

Subject Name Solutions

4351104 – Summer 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Explain selective cell.

Solution

Table 1: Selective Cell Characteristics

| Feature | Description |
|-------------|--------------------------------------|
| Purpose | Provides coverage for specific areas |
| Size | Small coverage area |
| Application | Indoor locations, tunnels, buildings |
| Antenna | Directional antenna system |

- **Selective coverage:** Targets specific geographical areas needing signal
- **Indoor solution:** Primarily used for building coverage enhancement
- **Directional transmission:** Uses focused beam patterns for efficiency

Mnemonic

“Select Special Spots”

Question 1(b) [4 marks]

Draw and explain umbrella cell.

Solution

Umbrella Cell

+{-{-}{-}+}

/ {}

/ {}

+ +

/ { / }

+ + + +

Micro Pico

Cells Cells

Table 2: Umbrella Cell Features

| Parameter | Description |
|-----------|--------------------------------|
| Coverage | Large area coverage |
| Purpose | Overlays smaller cells |
| Handoff | Manages inter-cell transitions |
| Capacity | Handles overflow traffic |

- **Large coverage:** Provides wide area signal coverage over smaller cells
- **Traffic management:** Handles overflow from micro and pico cells
- **Seamless handoff:** Ensures continuous communication during movement

Mnemonic

“Umbrella Covers All”

Question 1(c) [7 marks]

What is the cell? Explain frequency reuse.

Solution

Table 3: Cell and Frequency Reuse Concepts

| Concept | Definition | Purpose |
|-----------------|---|----------------------|
| Cell | Geographic coverage area | Service provision |
| Frequency Reuse | Same frequency in different cells | Spectrum efficiency |
| Cluster | Group of cells with unique frequencies | Interference control |
| Reuse Distance | Minimum distance between same frequencies | Signal quality |

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Cell Concept] --> B[Hexagonal Shape]
    A --> C[Base Station Coverage]
    D[Frequency Reuse] --> E[Cluster Pattern]
    D --> F[Co-channel Reuse]
    E --> G[N=4,7,12 patterns]
{Highlighting}
{Shaded}
```

- **Cell definition:** Geographical area covered by one base station antenna
- **Hexagonal pattern:** Most efficient shape for coverage without gaps
- **Frequency reuse:** Same frequencies used in non-adjacent cells for capacity
- **Cluster size:** Determines frequency reuse pattern (N=4,7,12)
- **Co-channel interference:** Controlled by minimum reuse distance

Mnemonic

“Cells Reuse Frequencies Efficiently”

Question 1(c) OR [7 marks]

Explain cellular concept in detail.

Solution

Table 4: Cellular System Components

| Component | Function | Benefit |
|--------------------|------------------------|-----------------------|
| Cell Division | Area split into cells | Coverage optimization |
| Base Stations | Serve individual cells | Signal transmission |
| Mobile Switching | Call routing | Network connectivity |
| Frequency Planning | Spectrum allocation | Interference control |

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Large Coverage Area] --{} B[Cell Division]
    B --{} C[Multiple Base Stations]
    C --{} D[Frequency Reuse]
    D --{} E[High Capacity System]
{Highlighting}
{Shaded}
```

- **Area division:** Large service area divided into smaller hexagonal cells
- **Power control:** Low power transmitters reduce interference
- **Frequency efficiency:** Same frequencies reused in distant cells
- **Capacity increase:** More simultaneous users served
- **Seamless coverage:** Continuous service across all cells

Mnemonic

“Divide Area For Better Service”

Question 2(a) [3 marks]

Define full forms: (i) IMEI (ii) LTE (iii) GSM

Solution

Table 5: Full Forms

| Abbreviation | Full Form | Purpose |
|--------------|---|------------------------|
| IMEI | International Mobile Equipment Identity | Device identification |
| LTE | Long Term Evolution | 4G technology standard |
| GSM | Global System for Mobile Communication | 2G cellular standard |

Mnemonic

“Identity, Long-term, Global”

Question 2(b) [4 marks]

Explain MAHO in detail.

