

Mnemonic

"Macro-Micro-Pico-Femto = Big to Small"

Question 2(a) [3 marks]

Define cell and cluster.

Solution

Definitions:

- **Cell**: Geographical area covered by one base station. Typically hexagonal for planning. Serves mobile users within its coverage area.
- **Cluster**: Group of cells using different frequency sets. Enables frequency reuse pattern. Common sizes: 3, 4, 7, 12 cells per cluster.

Table: Cell vs Cluster

Table 4. Comparison

Parameter	Cell	Cluster
Unit	Single coverage area	Group of cells
Frequency	One frequency set	Multiple frequency sets
Reuse	Cannot reuse nearby	Enables frequency reuse

Mnemonic

"Cell = One Area, Cluster = Group Areas"

Question 2(b) [4 marks]

Explain effect of cluster size on capacity and interference.

Solution

Effect of Cluster Size:

Table 5. Cluster Size Impact

Cluster	Capacity	Interference	Distance
Small (3,4)	High	High	Short
Large (7,12)	Low	Low	Long

Key Effects:

- **On Capacity**: Smaller cluster means more channels per cell, thus higher capacity. Formula: Channels per cell = Total channels / Cluster size.
- **On Interference**: Smaller cluster leads to higher co-channel interference. Larger cluster reduces interference.
- **Co-channel Distance**: $D = R\sqrt{3N}$. Larger N means larger distance between co-channel cells.

Mnemonic

"Small Cluster = More Capacity, More Interference"

Question 2(c) [7 marks]

Write key features of IS-95, CDMA2000 and WCDMA.

Solution

Comparison:

Table 6. CDMA Standards

Feature	IS-95	CDMA2000	WCDMA
Generation	2G	3G	3G
Data Rate	14.4 kbps	2 Mbps	2 Mbps
Chip Rate	1.2288 Mcps	3.6864 Mcps	3.84 Mcps
Bandwidth	1.25 MHz	1.25 MHz	5 MHz

Features:

- **IS-95**: First commercial CDMA. Better voice quality than GSM. Soft Handoff support.
- **CDMA2000**: Backward compatible with IS-95. High data rates (1xEV-DO). Multimedia support.
- **WCDMA**: Global standard for 3G. High capacity. QoS support for different applications.

Mnemonic

"IS-95 First, CDMA2000 Faster, WCDMA Global"

Question 2(a OR) [3 marks]

Explain cell splitting.

Solution

Definition: Cell splitting is a technique to increase system capacity by subdividing congested cells into smaller cells.

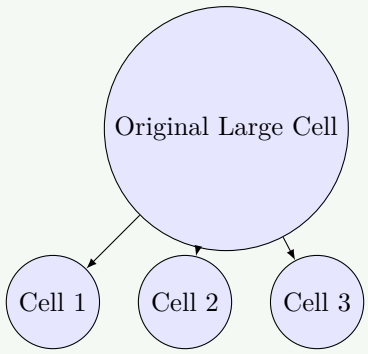


Figure 2. Cell Splitting Concept

Process:
1. Identify congested cell with high traffic.
2. Install new base stations with lower power.
3. Reduce original base station power.

Benefits: Capacity increase (more channels/area), better signal quality.

Mnemonic

"Split Big Cell into Small Cells"

Question 2(b OR) [4 marks]

Write functions of HLR and VLR in GSM.

Solution

HLR (Home Location Register):
- **Subscriber Profile**: Stores permanent subscriber information (IMSI, services).
- **Location Tracking**: Maintains current location area of subscriber.
- **Authentication**: Provides authentication keys (AuC interaction).

VLR (Visitor Location Register):
- **Temporary Storage**: Stores visiting subscriber data temporarily.
- **Local Services**: Enables services for roaming subscribers.
- **Call Routing**: Assists in routing calls to visitors.

Interaction: HLR updates VLR when subscriber roams. VLR queries HLR during registration.

