Savitribai Phule Pune University
Final Year of Information Technology (2019 Course)
(With effect from Academic Year 2022-23)

Semester VII

Course Code	Course Name	Teaching Scheme(Hours/week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Termwork	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
414441	Information and Storage Retrieval	03	-	-	30	70	-	-	-	100	3	-	-	3
414442	Software Project Management	03	-	-	30	70	-	-	-	100	3	-	-	3
414443	Deep Learning	03	-	-	30	70	-	-	-	100	3	-	-	3
414444	Elective III	03	-	-	30	70	-	-	-	100	3	-	-	3
414445	Elective IV	03	-	-	30	70	-	-	-	100	3	-	-	3
414446	Lab Practice III	-	04	-	-	-	25	-	25	50	-	2	-	2
414447	Lab Practice IV	-	02	-	-	-	25	25	-	50	-	1	-	1
414448	Project Stage-I	-	-	02	-	-	50	-	-	50	-	-	2	2
414449	Audit Course7													
										Total Credit	15	03	02	20
	Total	15	06	02	150	350	100	25	25	650	15	03	02	20

Elective III:

- Mobile Computing
- High Performance Computing
- Multimedia Technology
- Smart Computing

Elective IV:

- Bioinformatics
- Introduction to DevOps
- Computer Vision
- Wireless Communications

Lab Practice-III:

It is based on subjects:

- Information and Storage Retrieval

Lab Practice-IV:

It is based on subjects:

- Deep Learning

B.E. (INFORMATION TECHNOLOGY)

SEMESTER-VII

Time– 2.00 p.m. to 3.00 p.m.

Day& Date	SUBJECT (2019 Course)	SUBJECT CODE
Tuesday 19/08/2025	Information and Storage Retrieval	414441
Wednesday 20/08/2025	Software Project Management	414442
Thursday 21/08/2025	Deep Learning	414443
Friday 22/08/2025	(ELECTIVE-III) Mobile Computing	414444A
	(ELECTIVE-III) High Performance Computing	414444B
	(ELECTIVE-III) Multimedia Technology	414444C
	(ELECTIVE-III) Smart Computing	414444D
Saturday 23/08/2025	(ELECTIVE-IV)Bioinformatics	414445A
	(ELECTIVE-IV) Introduction to DevOps	414445B
	(ELECTIVE-IV) Computer Vision	414445C
	(ELECTIVE-IV) Wireless Communications	414445D

COURSE CONTENTS		
Unit I	**Introduction to Wireless Communication**	**(6hrs)**
Evolution of mobile communications, Types of Wireless Communication: Satellite Communication, Microwave Communication, Infrared, Generation of Cellular network, 2G/3G/4G/5G/6G.		
Unit II	**Fundamentals of Cellular and LTE Technology**	**(6hrs)**
Cellular system, hexagonal geometry cell and concept of frequency reuse, Need of LTE Long Term Evolution (LTE) Technology fundamentals: Architecture features. **4G:** LTE communication protocol: Protocol model, Air Interface Transport Protocols, Fixed Network Transport Protocols, User Plane Protocols , Signalling Protocols		

Q1)	a)	List and compare different types of wireless communication system.	**[5]**
	b)	Briefly explain the different generation of cellular systems (Any two)	**[5]**
	c)	Describe working of Infrared communication in details.	**[5]**
		OR	
Q2)	a)	Write a short note on types of wireless communication	**[5]**
	b)	Describe types of Satellite Communication? Elaborate working of Satellite Communication in details	**[5]**
	c)	Describe in detail Microwave communication	**[5]**
Q3)	a)	Explain Microcell Zone Concept.	**[5]**
	b)	Explain in detail a handoff scenario at cell boundary	**[5]**
	c)	Elaborate the concept of Cellular system in brief	**[5]**
		OR	
Q4)	a)	Write a short note with diagram of Cell and Cell Geometry.	**[5]**
	b)	Explain different features of LTE technology	**[5]**
	c)	Explain LTE Protocol Model	**[5]**

Q1) a) List and compare different types of wireless communication system. **[5]**

b) Briefly explain the different generation of cellular system. **[5]**

c) Explain importance of satellite communication in wireless communication. **[5]**

OR

Q2) a) What is 4G? Compare 4G with 5G. **[5]**

b) Explain infrared wireless communication. **[5]**

c) Explain microwave wireless communication. **[5]**

Q3) a) Explain Microcell Zone concept. **[5]**

b) Explain in detail a handoff scenario at the cell boundary. **[5]**

c) Explain hexagonal geometry cell structure in the cellular system. **[5]**

OR

Q4) a) What is the need for LTE? Explain the architecture of LTE. **[5]**

b) Explain the concept of frequency reuse. **[5]**

c) Explain signaling protocols of LTE. **[5]**

Unit I: Introduction to Wireless Communication *(6 hrs)*

•Evolution of mobile communications

•Types of Wireless Communication:
- Satellite Communication
- Microwave Communication
- Infrared Communication

•Generation of Cellular Networks: 2G / 3G / 4G / 5G / 6G

- Evolution of mobile communications

Generation	Years	Technology	Speed	Main Service
1G	1980s	Analog (AMPS, NMT)	~2.4 kbps	Voice only
2G	1990s	GSM, CDMA	14.4 – 64 kbps	Voice + SMS
2.5G/2.75G	Late 1990s	GPRS, EDGE	114 – 384 kbps	Basic internet
3G	2000s	UMTS, CDMA2000	2 Mbps – 42 Mbps	Mobile internet, video
4G/LTE	2010s	LTE, WiMAX	100 Mbps – 1 Gbps	HD video, apps, VoIP
5G	2019 – Now	NR, mmWave	1 – 10 Gbps	IoT, AR/VR, automation
6G	~2030	THz, AI-driven	Up to 1 Tbps	Holograms, metaverse

Wireless communication ek tarika hai data, voice, ya information transfer karne ka bina kisi physical wire ya cable ke, radio waves, microwaves, infrared, satellite ya Bluetooth jaise signals ka use karke.

"Wireless communication wo process hai jisme information ek jagah se dusri jagah electromagnetic waves ke zariye bina wires ke bheji ya receive ki jaati hai.“

Examples:
- Mobile phones
- Wi-Fi
- Bluetooth
- Satellite communication
- Radio & TV broadcasting

PYQS NEXT TOPIC

b) Explain infrared wireless communication.

c) Explain microwave wireless communication.

a) List and compare different types of wireless communication system. **[5]**

c) Explain importance of satellite communication in wireless communication.

