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

UNIT 01

COURSE CONTENTS		
Unit I	**Introduction**	**(06 hrs)**
Introduction to Mobile Computing: Applications of Mobile Computing, A short history of wireless communication, **Medium Access Control:** Motivation for a specialized MAC: Hidden and Exposed terminals. Near and Far terminals. **SDMA, FDMA, TDMA:** Fixed TDM, Classical Aloha, Slotted Aloha, Carrier sense multiple access, Demand assigned multiple access, PRMA packet reservation multiple access, Reservation TDMA, Multiple access with collision avoidance, Polling, Inhibit sense multiple access. **CDMA:** Spread Aloha multiple access.		

Q1) a) What is mobile computing? Explain various functions of mobile computing. **[5]**

b) Write a short note of CSMA/CD and CSMA/CA. **[5]**

c) Which are different method to access the channel based on their time. Explain in Details. **[5]**

OR

Q2) a) Write a short note on pure ALOHA. **[5]**

b) Explain Frequency Division Multiple Access (FDMA) in wireless communication with figure. **[5]**

c) Explain ISMA and importance of ISMA. **[5]**

Q1) a) List the applications of Mobile Computing. Explain in detail. **[5]**

b) Compare and contrast SDMA, TDMA, FDMA and CDMA schemes. **[5]**

c) Write a short note on Packet Reservation Multiple Access. **[5]**

OR

Q2) a) Describe the operations of the following technologies: **[8]**

i) Classical ALOHA.

ii) Slotted ALOHA.

b) Explain the following terms: **[7]**

i) Hidden terminal and Exposed terminal problem.

ii) Far and Near terminal problem.

Q1) a) What is mobile computing? Explain various functions of mobile computing. **[5]**

b) Compare the merits and demerits of TDMA and FDMA multiple access schemes. **[5]**

c) Write short note on : Telecommunication generations. **[5]**

OR

Q2) a) Explain with diagram far and near terminal problem. **[5]**

b) Explain carrier sense Multiple access with collision avoidance (CSMA/CA). **[5]**

What is the Reason for implementing CSMA with CA strategy in wireless networks?

c) Explain in detail Packet Reservation Multiple Access (PRMA). **[5]**

Q1) a) List the applications of Mobile Computing. Explain in detail. **[5]**

b) Compare and contrast SDMA, TDMA, FDMA and CDMA schemes. **[5]**

c) Write a short note on Packet Reservation Multiple Access. **[5]**

OR

Q2) a) Describe the operations of the following technologies: **[8]**

i) Classical ALOHA.

ii) Slotted ALOHA.

b) Explain the following terms: **[7]**

i) Hidden terminal and Exposed terminal problem.

ii) Far and Near terminal problem.

Introduction to Mobile Computing: Applications of Mobile Computing, A short history of wireless communication,

a) What is mobile computing? Explain various functions of mobile computing. **[5]**

a) List the applications of Mobile Computing. Explain in detail. **[5]**

Mobile Computing

👉 **Mobile Computing** ka matlab hai aisi technology jisme data, voice aur video ko **wireless network** ke through exchange kiya jaata hai, bina kisi fixed location ke. Matlab user chahe kahin bhi ho, wo apna kaam mobile devices (smartphone, laptop, tablet) ke through easily kar sakta hai.

Functions of Mobile Computing:

1.Communication

1. **Users ek dusre se voice call, video call aur messages bhej sakte hain.**
2. ***Example:*** **WhatsApp pe video call karna jab aap train me travel kar rahe ho.**

2.Information Access

1. **Internet ke through kisi bhi jagah se information access kar sakte ho.**
2. ***Example:*** **Google Maps use karke apne current location se destination tak ka shortest route dekhna.**

3.Entertainment

1. **Songs, movies aur games ko mobile device pe run kar sakte ho.**
2. ***Example:*** **YouTube pe movie dekhna ya Spotify pe songs sunna while travelling.**

4.Online Transactions

1. **Banking, shopping aur payments directly mobile ke through possible hain.**
2. ***Example:*** **Paytm/UPI se shopkeeper ko payment karna.**

5.Remote Work (Productivity)

1. **Office kaam, mails aur documents manage karna kahin se bhi possible hai.**
2. ***Example:*** **Laptop pe Google Meet join karna jab aap ghar pe nahi ho.**

Applications of Mobile Computing:

1.Business Applications

1. Employees kahin se bhi apne mails check kar sakte hain, reports bana sakte hain aur meetings join kar sakte hain.
2. *Example:* Manager Google Meet ya Zoom call join karta hai jab wo travel kar raha ho.