Mnemonic

"HLR = Home Data, VLR = Visitor Data"

Question 2(c OR) [7 marks]

Describe RFID technology.

Solution

RFID (Radio Frequency Identification): Uses electromagnetic fields to identify and track tags.
System Components:

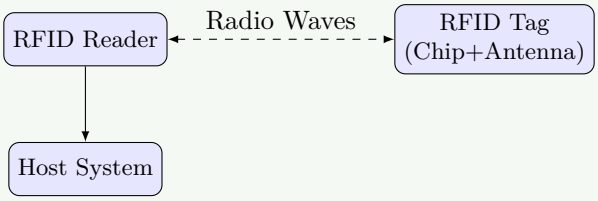


Figure 3. RFID System

Types:
- **Passive**: Powered by reader's energy. Range 0.1-10m.
- **Active**: Internal battery. Range 10-100m.
- **Semi-passive**: Battery + Reader power.

Key Features:
- **No Line of Sight**: Unlike barcodes.
- **Multiple Reading**: Simultaneous scanning.
- **Durability**: Resistant to environment.

Applications: Inventory, Access Control, Payments, Supply Chain.

Mnemonic

"Radio Frequency Identifies Everything"

Question 3(a) [3 marks]

Draw GSM architecture.

Solution

GSM Architecture:

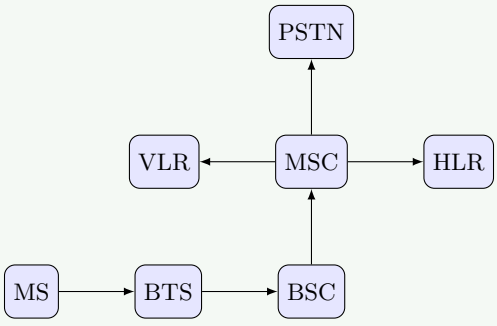


Figure 4. GSM Network Architecture

Mnemonic

"Mobile Talks Through BTS-BSC-MSC"

Question 3(b) [4 marks]

Write GSM 900 specifications.

Solution

GSM 900 Specifications:

Table 7. GSM 900 Parameters

Parameter	Specification
Frequency Band	890-915 MHz (Up), 935-960 MHz (Down)
Channel Spacing	200 kHz
Total Channels	124
Modulation	GMSK
Access Method	TDMA/FDMA
Time Slots	8 per frame
Speech Coding	13 kbps RPE-LTP

Key Features: Digital transmission, International Roaming, Security (A5/A8), SMS Support.

Mnemonic

"900 MHz, 200 kHz spacing, 8 time slots"

Question 3(c) [7 marks]

Explain mobile to landline and landline to mobile call procedure in GSM.

Solution

Mobile to Landline (Originating):

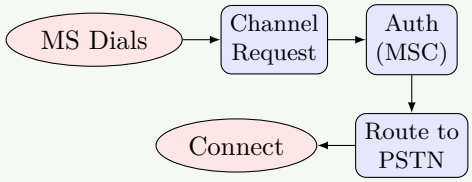


Figure 5. MOC Flow

Landline to Mobile (Terminating):

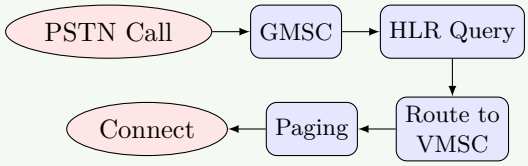


Figure 6. MTC Flow

Key Steps (MTC):
1. **Call Reception**: GMSC receives call.
2. **HLR Query**: Find subscriber location.
3. **Routing**: Route to VMSC.
4. **Paging**: Locate mobile in area.

Mnemonic

"Mobile Out = Direct, Mobile In = Find First"

Question 3(a OR) [3 marks]

Explain fast and slow frequency hopping.