Describe working of Infrared communication in details.

a) Write a short note on types of wireless communication **[5]**

b) Describe types of Satellite Communication? Elaborate working of Satellite Communication in details **[5]**

c) Describe in detail Microwave communication **[5]**

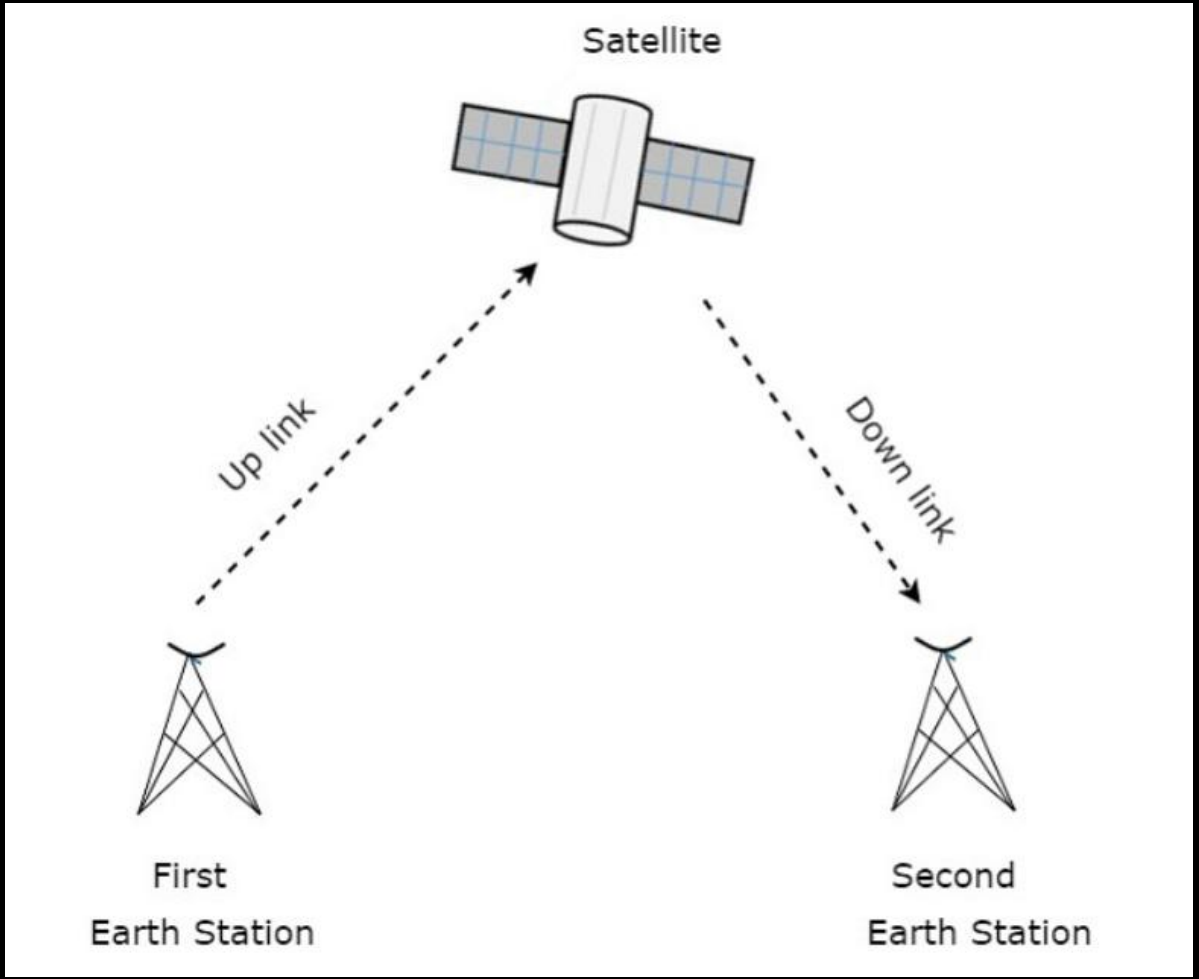
- Types of Wireless Communication:
  - Satellite Communication
  - Microwave Communication
  - Infrared Communication

1. **Satellite Communication** 🛰️

Definition:
Satellite communication me signals ko ek satellite ke through transmit aur receive kiya jata hai. Ground stations signal ko satellite tak bhejte hain, aur satellite us signal ko doosre station ya device tak wapas bhejti hai.

Kaise kaam karta hai:

•Aapka signal → Ground Station → Satellite → Doosri Ground Station → Receiver Device


Satellite
Up link
Down link
First
Earth Station
Second
Earth Station

Satellite Communication Working Process

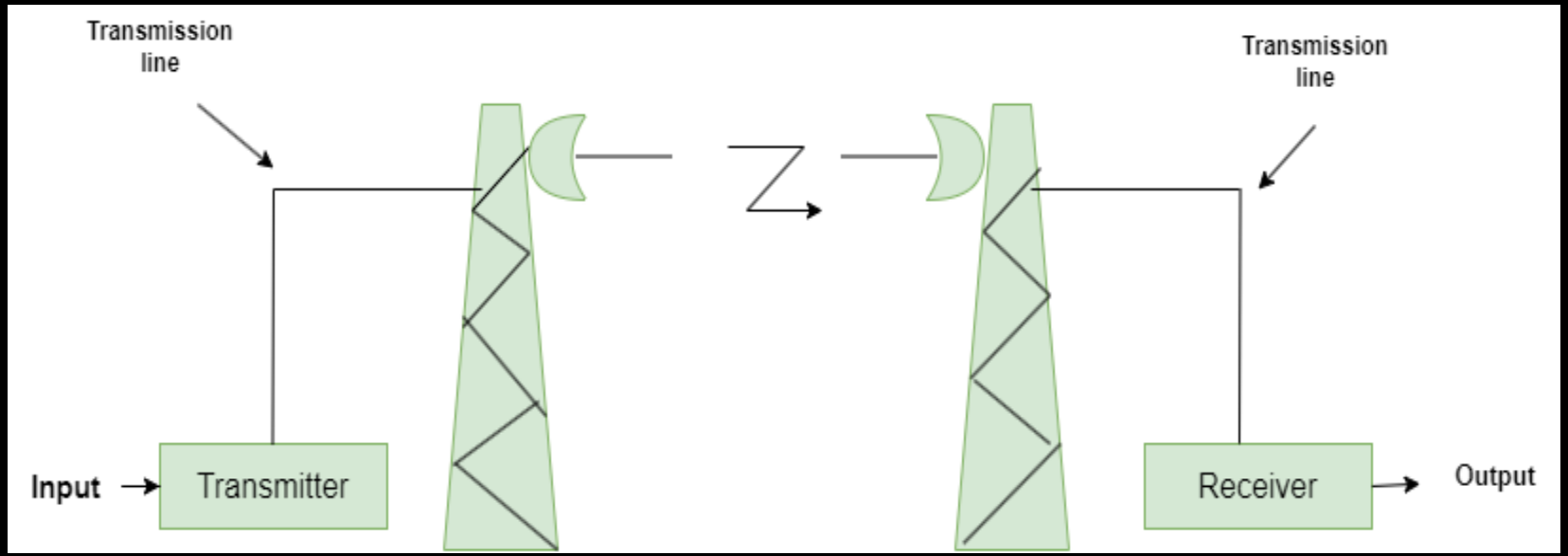
Step	Component	Explanation	Key Point
1	First Earth Station	Ground station jo signal ko satellite tak bhejta hai.	Transmitter station
2	Uplink	Signal First Earth Station se satellite tak bheja jata hai.	High frequency use hoti hai
3	Satellite	Satellite signal receive karta hai, amplify (strong) karta hai aur process karta hai.	Acts as a relay
4	Downlink	Processed signal satellite se Second Earth Station tak bheja jata hai.	Frequency uplink se thodi low hoti hai
5	Second Earth Station	Ground station jo satellite se signal receive karke users tak pahunchata hai.	Receiver station

Application	Uplink Process	Satellite Role	Downlink Process	Example
DTH TV (Tata Sky, Airtel)	TV channel ka signal broadcaster se satellite tak bheja jata hai	Satellite signal ko amplify karke set-top box tak bhejta hai	Set-top box signal receive karke TV par channel chalata hai	Tata Sky, Dish TV
GPS Navigation	GPS receiver signal request satellite ko bhejta hai	Satellite accurate location calculate karta hai	Location data wapas GPS device ko bhejta hai	Google Maps, Uber
International Calls	Voice data First Earth Station se satellite tak jata hai	Satellite data ko doosre desh tak route karta hai	Call receiver ke desh ke tower tak data bhejta hai	India → USA Calls
Weather Forecasting	Ground station weather data satellite tak bhejta hai	Satellite images aur data process karta hai	Weather images aur reports Earth Station tak bhejta hai	IMD, NASA

Microwave Communication

Microwave Communication

Definition
Microwave communication ek wireless communication technique hai jisme **high frequency electromagnetic waves (1 GHz – 300 GHz)** ka use hota hai. Ye system transmitter aur receiver ke beech **line of sight (LOS)** par work karta hai aur fast data transmission provide karta hai.