2.Mobile Banking and E-Commerce

1. Users apne account check kar sakte hain, online shopping kar sakte hain aur instant payments kar sakte hain.
2. *Example:* Paytm, PhonePe, Amazon aur Flipkart apps use karke transactions karna.

3.Education (m-Learning)

1. Students kahin se bhi online classes attend kar sakte hain aur study material download kar sakte hain.
2. *Example:* Byju's, Coursera, YouTube lectures dekhna mobile pe.

4.Healthcare

1. Doctors remotely patients ki health monitor kar sakte hain aur reports check kar sakte hain.
2. *Example:* Telemedicine apps jahan patient doctor se video call pe consult karta hai.

5.Transportation and Navigation

1. Drivers aur travellers ko GPS ke through real-time direction aur traffic updates milte hain.
2. *Example:* Google Maps ya Ola/Uber app use karna for location tracking.

6.Entertainment and Social Media

1. Movies, games, songs aur social networking anytime available hain.
2. *Example:* Netflix pe movies dekhna ya Instagram scroll karna while travelling.

Medium Access Control: Motivation for a specialized MAC: Hidden and Exposed terminals. Near and Far terminals.

Explain the following terms: **[7]**

i) Hidden terminal and Exposed terminal problem.

ii) Far and Near terminal problem.

OR

) Explain with diagram far and near terminal problem. **[5]**

1. Medium Access Control (MAC)

•**Definition**:
MAC ek **sub-layer** hai **Data Link Layer** ke andar, jo decide karti hai ki **kaunsa device** kab aur kaise **channel** use karega.

•**Purpose**:

- Channel ko efficiently share karna.
- Data collision avoid karna.
- Fair access dena sabhi devices ko.

Example:
Socho ki ek classroom hai, jaha sab students teacher se baat karna chahte hain.
Teacher (channel) ek hi hai, toh ek time pe sirf ek student bol sakta hai.
MAC wahi “rules” banata hai ki kaun kab bolega.

2. Motivation for a Specialized MAC

Wireless communication me **interference** aur **collisions** common hoti hain. Isliye hume **specialized MAC techniques** ki zarurat hai jo problems ko solve karein:

- **Hidden Terminal Problem**
- **Exposed Terminal Problem**
- **Near Terminal Problem**
- **Far Terminal Problem**

3. Hidden Terminal Problem 🦉

A ------> B <------ C

•**Node A** aur **Node C** dono **Node B** ko data bhejna chahte hain.
•Lekin **A** aur **C** ek doosre ke **range** me **nahi** hain, isliye ek doosre ka signal detect nahi kar paate.

Problem:

•A aur C dono sochte hain ki channel free hai → dono ek hi time par transmit karte hain.
•Result → **Collision at B** ❌

Impact:
•B par data corrupt ho jata hai.
•Network efficiency **kam** ho jati hai.

Solution:
•**RTS/CTS mechanism** (Request to Send / Clear to Send) use hota hai.
•A agar data bhejna chahta hai, toh pehle B se permission lega.
•B permission deta hai, phir hi A data bhejta hai → Collision avoid hoti hai.

4. Exposed Terminal Problem 👂

A -----> B C -----> D

- **Node B** data bhej raha hai **A** ko.
- **Node C** data bhejna chahta hai **D** ko.