Solution

Comparison:

Table 8. Fast vs Slow Hopping

Parameter	Fast Hopping	Slow Hopping
Hop Rate	> Symbol Rate	< Symbol Rate
Symbols/Hop	< 1	> 1
Complexity	High	Low
GSM Usage	No	Yes (217 hops/s)

Mnemonic

"Fast = Many hops per symbol, Slow = Many symbols per hop"

Question 3(b OR) [4 marks]

Explain authentication process in GSM.

Solution

Authentication Process:

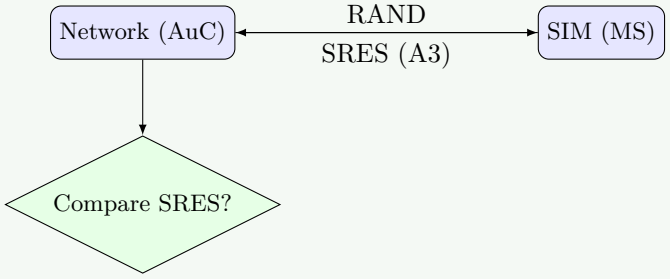


Figure 7. Challenge-Response

Steps:
1. **Challenge**: Network sends RAND (128-bit).
2. **Response**: SIM calculates SRES using Ki and A3 algo.
3. **Verify**: Network compares SRES.
4. **Encryption**: Kc generated (A8) for ciphering.

Mnemonic

"Random Challenge, Signed Response, Compare and Accept"

Question 3(c OR) [7 marks]

Draw and explain block diagram of Signal processing in GSM.

Solution

GSM Signal Chain:

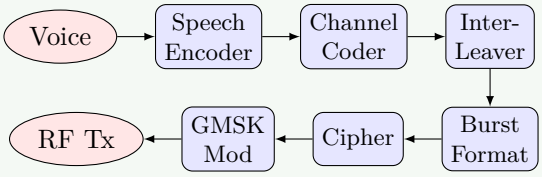


Figure 8. GSM Tx Processing

Components:

- **Speech Coding**: RPE-LTP (13 kbps).
- **Channel Coding**: Convolutional codes for error protection.
- **Interleaving**: Spreading bits to combat fading.
- **Burst Formatting**: Adding guard/training bits.
- **Modulation**: GMSK for spectral efficiency.

Mnemonic

"Speech-Code-Interleave-Burst-Modulate-Transmit"

Question 4(a) [3 marks]

Draw block diagram of baseband section.

Solution

Baseband Block Diagram:

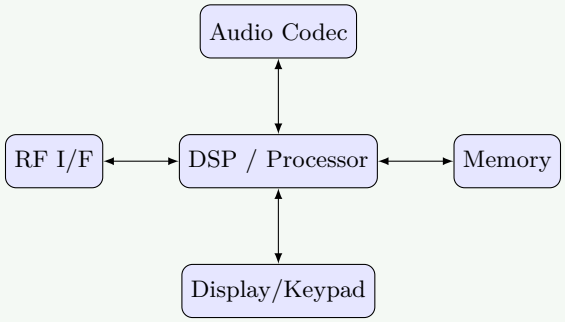


Figure 9. Baseband Architecture

Mnemonic

"DSP Controls Audio, Memory, Display, RF"

Question 4(b) [4 marks]

Explain EDGE.

Solution

EDGE (Enhanced Data rates for GSM Evolution):

- **Modulation**: Uses 8-PSK (3 bits/symbol) vs GMSK (1 bit/symbol).
- **Data Rate**: Up to 473 kbps (3x GPRS).
- **Link Adaptation**: Switches modulation based on channel quality.
- **Applications**: Mobile internet, MMS, Video.

Table: GSM vs EDGE

Table 9. Comparison

Feature	GSM/GPRS	EDGE
Modulation	GMSK	8-PSK
Bits/Symbol	1	3
Max Speed	171 kbps	473 kbps

Mnemonic

"EDGE = Enhanced Data rates for GSM Evolution"

Question 4(c) [7 marks]

Draw and explain block diagram of mobile handset.