Solution

Table 6: MAHO Characteristics

| Feature | Description |
|-------------|----------------------------------|
| Full Form | Mobile Assisted Handoff |
| Function | Mobile helps in handoff decision |
| Measurement | Signal strength monitoring |
| Reporting | Mobile reports to network |

sequenceDiagram

```
Mobile{-Base Station: Signal strength report}
Base Station{-MSC: Handoff request}
MSC{-Target BS: Prepare handoff}
Target BS{-MSC: Ready confirmation}
MSC{-Mobile: Handoff command}
```

- **Mobile assistance:** Mobile unit measures neighboring cell signals
- **Signal reporting:** Continuous measurement reports sent to network
- **Decision support:** Network uses mobile data for handoff decisions
- **Quality improvement:** Better handoff decisions with mobile input

Mnemonic

“Mobile Assists Network Decisions”

Question 2(c) [7 marks]

Explain GSM architecture with diagram

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Mobile Station] --{} B[Base Transceiver Station]
    B --{} C[Base Station Controller]
    C --{} D[Mobile Switching Center]
    D --{} E[Home Location Register]
    D --{} F[Visitor Location Register]
    D --{} G[Authentication Center]
    D --{} H[PSTN/ISDN]
{Highlighting}
{Shaded}
```

Table 7: GSM Architecture Components

| Component | Function | Purpose |
|-----------|---------------------------|---------------------------|
| MS | Mobile Station | User equipment |
| BTS | Base Transceiver | Radio interface |
| BSC | Base Station Controller | Radio resource management |
| MSC | Mobile Switching Center | Call switching |
| HLR | Home Location Register | Subscriber database |
| VLR | Visitor Location Register | Temporary subscriber data |

- **Radio subsystem:** BTS and BSC handle radio communications
- **Network subsystem:** MSC, HLR, VLR manage calls and mobility
- **Database management:** HLR stores permanent, VLR stores temporary data
- **Authentication:** AuC provides security functions

Mnemonic

“Mobile Base Network Database”

Question 2(a) OR [3 marks]

Explain cell splitting.

Solution

Table 8: Cell Splitting Process

| Step | Action | Result |
|------|-----------------------|-------------------------------|
| 1 | Reduce transmit power | Smaller coverage |
| 2 | Add new base stations | Fill coverage gaps |
| 3 | Frequency planning | Maintain interference control |
| 4 | Capacity increase | More users served |

- **Power reduction:** Original cell power decreased to shrink coverage
- **New cells:** Additional base stations installed in coverage gaps
- **Capacity gain:** More cells mean higher user capacity in same area

Mnemonic

“Split Cells Double Capacity”

Question 2(b) OR [4 marks]

What is handoff? Explain soft and hard handoffs.

Solution

Table 9: Handoff Types Comparison

| Type | Process | Technology | Quality |
|--------------|-----------------|------------|---------------------|
| Hard Handoff | Break-then-make | GSM, TDMA | Brief interruption |
| Soft Handoff | Make-then-break | CDMA | Seamless transition |

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Mobile Moving] --> B[Handoff Type]
    B --> C[Disconnect old, Connect new]
    B --> D[Connect new, then disconnect old]
{Highlighting}
{Shaded}
```

- **Handoff definition:** Process of transferring call from one cell to another
- **Hard handoff:** Connection broken before establishing new connection
- **Soft handoff:** New connection established before breaking old one
- **Quality difference:** Soft handoff provides better call quality

Mnemonic

“Hard Breaks, Soft Connects”

Question 2(c) OR [7 marks]

Explain GSM signal processing with diagram

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
```

```

A[Voice Input] --> B[Speech Codec]
B --> C[Channel Coding]
C --> D[Interleaving]
D --> E[Encryption]
E --> F[Burst Formatting]
F --> G[Modulation]
G --> H[RF Transmission]

```

{Highlighting}
{Shaded}

Table 10: GSM Signal Processing Stages

| Stage | Function | Purpose |
|----------------|------------------------|--------------------------|
| Speech Codec | Voice compression | Bandwidth efficiency |
| Channel Coding | Error correction | Transmission reliability |
| Interleaving | Burst error protection | Data integrity |
| Encryption | Security | Privacy protection |
| Modulation | RF conversion | Air interface |

- **Speech processing:** Voice compressed using RPE-LTP codec
- **Error protection:** Convolutional coding adds redundancy
- **Security layer:** A5 algorithm encrypts data
- **Burst structure:** Data organized in time slots
- **Modulation:** GMSK modulation for RF transmission

Mnemonic

“Voice Coded Interleaved Encrypted Modulated”

Question 3(a) [3 marks]

Explain cell sectoring.

Solution

Table 11: Cell Sectoring Benefits

| Feature | Description |
|-----------------|--|
| Antenna Pattern | Directional instead of omnidirectional |
| Sectors | 3 or 6 sectors per cell |
| Capacity | 3x or 6x capacity increase |
| Interference | Reduced co-channel interference |

- **Directional antennas:** Replace omnidirectional with sector antennas
- **Capacity multiplication:** Each sector treated as separate cell
- **Interference reduction:** Directional pattern reduces interference

Mnemonic

“Sector Antennas Triple Capacity”

Question 3(b) [4 marks]

Explain GSM call procedure.

Solution