Problem:

- **C B ka signal detect karta hai aur sochta hai ki channel busy hai → apna transmission delay karta hai.**
- **Lekin C ka data D ko ja raha hai jo B ke range ke bahar hai → actually collision nahi hoti.**

Impact:

- **Channel underutilized hota hai.**
- **Network ka efficiency girta hai.**

Solution:

- **RTS/CTS mechanism se pata chal jata hai ki D B ke interference me nahi hai.**
- **C confidently D ko data bhej sakta hai.**

5. Near and Far Terminal Problem 📡

Near Node (N) ---> Receiver (R) <--- Far Node (F)

Problem:
- **Receiver ko near node ka signal bohot strong milta hai.**
- **Far node ka weak signal overpower ho jata hai.**
- **Result → Far node ka data loss ho jata hai.**

Impact:
- **Far devices ka communication unreliable hota hai.**
- **Wireless network imbalance ho jata hai.**

Solution:
- **Power control techniques use hote hain taaki sabhi nodes ka signal receiver par almost equal strength se aaye.**

- **Near node** receiver ke bohot paas hai.
- **Far node** receiver se door hai.
- Dono simultaneously data bhejte hain.

Problem	Scenario	Issue	Solution
Hidden Terminal	A → B ← C	A aur C ek dusre ko sense nahi karte, collision hoti hai	RTS/CTS
Exposed Terminal	A ← B C → D	C unnecessarily wait karta hai, channel free hote hue bhi	RTS/CTS
Near Terminal	Near → Receiver ← Far	Near ka strong signal, far ka weak signal block kar deta hai	Power Control
Far Terminal	Far node ka data weak	Far ka data receiver tak nahi pahunchta	Power Control

SDMA, FDMA, TDMA: Fixed TDM, Classical Aloha, Slotted Aloha, Carrier sense multiple access, Demand assigned multiple access, PRMA packet reservation multiple access, Reservation TDMA, Multiple access with collision avoidance, Polling, Inhibit sense multiple access.

c) Which are different method to access the channel based on their time. Explain in Details. **[5]**

b) Explain Frequency Division Multiple Access (FDMA) in wireless communication with figure. **[5]**

c) Explain ISMA and importance of ISMA. **[5]**

b) Compare and contrast SDMA, TDMA, FDMA and CDMA schemes. **[5]**

c) Write a short note on Packet Reservation Multiple Access. **[5]**

OR

Q2) a) Describe the operations of the following technologies: **[8]**

i) Classical ALOHA.

ii) Slotted ALOHA.

Q2) a) Write a short note on pure ALOHA. **[5]**

b) Compare the merits and demerits of TDMA and FDMA multiple access schemes. **[5]**

c) Write short note on : Telecommunication generations. **[5]**

OR

c) Explain in detail Packet Reservation Multiple Access (PRMA).

b) Compare and contrast SDMA, TDMA, FDMA and CDMA schemes. **[5]**

c) Write a short note on Packet Reservation Multiple Access. **[5]**

- SDMA, FDMA, TDMA
- Fixed TDM
- Classical Aloha
- Slotted Aloha
- Carrier Sense Multiple Access (CSMA)
- Demand Assigned Multiple Access
- PRMA (Packet Reservation Multiple Access)
- Reservation TDMA
- Multiple Access with Collision Avoidance
- Polling
- Inhibit Sense Multiple Access