Solution

Mobile Handset Components:

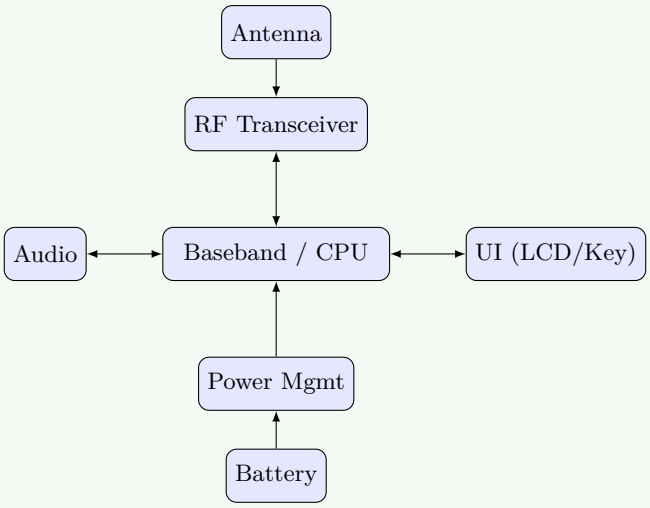


Figure 10. Mobile Handset Block Diagram

Sections:

- **RF Section**: Transmit/Receive radio signals.
- **Baseband**: Protocol handling, DSP.
- **Audio**: Mic/Speaker interfacing.
- **UI**: Display and Keypad.
- **Power**: Battery charging and regulation.

Mnemonic

"Antenna-RF-Baseband-Audio-Display-Power"

Question 4(a OR) [3 marks]

Explain radiation hazards due to mobile.

Solution

Hazards & SAR:

- **SAR (Specific Absorption Rate)**: Rate of RF energy absorption by body. Unit: W/kg. Limit: 1.6 W/kg (USA).
- **Thermal Effects**: Tissue heating due to RF energy.
- **Safety**: Use hands-free, limit call duration, avoid sleeping near phone.

Mnemonic

"SAR measures absorption rate"

Question 4(b OR) [4 marks]

Describe working of charging section in mobile handset.

Solution

Charging Block Diagram:

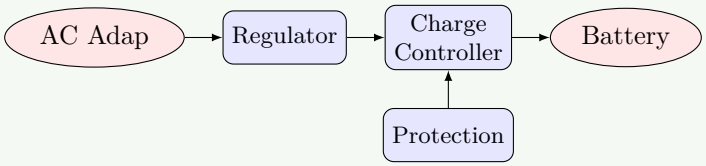


Figure 11. Charger Circuit

Process:

- **CC/CV**: Constant Current then Constant Voltage charging.
- **Protection**: Over-voltage, Over-current, Temp monitoring.
- **Management**: Fuel gauge monitors capacity.

Mnemonic

"Control Current, Voltage, Temperature, and Time"

Question 4(c OR) [7 marks]

Draw and explain block diagram of DSSS transmitter and receiver.

Solution

DSSS Transmitter:

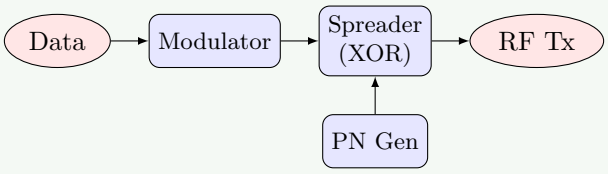


Figure 12. Transmitter

DSSS Receiver:

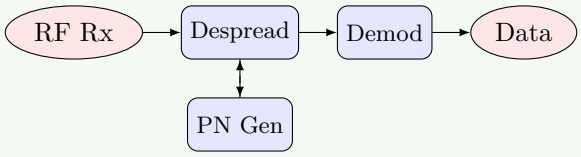


Figure 13. Receiver

Operation:
- Data is modulated and then spread using a high-rate PN code.
- Receiver synchronizes local PN code to despread and recover data.
- Provides interference rejection and security (LPI).