```

sequenceDiagram
    Mobile->>BTS: Call request

```

```

BTS{-BSC: Forward request}
BSC{-MSC: Route call}
MSC{-HLR: Authenticate user}
HLR{-MSC: Authentication OK}
MSC{-PSTN: Establish connection}

```

Table 12: Call Setup Steps

| Step | Process | Purpose |
|------|--------------------|---------------------|
| 1 | Authentication | User verification |
| 2 | Channel allocation | Resource assignment |
| 3 | Call routing | Path establishment |
| 4 | Connection setup | Communication link |

- **Authentication:** Network verifies subscriber identity
- **Resource allocation:** Traffic channel assigned to call
- **Routing:** Call path determined through network
- **Connection:** End-to-end communication established

Mnemonic

“Authenticate Allocate Route Connect”

Question 3(c) [7 marks]

Explain GPRS.

Solution

Table 13: GPRS Features

| Feature | Description | Benefit |
|--------------|------------------------------|---------------|
| Technology | General Packet Radio Service | Data service |
| Data Rate | Up to 114 kbps | High speed |
| Connection | Packet switched | Always on |
| Applications | Internet, email | Data services |

graph TB

```

A[GPRS Network] --{-} B[SGSN]}
A --{-} C[GGSN]}
B --{-} D[Packet Data]}
C --{-} E[Internet Gateway]}
F[Mobile] --{-} B}
C --{-} G[External Networks]}

```

- **Packet switching:** Data transmitted in packets, not circuits
- **Always-on connection:** No dial-up required for data access
- **Higher speeds:** Significant improvement over circuit-switched data
- **New nodes:** SGSN and GGSN added to GSM architecture
- **Internet access:** Direct connection to IP networks

Mnemonic

“General Packet Radio Service”

Question 3(a) OR [3 marks]

Explain advantage of CDMA

Solution

Table 14: CDMA Advantages

| Advantage | Description |
|-----------|-------------------------|
| Capacity | Higher user capacity |
| Security | Built-in encryption |
| Quality | Better voice quality |
| Power | Efficient power control |

- **Increased capacity:** More users per frequency band
- **Enhanced security:** Spread spectrum provides natural encryption
- **Soft handoff:** Better call quality during handoffs

Mnemonic

“Capacity Security Quality”

Question 3(b) OR [4 marks]

Explain frequency hopping techniques.

Solution

Table 15: Frequency Hopping Types

| Type | Hopping Rate | Application |
|---------|--------------------------|-------------|
| Slow FH | Less than symbol rate | GSM |
| Fast FH | Greater than symbol rate | Military |

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Data] --> B[Spread Spectrum]
    B --> C[Frequency Synthesizer]
    C --> D[Hop Sequence]
    D --> E[RF Transmission]
{Highlighting}
{Shaded}
```

- **Frequency hopping:** Carrier frequency changes according to pattern
- **Interference resistance:** Reduces effect of narrowband interference
- **Security enhancement:** Difficult to intercept hopping signals
- **GSM implementation:** Slow frequency hopping used for quality

Mnemonic

“Frequency Hops For Security”

Question 3(c) OR [7 marks]

Explain EDGE.

Solution

Table 16: EDGE Specifications

| Parameter | Value | Improvement |
|---------------|--------------------------------------|---------------------|
| Full Form | Enhanced Data rate for GSM Evolution | - |
| Data Rate | Up to 384 kbps | 3x GPRS |
| Modulation | 8-PSK | Higher order |
| Compatibility | GSM/GPRS | Backward compatible |

graph TB

```

A[EDGE Enhancement] --> B[8-PSK Modulation]
A --> C[Link Adaptation]
A --> D[Incremental Redundancy]
B --> E[Higher Data Rate]
C --> F[Better Quality]
D --> G[Error Correction]

```

- **Enhanced modulation:** 8-PSK instead of GMSK increases data rate
- **Link adaptation:** Modulation scheme adapts to channel conditions
- **Incremental redundancy:** Improved error correction mechanism
- **Backward compatibility:** Works with existing GSM/GPRS infrastructure
- **3G stepping stone:** Bridge between 2G and 3G technologies

Mnemonic

“Enhanced Data Gets Excellence”

Question 4(a) [3 marks]