1. SDMA (Spatial Division Multiple Access) :

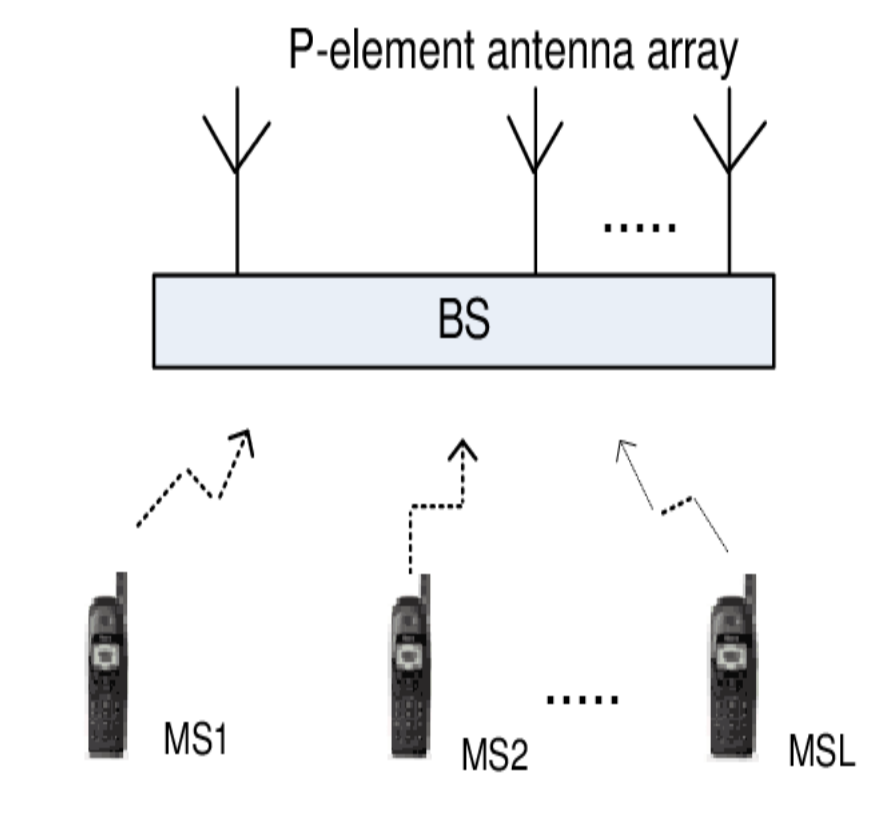
•**Definition**:
SDMA ek **multiple access technique** hai jahan **same frequency** aur **same time** par **multiple users** communicate kar sakte hain, **lekin alag-alag spatial directions** mein.

•Ye **antenna technology** par based hota hai—specially **smart antennas** ya **beamforming** techniques use karke.

SDMA **space domain** ka use karta hai.
Base station ya access point **multiple directional beams** generate karta hai, har beam **ek user** ya **user group** ko target karti hai.
How It Works:
1.User Detection → System har user ki location identify karta hai.
2.Beamforming → Antennas specific directions mein beam banate hain.
3.Spatial Separation → Users ko alag-alag directions mein communicate karwaya jata hai.
4.Interference Reduction → Kyunki beams alag direction mein focused hoti hain, **signal overlap nahi hota**.

3. Example
Maan lo ek Wi-Fi router hai jo **MU-MIMO (Multi-User Multiple Input Multiple Output)** technology support karta hai:

•**User 1** north side baitha hai.
•**User 2** south side baitha hai.
•Router dono ko **same frequency** aur **same time** par **alag-alag beams** bhejta hai.
•Dono users bina interference ke data receive karte hain.



•Base station multiple **narrow beams** banata hai.
•Har beam ek alag-alag user tak data bhejta hai.
•Same channel reuse hota hai without collision.

5. Advantages of SDMA

✅ **Higher capacity** → Same frequency reuse hoti hai.
✅ **Less interference** → Beams targeted hoti hain.
✅ **Better coverage** → Smart antennas direction optimize karte hain.
✅ **Efficient resource utilization** → Time aur frequency reuse hota hai.

6. Disadvantages of SDMA

❌ **Complex implementation** → Smart antennas aur beamforming costly hai.
❌ **High processing power needed** → User location tracking continuously hoti hai.
❌ **Mobility issue** → Agar users fast move karein toh tracking challenging ho jata hai.

7. Real-Life Applications

- **5G Networks** → Beamforming-based SDMA use hota hai.
- **MU-MIMO Wi-Fi Routers**.
- **Satellite Communications**.
- **Radar and Defense Systems**.

1. FDMA (Frequency Division Multiple Access)

•Definition:
FDMA ek multiple access technique hai jahan available frequency band ko multiple smaller sub-bands me divide kiya jata hai.
•Har user ko unique frequency channel diya jata hai aur wo continuous transmission ke liye usi pe kaam karta hai.

•FDMA mainly use hota hai:

- 1G Mobile Networks
- Satellite Communication
- Radio Broadcasting

2. Working of FDMA
FDMA me **total available bandwidth** ko **N users** ke liye **N frequency channels** me split kiya jata hai. Har channel ke beech me **guard band** hoti hai taaki interference na ho.