Transmission line
Transmission line
Input
Transmitter
Receiver
Output

Working of Microwave Communication

Step	Process
1	Input signal transmitter me diya jata hai.
2	Transmitter input ko high frequency microwave signal me convert karta hai.
3	Signal ko transmission line ke through antenna se space me bheja jata hai.
4	Microwave signal free space se travel karta hai aur receiving antenna tak pahuchta hai.
5	Receiver antenna signal ko receive karta hai aur transmission line ke through receiver ko bhejta hai.
6	Receiver signal ko amplify aur demodulate karke original output generate karta hai.

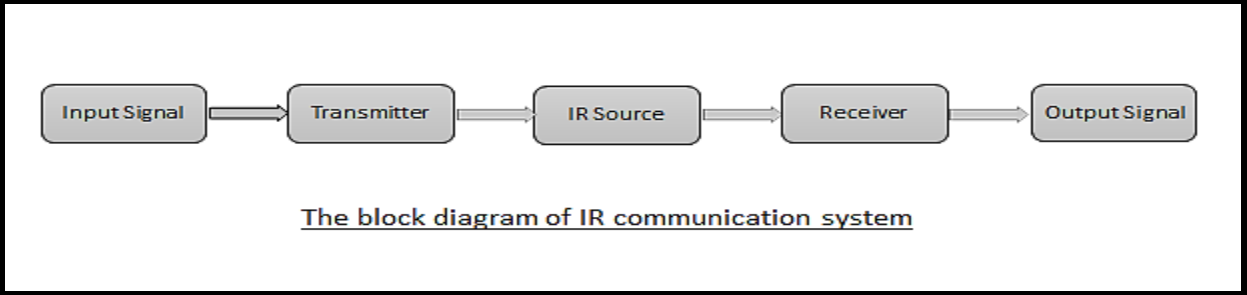
Applications of Microwave Communication

Application	Explanation
Satellite Communication	Earth station se satellite aur wapas tak signal bhejne/receive karne ke liye.
Mobile Networks	Cellular towers ke beech data transfer ke liye.
TV Broadcasting	Live TV aur DTH service ke liye.
Radar Systems	Aircraft, weather forecast aur military applications me.
Internet Backbone	High-speed internet backbone links provide karne ke liye.

Infrared (IR) Communication

Definition
Infrared communication ek **wireless communication system** hai jo **infrared rays (300 GHz – 430 THz)** ka use karta hai short-range data transfer ke liye. Ye mostly **line of sight (LOS)** based hota hai aur TV remote, wireless mouse, aur data sharing devices me use hota hai.

Working of Infrared Communication



The block diagram of IR communication system

Step	Process
1	Input signal transmitter me diya jata hai.
2	Transmitter input ko modulate karke IR Source (LED/Laser diode) ko bhejta hai.
3	IR source signal ko infrared rays ke form me emit karta hai.
4	Receiver (photodiode/IR sensor) infrared rays ko detect karta hai.
5	Receiver demodulation aur amplification karke signal ko process karta hai.
6	Output signal original form me milta hai.

Applications of Infrared Communication

Application	Explanation
TV Remotes	Channel change, volume control, etc. ke liye.
Wireless Mouse/Keyboard	Short distance device communication ke liye.
Data Transfer	Mobile phones/laptops ke beech short range data exchange (old tech).
IR Cameras	Night vision aur surveillance ke liye.
Medical Devices	Patient monitoring aur wireless sensors me.

a) List and compare different types of wireless communication system. [5]

Feature	Satellite Communication	Microwave Communication	Infrared (IR) Communication
Frequency Range	1 GHz – 40 GHz	1 GHz – 300 GHz	300 GHz – 430 THz
Distance Coverage	Very long (thousands of km, global)	Medium (tens to hundreds of km)	Very short (few meters)
Line of Sight (LOS)	Satellite to Earth stations	Tower-to-tower LOS required	Strict LOS required
Medium Used	Space (satellite in orbit)	Atmosphere (terrestrial towers)	Direct air (short distance)
Speed / Data Rate	High (depends on bandwidth, latency high)	High-speed, low latency	Low to medium speed
Delay	High (due to long distance, ~250ms)	Very low	Negligible
Main Devices	Satellite, Earth station antennas	Parabolic dish antennas, towers	IR LEDs, Photodiodes
Cost	Very high (launch + maintenance)	Medium (infrastructure required)	Very low (cheap IR devices)
Applications	Global communication, GPS, TV broadcasting, weather monitoring	Mobile networks, radar, backbone links, TV relay	TV remote, wireless mouse/keyboard, short-range data transfer

c) Explain importance of satellite communication in wireless communication.

Importance of Satellite Communication

1.Global Coverage

1. Satellite se poore globe ke kisi bhi corner me communication possible hai.
2. Remote aur rural areas me bhi connectivity milti hai.

2.Long Distance Communication

1. Ek satellite thousands of kilometers tak data transmit kar sakti hai.
2. International calling, TV broadcasting, aur internet ke liye useful.

3.Broadcasting Services

1. Satellite ek hi time me millions of users ko TV, Radio aur DTH signal bhej sakti hai.

4.Disaster Management

1. Flood, earthquake, cyclone jaise natural disasters ke time terrestrial networks fail ho jaate hain.
2. Satellite se emergency communication aur rescue operation chalaya jaa sakta hai.

5.Navigation & GPS

1. GPS (Global Positioning System) aur navigation services satellites par hi depend karti hain.
2. Transport, aviation aur defense me bahut important.

6.Scientific & Weather Forecasting

1. Weather satellites climate, storm prediction aur environmental monitoring me help karte hain.
2. Research aur space exploration me bhi use hota hai.

7.Military & Security

1. Defense forces secure communication, surveillance aur reconnaissance ke liye satellite use karti hain.

8.High Data Capacity

1. Satellite ek hi bar me huge amount of data carry kar sakti hai (TV, internet, phone signals).

•Generation of Cellular Networks: 2G / 3G / 4G / 5G / 6G

b) Briefly explain the different generation of cellular systems (Any two) **[5]**

a) What is 4G? Compare 4G with 5G.

📱 Cellular Networks Generalization (1G to 5G)

1G – First Generation (1980s)

- Pure analog system tha.
- Sirf **voice call** support karta tha, koi SMS ya data nahi.
- Security bahut weak thi, calls easily tap ho sakti thi.
- Speed: ~2.4 kbps

👉 Example: Large mobile phones, sirf calling ke liye (Motorola DynaTAC).

2G – Second Generation (1990s)
•Digital technology introduce hui.
•**Voice + SMS (text messages)** possible hua.
•Internet bhi tha lekin bahut slow (kbps).
•Speed: ~64 kbps
👉 Example: Nokia 1100, SMS & ringtones ka zamana.

3G – Third Generation (2000s)
•Data services improve hue.
•**Voice + SMS + Internet + Video calling** support karta tha.
•Internet speed zyada (kbps → few Mbps).
•Multimedia services (email, browsing, video chat) popular hue.
•Speed: 2 Mbps – 21 Mbps
👉 Example: Early Android phones, Airtel 3G SIM.