Draw FHSS transmitter block diagram

Solution

```

Data --> Modulator --> Frequency --> RF Amp --> Antenna
Input      Synthesizer
           \~{}
           PN Sequence
           Generator

```

Table 17: FHSS Components

| Component | Function |
|-----------------------|---------------------------|
| PN Generator | Produces hopping sequence |
| Frequency Synthesizer | Changes carrier frequency |
| Modulator | Modulates data |

Mnemonic

“Data Modulated Frequency Hops”

Question 4(b) [4 marks]

Explain call processing in CDMA

Solution

Table 18: CDMA Call Processing

| Phase | Process | Purpose |
|----------------|-----------------------|--------------------|
| Access | System access | Initial connection |
| Authentication | Identity verification | Security |
| Traffic | Communication | Data transfer |

Release

Call termination

Resource cleanup

- **System access:** Mobile acquires pilot channel and synchronizes
- **Authentication:** Network verifies subscriber credentials
- **Traffic state:** Active communication with power control
- **Call release:** Resources freed when call ends

Mnemonic

“Access Authenticate Transfer Release”

Question 4(c) [7 marks]

Draw OFDM receiver and explain its working

Solution

RF Input → Down Converter → ADC → Remove Cyclic Prefix → FFT to Serial Converter → Parallel Decoder → Channel Output → Data

Table 19: OFDM Receiver Functions

| Component | Function | Purpose |
|-----------------|------------------------|-----------------------|
| Down Converter | RF to baseband | Frequency conversion |
| ADC | Analog to digital | Signal digitization |
| Remove CP | Cyclic prefix removal | ISI elimination |
| FFT | Fast Fourier Transform | Subcarrier separation |
| Channel Decoder | Error correction | Data recovery |

- **RF processing:** Converts received RF signal to baseband
- **Digital conversion:** ADC samples the analog signal
- **Prefix removal:** Cyclic prefix removed to eliminate ISI
- **FFT processing:** Separates orthogonal subcarriers
- **Data recovery:** Channel decoding recovers original data

Mnemonic

“Receive Convert Remove Transform Decode”

Question 4(a) OR [3 marks]

Explain radiation hazard due to mobile.

Solution

Table 20: Mobile Radiation Effects

| Parameter | Value | Effect |
|-----------|--------------------------|-------------------|
| SAR | Specific Absorption Rate | Tissue heating |
| Frequency | 900/1800 MHz | Penetration depth |
| Power | Transmit power | Exposure level |

- **SAR measurement:** Specific Absorption Rate measures energy absorption
- **Thermal effects:** High SAR can cause tissue heating
- **Safety limits:** International standards limit SAR values

Mnemonic

“SAR Safety Absorption Rate”

Question 4(b) OR [4 marks]

Explain Li-Po type batteries used in mobile handset.

Solution

Table 21: Li-Po Battery Characteristics

| Feature | Description | Advantage |
|-----------|----------------------|---------------------|
| Chemistry | Lithium Polymer | High energy density |
| Shape | Flexible form factor | Design freedom |
| Weight | Lightweight | Portability |
| Charging | Fast charging | User convenience |

- **Polymer electrolyte:** Uses polymer instead of liquid electrolyte
- **Flexible packaging:** Can be shaped to fit device design
- **High energy density:** More capacity in smaller size
- **Fast charging:** Supports rapid charging protocols

Mnemonic

“Lithium Polymer Power”

Question 4(c) OR [7 marks]

Explain mobile handset block diagram.

Solution

```
graph TB
    A[Antenna] --- B[RF Section]
    B --- C[Baseband Processor]
    C --- D[Audio Codec]
    C --- E[Display Controller]
    C --- F[Keypad Interface]
    G[Battery] --- H[Power Management]
    H --- B
    H --- C
    I[SIM Interface] --- C
```

Table 22: Mobile Handset Components

| Section | Function | Purpose |
|------------------|----------------------------|---------------------|
| RF Section | Radio frequency processing | Air interface |
| Baseband | Digital signal processing | Protocol handling |
| Audio Codec | Voice processing | Sound conversion |
| Power Management | Battery control | Power efficiency |
| SIM Interface | Subscriber identity | User authentication |

- **RF section:** Handles transmission and reception of radio signals
- **Baseband processor:** Implements communication protocols
- **Audio subsystem:** Processes voice and audio signals
- **Power management:** Controls battery usage and charging
- **User interface:** Display, keypad, and user interaction

Mnemonic

“Radio Baseband Audio Power Interface”

Question 5(a) [3 marks]

Compare CDMA and GSM

Solution

Table 23: CDMA vs GSM Comparison

| Feature | CDMA | GSM |
|---------------|---------------|---------------|
| Access Method | Code Division | Time Division |
| Capacity | Higher | Lower |
| Handoff | Soft | Hard |
| SIM Card | Not required | Required |

Mnemonic

“Code vs Time Division”

Question 5(b) [4 marks]

Explain HSDPA.