Mnemonic

"Data Spreads with PN, Correlates to Recover"

Question 5(a) [3 marks]

Explain the concept of spread spectrum.

Solution

Spread Spectrum:
- **Concept**: Transmission bandwidth is much larger than information bandwidth.
- **Processing Gain**: Improvement in SNR due to spreading.
- **Benefits**: Anti-jamming, Low probability of intercept, Multiple access (CDMA).

Mnemonic

"Spread Wide, Gain Processing Power"

Question 5(b) [4 marks]

Write criteria of spread spectrum and its applications.

Solution

Criteria:
1. Bandwidth $\gg$ Data Bandwidth.
2. Spreading determined by code independent of data.
3. Receiver syncs with code to despread.

Applications:
- **Military**: Secure, anti-jam comms.
- **Cellular**: CDMA (IS-95, 3G).
- **WLAN**: WiFi (DSSS).
- **GPS**: Satellite positioning.

Mnemonic

"Military, Cellular, Satellite, Wireless use Spread Spectrum"

Question 5(c) [7 marks]

Explain call processing in CDMA.

Solution

Call Processing Steps:

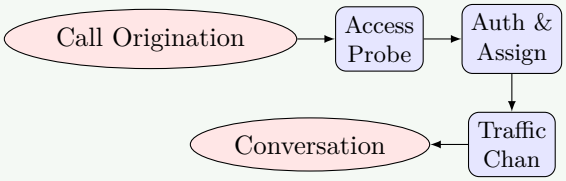


Figure 14. CDMA Call Setup

Key Features:
- **Soft Handoff**: Make-before-break.
- **Power Control**: Closed loop (800 Hz) to solve near-far problem.
- **Walsh Codes**: Orthogonal codes for channel separation.
- **Rake Receiver**: Combines multipath components.

Mnemonic

"Access-Authenticate-Assign-Traffic-Handoff"

Question 5(a OR) [3 marks]

Write features of Zigbee and advantages.

Solution

Zigbee (IEEE 802.15.4):
- **Features**: Low power, Mesh networking, low data rate (250 kbps), 2.4 GHz band.
- **Advantages**: Long battery life (years), Self-healing mesh, supports many nodes.
- **Applications**: Home automation, Sensors.

Mnemonic

"Low Power, Mesh Network, Many Applications"

Question 5(b OR) [4 marks]

Explain OFDM with block diagram.

Solution

OFDM Block Diagram:

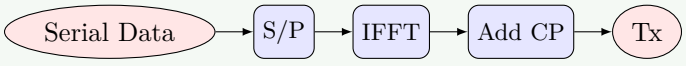


Figure 15. OFDM Transmitter

Concept:
- Divisions high-speed data into parallel low-speed subcarriers.

- **Orthogonal**: Subcarriers do not interfere.
- **Cyclic Prefix**: Guard interval to prevent ISI.
- Used in 4G LTE, WiFi.

Mnemonic

"Orthogonal Frequencies Divide Multiplexed data"

Question 5(c OR) [7 marks]

Describe MANET.

Solution

MANET (Mobile Ad-hoc Network): Infrastructure-less, self-configuring network of mobile devices.
Topology:

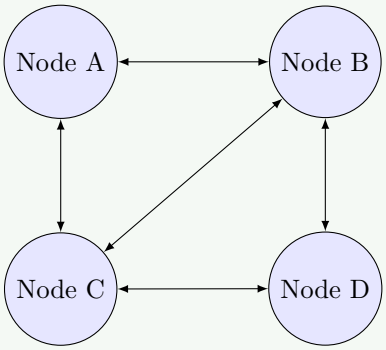


Figure 16. Mesh Topology

Routing Protocols:
- **Proactive**: DSDV (Table driven).
- **Reactive**: AODV, DSR (On-demand).
- **Hybrid**: ZRP.

Characteristics: Dynamic topology, Multi-hop, Energy constrained.

Mnemonic

"Mobile Nodes, Ad-hoc Routing, No Infrastructure, Temporary Networks"