4G – Fourth Generation (2010s)

•High-speed internet revolution.

•**VoLTE (Voice over LTE)** → high-quality voice calls.

•**HD video streaming, fast browsing, online gaming**.

•Speed: 100 Mbps – 1 Gbps

👉 Example: Jio 4G launch in India (2016) → YouTube, OTT platforms boom.

5G – Fifth Generation (2020s)

•Latest generation.

•**Ultra-fast Internet (1–10 Gbps)**.

•**Very low latency (<1 ms)** → real-time response.

•Support for **IoT, smart cities, AR/VR, self-driving cars, remote surgeries**.

👉 Example: 5G phones in India (2022 onwards).

Feature	1G	2G	3G	4G	5G
Launch Year	1980s	1990s	2000s	2010s	2020s
Technology	Analog	Digital (GSM/CDMA)	WCDMA/UMTS	LTE	New Radio (NR)
Services	Only voice	Voice + SMS	Voice + SMS + Data (Video call)	Voice + High-speed data (VoLTE, HD streaming)	Ultra-high-speed Internet, IoT, AR/VR
Speed	~2.4 kbps	~64 kbps	2–21 Mbps	100 Mbps – 1 Gbps	1–10 Gbps
Latency	High	High	Medium	Low (~50 ms)	Ultra low (<1 ms)
Security	Poor	Better than 1G	Stronger	Strong	Very Strong
Example Device	Big analog phones	Nokia 1100	Early Androids	4G smartphones	5G smartphones, IoT devices

Unit 2

Unit II: Fundamentals of Cellular and LTE Technology *(6 hrs)*

- Cellular system
- Hexagonal geometry cell and concept of frequency reuse
- Need for LTE (Long Term Evolution)
- LTE Technology fundamentals: Architecture features

- **4G LTE Communication Protocols**:
  - Protocol model
  - Air Interface Transport Protocols
  - Fixed Network Transport Protocols
  - User Plane Protocols
  - Signalling Protocols

Q3)	a)	Explain Microcell Zone Concept.	**[5]**
	b)	Explain in detail a handoff scenario at cell boundary	**[5]**
	c)	Elaborate the concept of Cellular system in brief	**[5]**

OR

Q4)	a)	Write a short note with diagram of Cell and Cell Geometry.	**[5]**
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Q4)	a)	What is the need for LTE? Explain the architecture of LTE.	**[5]**
	b)	Explain the concept of frequency reuse.	**[5]**
	c)	Explain signaling protocols of LTE.	**[5]**

•Cellular system

c) Elaborate the concept of Cellular system in brief

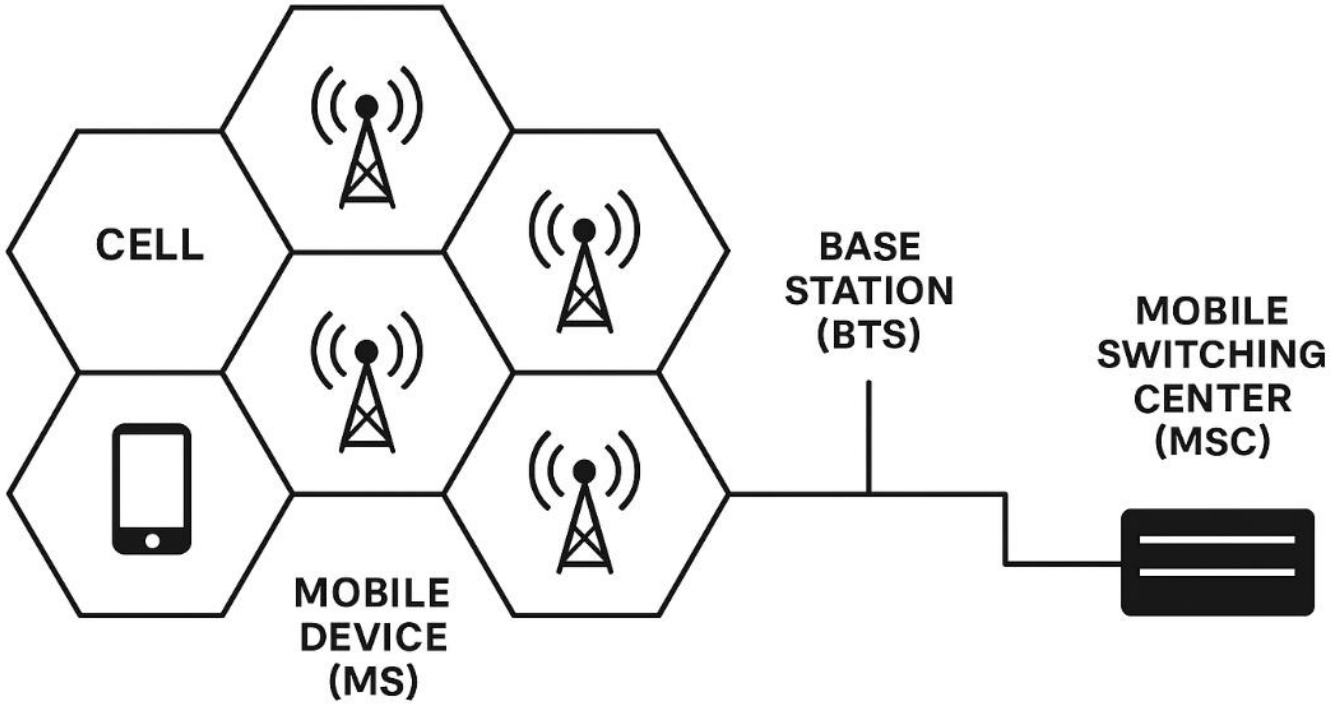
- **1. Cellular System kya hai?**

Cellular system ek **wireless communication system** hai jo large area ko **chhote-chhote cells** me divide karta hai.

Har cell ka apna **Base Station (BTS)** hota hai jo ek limited area me mobile users ko network provide karta hai.

👉 Iska main use hai – **frequency reuse** aur **efficient coverage** dena bina interference ke.

CELLULAR SYSTEM



2. Cellular System ka Structure

Cellular system ke important components:

1.Cell –
Ek hexagonal (jaise honeycomb) shaped area jo ek BTS cover karta hai.

2.Base Station (BTS) –
Har cell ka apna antenna hota hai jo us cell ke andar ke mobile phones ke sath communicate karta hai.

3.Mobile Switching Center (MSC) –
Ye ek central hub hota hai jo multiple BTS ko connect karta hai aur call routing, SMS, handoff handle karta hai.

4.Mobile Phone (MS) –
User device jo BTS ke sath signals exchange karta hai.

🔹 3. Kaam kaise karta hai?

👉 Example lete hain:
•Agar tum ek city me ho aur phone call karte ho → tumhara signal nearest BTS ke pass jata hai.

•BTS → MSC → phir dusre user ke BTS ke pass jata hai.

•Call connect ho jata hai.

Jab tum move karte ho ek cell se dusre cell me → system handoff kar deta hai (tumhara call cut nahi hota, seamlessly transfer ho jata hai).

4. Important Concepts

1.Frequency Reuse –
Same frequencies ko alag-alag cells me reuse kiya jata hai jo ek dusre se door hote hain → isse spectrum efficiently use hota hai.

2.Handoff –
Jab ek user ek cell se dusre cell me move karta hai → call/data transfer automatically new BTS me shift ho jata hai.

3.Cell Splitting –
Jab traffic zyada ho jata hai to bada cell chhote-chhote cells me divide kar diya jata hai to increase capacity.