Solution

Table 24: HSDPA Features

| Feature | Description |
|------------|-----------------------------------|
| Full Form | High Speed Downlink Packet Access |
| Data Rate | Up to 14.4 Mbps |
| Technology | 3.5G enhancement |
| Direction | Downlink optimization |

- **3.5G technology:** Enhancement to 3G UMTS system
- **High speed downlink:** Optimized for download applications
- **Adaptive modulation:** QPSK to 16-QAM based on channel
- **Fast scheduling:** 2ms scheduling intervals

Mnemonic

“High Speed Download Access”

Question 5(c) [7 marks]

Explain architecture, features and advantage of Bluetooth.

Solution

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Application Layer] --> B[L2CAP]
    B --> C[HCI]
    C --> D[Link Manager]
    D --> E[Baseband]
```

E {-{-}} F[Radio Layer]}
 {Highlighting}
 {Shaded}

Table 25: Bluetooth Features

| Feature | Description | Advantage |
|-----------|-----------------|-----------------------|
| Range | 10 meters | Personal area network |
| Frequency | 2.4 GHz ISM | Unlicensed band |
| Topology | Star/Scatternet | Flexible connections |
| Power | Low power | Battery efficiency |

Table 26: Bluetooth Applications

| Application | Use Case |
|-------------|-------------------------|
| Audio | Wireless headphones |
| Data | File transfer |
| Input | Wireless keyboard/mouse |
| Networking | Internet sharing |

- **Short range:** Designed for personal area networks
- **Low power:** Optimized for battery-powered devices
- **Frequency hopping:** 79 channels for interference resistance
- **Master-slave:** One master can connect to 7 slaves
- **Applications:** Audio, data transfer, input devices

Mnemonic

“Blue Personal Area Network”

Question 5(a) OR [3 marks]

Explain basic concept of RFID.

Solution

Table 27: RFID Components

| Component | Function |
|----------------|----------------------------|
| RFID Tag | Stores identification data |
| RFID Reader | Reads tag information |
| Antenna | RF communication |
| Backend System | Data processing |

- **Radio frequency identification:** Uses RF waves for identification
- **Contactless operation:** No physical contact required
- **Automatic identification:** Reads tags automatically in range

Mnemonic

“Radio Frequency Identifies”

Question 5(b) OR [4 marks]

Explain architecture of 5G system.

Solution

Table 28: 5G Architecture Components

| Component | Function |
|-----------|------------------------------|
| gNodeB | 5G base station |
| AMF | Access and Mobility Function |
| SMF | Session Management Function |
| UPF | User Plane Function |

- **Service-based architecture:** Modular network functions
- **Network slicing:** Virtual networks for different services
- **Edge computing:** Processing closer to users
- **Massive MIMO:** Multiple antenna technology

Mnemonic

“Service Based Network Slicing”

Question 5(c) OR [7 marks]

Explain MANET in detail.

Solution

Table 29: MANET Characteristics

| Feature | Description | Benefit |
|-----------------|-------------------------|-------------------------|
| Infrastructure | Infrastructure-less | No base stations needed |
| Mobility | Mobile nodes | Dynamic topology |
| Routing | Multi-hop routing | Extended coverage |
| Self-organizing | Automatic configuration | Easy deployment |

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Node A] --{} B[Node B]}
    B --{} C[Node C]}
    A --{} D[Node D]}
    C --{} E[Node E]}
    D --{} E}
    B --{} E}
{Highlighting}
{Shaded}
```

Table 30: MANET vs Cellular Network

| Parameter | MANET | Cellular |
|----------------|-----------|--------------------------|
| Infrastructure | None | Base stations required |
| Topology | Dynamic | Fixed |
| Range | Multi-hop | Single hop |
| Cost | Low | High infrastructure cost |

- **Mobile Ad-hoc Network:** Self-configuring network of mobile devices
- **No infrastructure:** Nodes communicate directly without base stations
- **Dynamic routing:** Routes change as nodes move
- **Multi-hop communication:** Messages relay through intermediate nodes
- **Applications:** Military, disaster recovery, sensor networks

Mnemonic

“Mobile Adhoc Network”