🔹 5. Advantages

✅ Efficient use of frequency spectrum
✅ Large area coverage
✅ Mobility support (handoff feature)
✅ High capacity (zyada users support)

🔹 6. Real Life Example

•Tum Mumbai se Pune bus me travel kar rahe ho aur call pe baat kar rahe ho.
•Bus move karte waqt tum ek cell se dusre cell me ja rahe ho → har jagah BTS ke through network mil raha hai.
•Call bina cut hue transfer hota hai → ye hai Cellular System ka magic.

•Hexagonal geometry cell and concept of frequency reuse

a) Write a short note with diagram of Cell and Cell Geometry.

OR

c) Explain hexagonal geometry cell structure in the cellular system.

b) Explain the concept of frequency reuse.

📱 Hexagonal Geometry Cell Structure

1. Cell ka shape kyu zaroori hai?

Cellular system me pura service area ko chhote–chhote parts (cells) me divide kiya jata hai.

Har cell ka ek **base station** hota hai jo us area me coverage deta hai.
Lekin question aata hai – cell ka shape kaisa ho?

🔹 2. Possible Shapes

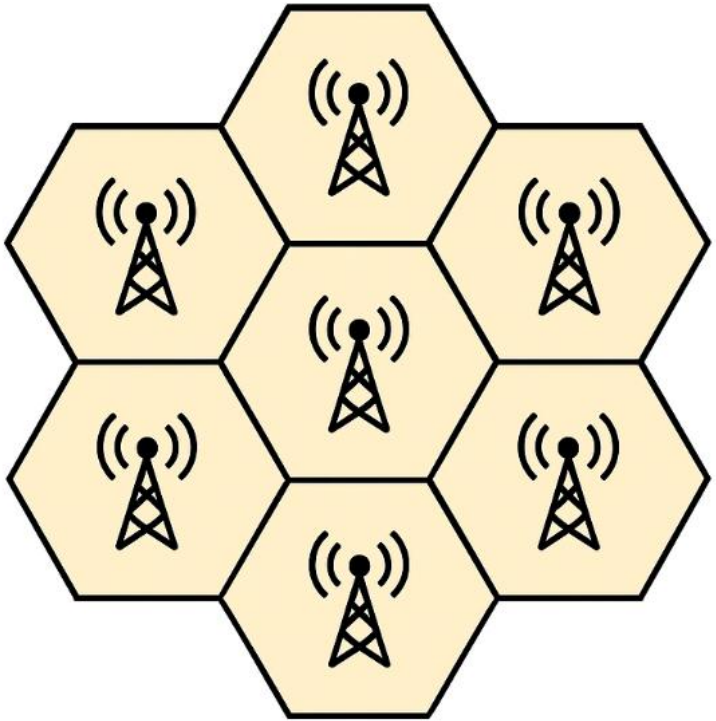
•**Circle** – coverage achha deta hai, lekin circles jab ek saath rakhenge to gap ya overlap hoga.

•**Square / Triangle** – ek dusre ko cover kar lete hain, lekin center se distance har jagah equal nahi hota.

•**Hexagon (Best choice)** –

- Har jagah se equal distance
- Na gap bachta hai, na overlap hota hai
- Spectrum efficiently use hota hai

Hexagonal Geometry Cell Structure in the Cellular System



Base Station (BTS)

🔹 3. Hexagonal Cell Geometry

•Har cell ko **hexagon shape** me consider kiya jata hai.
•Har hexagon ke center me ek **Base Station (BTS)** hota hai.
•Hexagons ek honeycomb structure banate hain → jisse **poora area efficiently cover hota hai**.

🔹 4. Advantages of Hexagonal Geometry

✅ **Uniform coverage bina gap ya overlap ke**
✅ **Frequency reuse easy ho jata hai**
✅ **Handoff (ek cell se dusre cell) easy aur efficient hota hai**
✅ **Mathematical calculation (radius, area) simple hoti hai**

- **5. Example**

Socho ek city ko hexagons me divide kar diya.
Har hexagon ke beech me tower laga.
Ab tum ghoomte-phरते bhi ho to har jagah continuous network milega → bina call cut hue.

"Cellular system me hexagonal geometry isliye use hoti hai kyunki ye ek aisa shape hai jo pura area efficiently cover karta hai bina overlap aur gap ke, frequency reuse ko easy banata hai aur handoff process ko smooth karta hai."

📡 Frequency Reuse

🔹 1. Concept

Cellular system me available spectrum (frequency bands) limited hota hai. Agar har user ko alag frequency deni pade to frequencies jaldi khatam ho jaayengi.

👉 Is problem ko solve karne ke liye **Frequency Reuse** concept use hota hai.

🔹 2. Definition

Frequency reuse ka matlab hai ek hi frequency set ko alag–alag cells me dobara use karna, lekin is tarah se ki interference na ho.

🔹 3. Kaise hota hai?

•Pure service area ko hexagonal cells me divide karte hain.
•Har cell ko kuch specific frequency band assign hota hai.
•Door–door wale cells (jo ek dusre ke close nahi hain) same frequency use kar sakte hain.

👉 Matlab ek hi frequency multiple jagah par use hoti hai, bas unke beech ka distance aisa rakha jata hai ki signals interfere na kare.

🔹 4. Example

Socho tumhare paas sirf **3 frequencies (F1, F2, F3)** available hain.
•Ek hexagonal cluster banaoge jisme ye 3 alag-alag cells me assign kar doge.
•Ab next cluster (jo door hoga) me phir se F1, F2, F3 use kar loge.

🔹 5. Advantages

✅ Limited spectrum ka efficient use hota hai
✅ Zyada users ko serve kar paate hain
✅ Cellular system ki capacity badh jaati hai

🔹 6. Real Life Example

Tum Mumbai ke ek area me ho, aur kisi frequency (F1) pe call kar rahe ho. Dusra banda Pune me bhi same frequency (F1) use kar raha hai → dono calls ek dusre me interfere nahi karenge kyunki cells ka distance kaafi hai.

"Frequency reuse ek technique hai jisme same frequency ko multiple cells me dobara use kiya jata hai, lekin un cells ko itna door rakha jata hai ki interference na ho. Isse limited spectrum ka efficient use hota hai."

a) Write a short note with diagram of Cell and Cell Geometry.

📱 Cell and Cell Geometry :

🔹 1. Cell (Concept)

•**Cell** ek chhota geographic area hota hai jo ek **Base Station (BTS)** cover karta hai.
•Cellular system me pura service area ko chhote–chhote **cells** me divide kiya jata hai.
•Har cell ke andar ek antenna/base station hota hai jo users ke mobile phones se communicate karta hai.
•Is tarike se large area me bhi efficient coverage possible hota hai.

🔹 2. Cell Geometry

•Cell ke shape ko **hexagon** maana jata hai.
•Kyun hexagon?

- Circle → overlap ya gap create karta hai.
- Square/Triangle → coverage equal nahi hoti.
- Hexagon → best choice, kyunki poore area ko bina gap/overlap ke efficiently cover karta hai.

•Hexagonal cells ek **honeycomb structure** banate hain, jisse frequency reuse aur network planning easy hoti hai.

b) Explain in detail a handoff scenario at cell boundary

📌 **Handoff at Cell Boundary:**

•**Handoff** = Jab ek mobile user ek cell ke coverage area se dusre cell me move karta hai, to ongoing call/data ko ek base station se dusre base station me transfer kiya jata hai.

•**At Cell Boundary**:

- Current cell ka signal weak ho jata hai.
- Neighboring cell ka signal strong ho jata hai.
- System automatically user ko new cell pe shift kar deta hai bina call drop ke.

•**Steps**:

- Mobile station signals measure karta hai.
- MSC decide karta hai ki kis tower ka signal strong hai.
- Naya channel allocate hota hai.
- Connection smoothly transfer ho jata hai.

•**Types**:

- **Hard handoff** → Break before make.
- **Soft handoff** → Make before break.

•**Example**: Call karte hue bike pe ek tower se dusre tower area me jaana → call continue rahta hai.

a) Explain Microcell Zone concept.

📌 **Microcell Zone Concept**

1.Definition

1. Cellular system mein ek **cell** ko chhote-chhote zones (microcells) me divide kiya jata hai.
2. Ye concept mainly **urban areas** me use hota hai jaha **traffic zyada hota hai** aur coverage improve karni hoti hai.

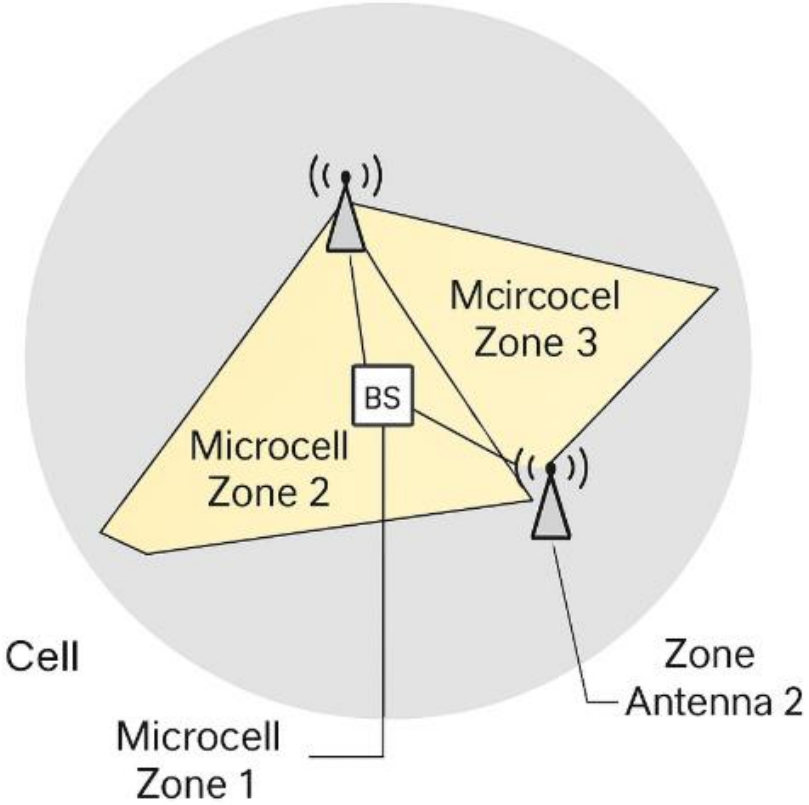
2.Working

1. Ek single **Base Station (BS)** multiple small **zone antennas** ko serve karta hai.
2. Har microcell zone ka apna **directional antenna** hota hai jo users ko cover karta hai.
3. Jab user move karta hai to call **zone se zone** handover hoti hai, par **cell ke andar hi** rehti hai.
4. Isse **handover load kam** hota hai aur **capacity increase** hoti hai.

3.Advantages

1. High user density handle karta hai.
2. Call quality improve hoti hai.
3. Handover latency kam hota hai (kyunki same BS ke andar zone change hota hai).
4. Frequency reuse efficiently hota hai.

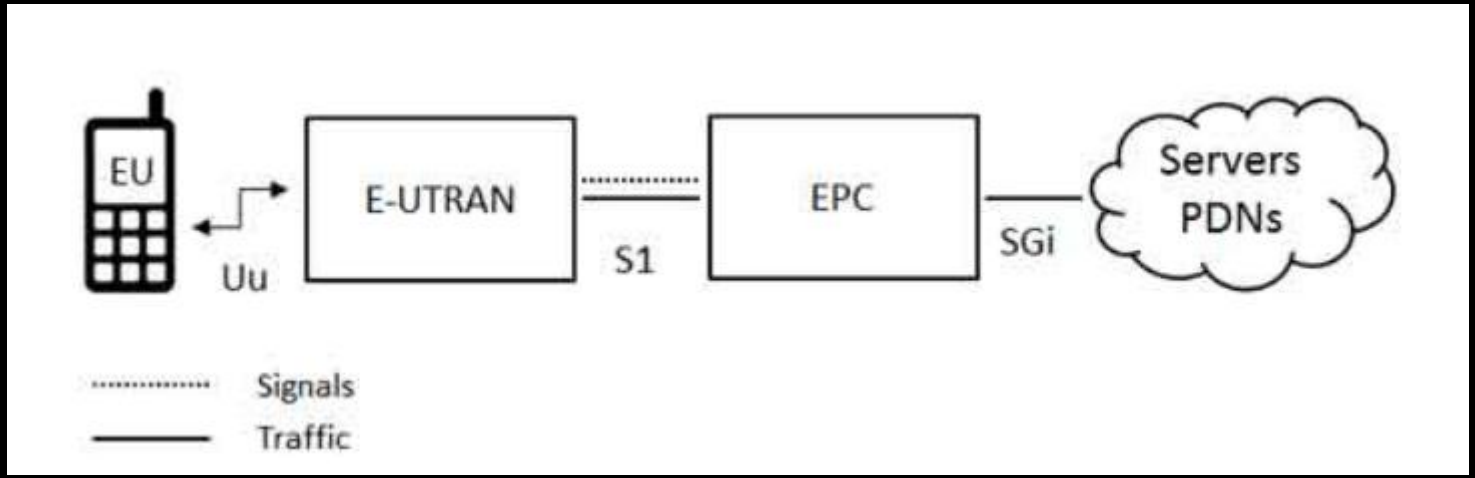
Microcell Zone Concept



•Need for LTE (Long Term Evolution)

a) What is the need for LTE? Explain the architecture of LTE. [5]

Point	Need / Requirement	Explanation (Easy)
1	High Data Rate	LTE provide karta hai fast speed (up to 100 Mbps DL, 50 Mbps UL) jo 3G se bahut zyada hai.
2	Low Latency	Delay sirf ~10 ms tak hai → video call, gaming, aur real-time apps ke liye best.
3	More Users Handle	Smartphones aur internet users badhne ke wajah se LTE large data traffic handle karta hai.
4	Better Spectrum Use	LTE flexible bandwidth (1.25 MHz – 20 MHz) support karta hai → spectrum efficiently use hota hai.
5	Seamless Mobility	High speed train/car me bhi network stable rehta hai, call drop kam hota hai.
6	All-IP Network	Sab services (voice, data, video) IP-based hai → future ready aur VoLTE possible.


EU
Uu
E-UTRAN
S1
EPC
SGi
Servers
PDNs
Signals
Traffic

1. **EU (End User / Mobile Device / UE – User Equipment)**
    - Ye tumhara **mobile phone, tablet, dongle** ho sakta hai.
    - Ye device network ke saath communicate karta hai wireless signals ke through.
    - Communication link ka naam hai **Uu interface** (wireless interface between UE and eNodeB).

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2. **E-UTRAN (Evolved UMTS Terrestrial Radio Access Network)**
    - Ye basically **eNodeB (Base Stations)** ka group hota hai.
    - UE (mobile) se direct connect hota hai.
    - **Functions:**
        - Radio resource management (frequency allocation, power control).
        - Handover management (jab ek tower se dusre tower pe shift karte ho).
        - Data aur signaling ko EPC tak bhejna.

3. **EPC (Evolved Packet Core)**
   - Ye LTE ka **brain + backbone network** hai.
   - Isme multiple components hote hain (MME, SGW, PGW, HSS) jo together kaam karte hain:
     - **MME (Mobility Management Entity):** Authentication, roaming, handover.
     - **SGW (Serving Gateway):** User data packets ko forward karta hai.
     - **PGW (Packet Data Gateway):** Internet / external networks ke saath connect karta hai.
     - **HSS (Home Subscriber Server):** User info + subscription database.
   - UE aur E-UTRAN ke beech jo interface hai use **S1 interface** bolte hain.

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4. **Servers / PDNs (Packet Data Networks)**
   - Ye external world hai jaha tumhare apps, internet services aur servers hote hain.
   - Example → YouTube server, WhatsApp server, Google cloud, etc.
   - EPC inhe connect karta hai via **SGi interface**.

🔑 Traffic vs Signaling (as shown in diagram)

- **Dashed Line (---)** = Signaling (control messages, authentication, handover instructions).
- **Solid Line (—)** = Traffic (actual user data → calls, video, browsing packets).

b) Explain different features of LTE technology

📌 **Features of LTE Technology (6 Points with Detail)**

1.High Data Rate

1. LTE provide karta hai up to **100 Mbps download** aur **50 Mbps upload** speed.
2. Ye HD video streaming, cloud apps aur online gaming ke liye useful hai.

2.Low Latency

1. LTE ka delay sirf **~10 ms** hota hai.
2. Is wajah se **real-time applications** (video call, VoIP, gaming) smoothly chalti hain.

3.All-IP Network

1. LTE ek **pure IP-based system** hai.
2. Voice bhi **VoLTE (Voice over LTE)** ke through hoti hai, data aur video bhi IP pe.

4.Spectrum Flexibility

1. LTE multiple bandwidths (1.25 MHz – 20 MHz) support karta hai.
2. Isse operators efficiently spectrum use kar sakte hain aur zyada users serve kar sakte hain.

5.High Mobility Support

1. LTE users ko **seamless service** deta hai even at **350 km/h speed** (train/car).
2. Call drops kam hote hain aur handover smooth hota hai.

6.MIMO Technology (Multiple Input Multiple Output)

1. LTE multiple antennas use karta hai transmission/reception ke liye.
2. Isse **data rate aur reliability** dono improve hote hain.

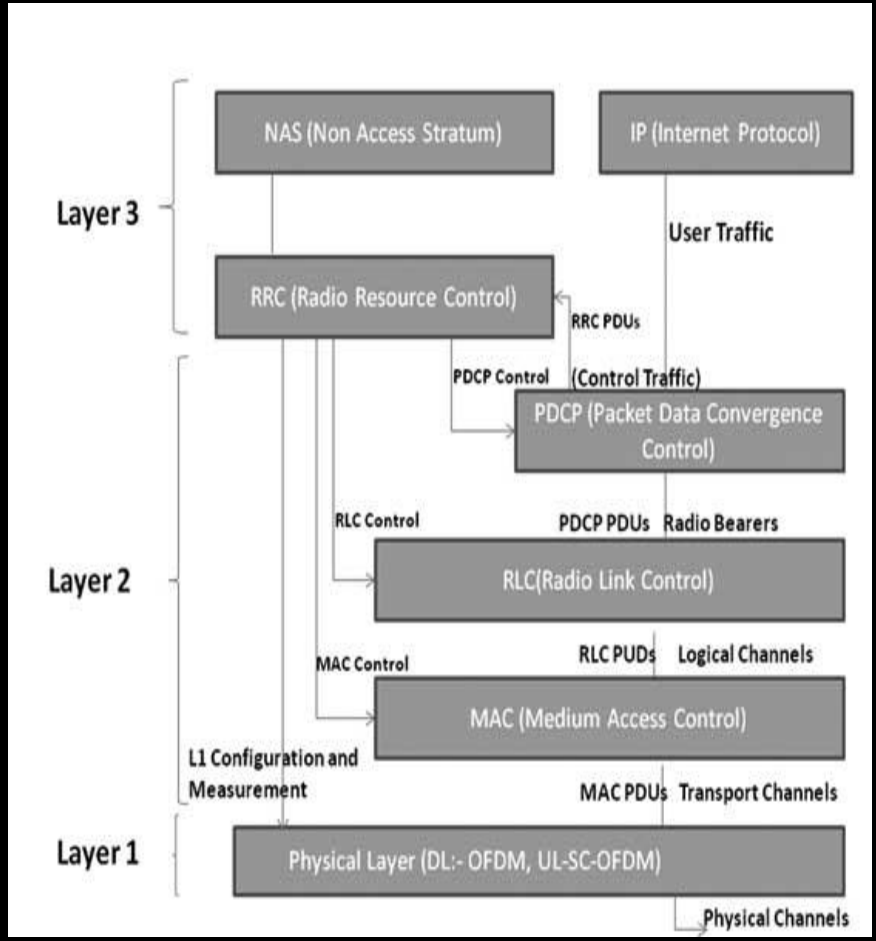
- **4G LTE Communication Protocols**:
  - Protocol model
  - Air Interface Transport Protocols
  - Fixed Network Transport Protocols
  - User Plane Protocols
  - Signalling Protocols

LTE Protocol Model

Protocol Model ka matlab hota hai – **Network ke andar ka communication kaise layers ke through hota hai (user plane + control plane)**.
Ye mainly **E-UTRAN (LTE Radio Access Network)** ke liye banaya gaya hai.

LTE Protocol Model

Layer	Plane	Kaam (Simple Explanation)
PHY (Physical)	User + Control	Data ko air (wireless signal) me bhejna aur receive karna
MAC (Medium Access Control)	User + Control	Data ko chhote blocks me todna, scheduling karna, aur error correct karna
RLC (Radio Link Control)	User + Control	Data ko segment/reassemble karna aur ensure karna ki order sahi ho
PDCP (Packet Data Convergence Protocol)	User + Control	Data ko compress (header chhota) karna, encrypt karna aur duplicate remove karna
RRC (Radio Resource Control)	Control	Connection setup/release, handover aur paging manage karna
NAS (Non-Access Stratum)	Control	Mobility (roaming), session management, aur authentication handle karna



Yaad rakhne ka simple trick:

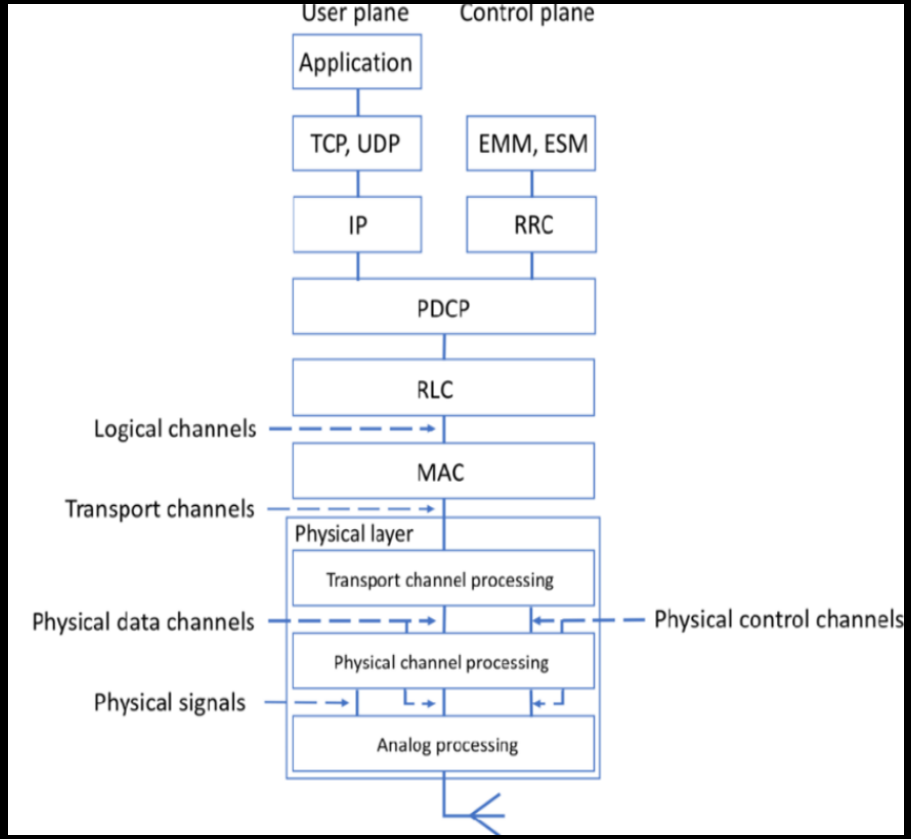
- **PHY → Data bhejna (wireless)**
- **MAC → Blocks + error control**
- **RLC → Order + segments**
- **PDCP → Compress + secure**
- **RRC → Connection control**
- **NAS → Mobility & session**

- **User Plane (U-plane):** Data (internet, voice, video) carry karta hai → PHY, MAC, RLC, PDCP layers use karta hai.

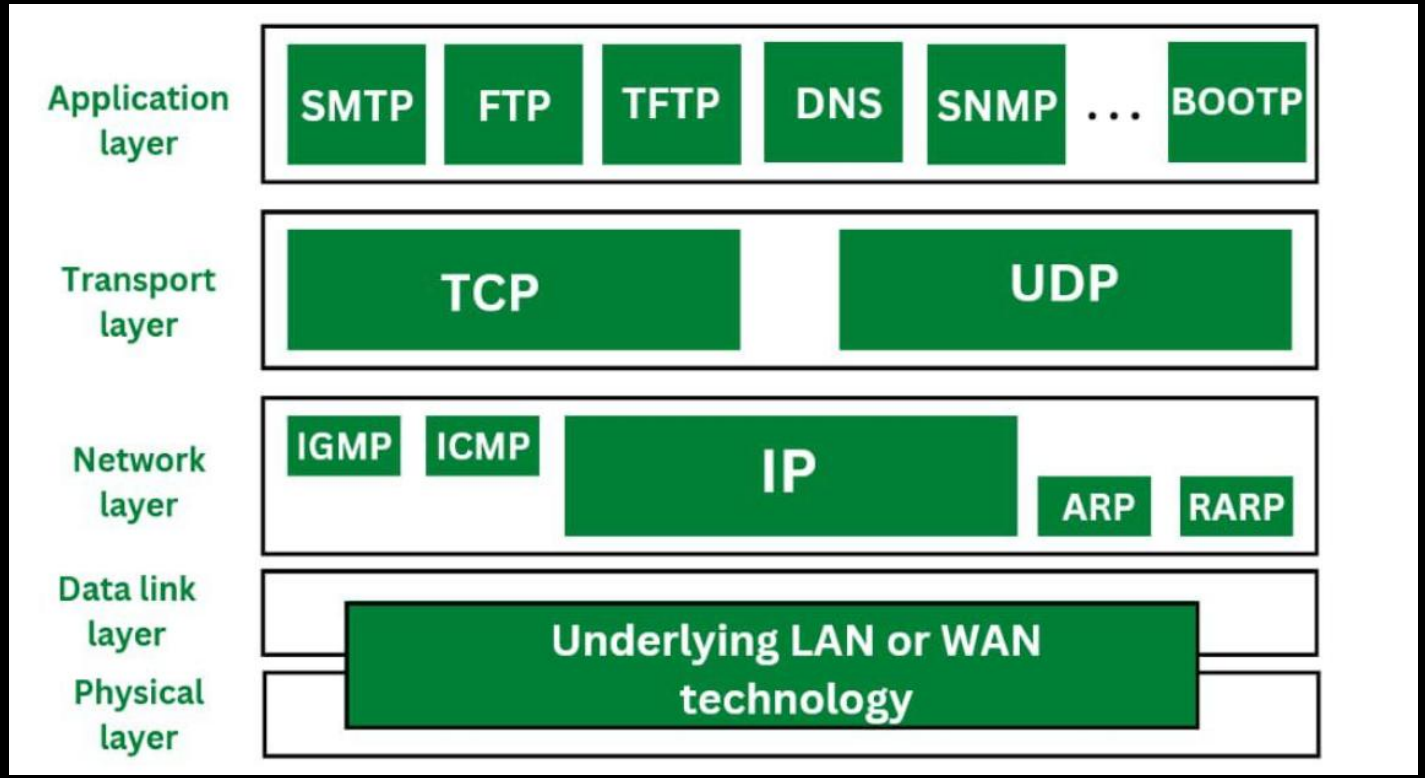
- **Control Plane (C-plane):** Signaling aur control messages (connection, mobility, security) handle karta hai → PHY, MAC, RLC, PDCP + RRC + NAS.

2. Air Interface Transport Protocols

Protocol	Kaam (Simple Explanation)
PHY	Wireless pe data bhejna/receive karna
MAC	Data ko blocks me todna aur error correct karna
RLC	Data ko sahi order me lana
PDCP	Compression + Security (encrypt)
RRC	Connection, paging, handover



2. **Fixed Network Transport Protocols**



Protocol	Kaam (Simple Explanation)
IP (Internet Protocol)	Data packets ko route karna
UDP (User Datagram Protocol)	Fast transfer (voice, video) bina connection
TCP (Transmission Control Protocol)	Reliable transfer (error check + order)
SCTP (Stream Control Transmission Protocol)	Signaling messages reliable bhejna
Ethernet	Local wired network communication

3. User Plane Protocols

Protocol	Kaam (Simple Explanation)
PDCP	Header compression + encryption
RLC	Segmentation + order maintain
MAC	Multiplexing + error control
PHY	Data ko wireless pe bhejna
GTP-U (GPRS Tunneling Protocol – User)	UE se internet tak user data carry karna

4. Signalling Protocols (Control Plane)

👉 **Signalling protocols hamesha Control Plane ke liye hote hain.**
Ye **UE (User Equipment)**, **eNodeB (Base Station)**, aur **MME (Mobility Management Entity)** ke beech ka signaling handle karte hain.

✅ **Correct Signalling Protocols in LTE:**

1.RRC (Radio Resource Control)
1. UE ↔ eNodeB
2. Connection setup/release, paging, handover, security keys

2.NAS (Non-Access Stratum)
1. UE ↔ MME (via eNodeB)
2. Mobility management (location update, attach/detach, roaming)
3. Session management (IP assign, bearer setup)

3.S1-AP (S1 Application Protocol)
1. eNodeB ↔ MME
2. Bearer management, handover signaling, paging

4.X2-AP (X2 Application Protocol)
1. eNodeB ↔ eNodeB
2. Direct handover signaling, load balancing

5.SCTP (Stream Control Transmission Protocol)
1. Transport layer protocol
2. Reliable delivery of S1-AP and X2-AP messages