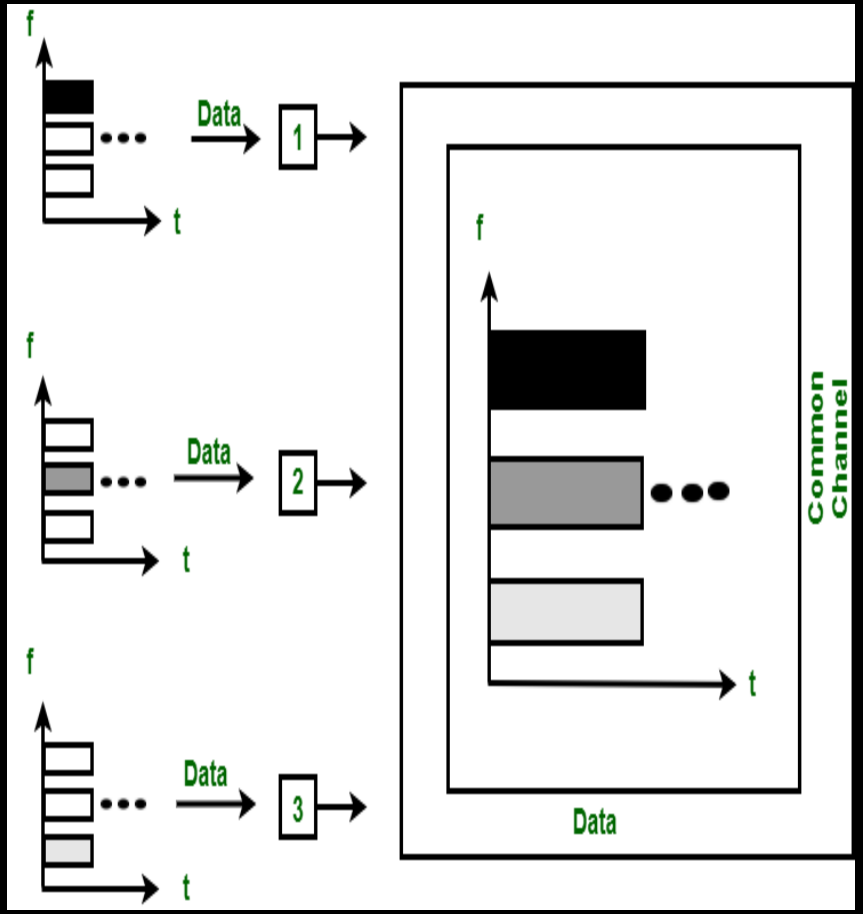
Steps:
1.Frequency Allocation → Har user ko ek unique frequency milti hai.
2.Continuous Transmission → Jab tak user active hai, wo usi channel par transmit karta hai.
3.Guard Bands → Adjacent channels ke beech thoda bandwidth chhoda jata hai taaki overlap na ho.
4.Independent Users → Har user ka communication alag frequency par hota hai, isliye collision nahi hoti.

3. FDMA Example

Maan lo total **bandwidth = 30 MHz** hai, aur **10 users** hain:

- Har user ko **3 MHz ka fixed frequency slot** milta hai.
- Example:
  - User 1 → 0 – 3 MHz
  - User 2 → 3 – 6 MHz
  - User 3 → 6 – 9 MHz
  - ...and so on.

Is tarah **sabhi users simultaneously communicate** kar sakte hain, **bina collision** ke.



•Available spectrum ko alag-alag **frequency channels** me divide kiya gaya hai.

•Har user ek **dedicated frequency** par communicate karta hai.

•Channels ke beech **guard bands** diye gaye hain to avoid interference.

5. Characteristics of FDMA

- **Channel Separation** → Har user ko ek alag channel milta hai.
- **Continuous Transmission** → Channel release nahi hota jab tak call active hai.
- **Low Latency** → Dedicated channels hone ki wajah se delay kam hota hai.
- **Guard Bands Required** → Interference avoid karne ke liye extra bandwidth chahiye hoti hai.

6. Advantages of FDMA

✅ **Simple Implementation** → Easy to design hardware
✅ **No Collisions** → Dedicated frequency har user ke liye
✅ **Low Latency** → Real-time voice calls possible
✅ **Less Synchronization Needed** → TDMA ki tarah time synchronization zaruri nahi

7. Disadvantages of FDMA

❌ **Wastage of Bandwidth** → Guard bands kaafi bandwidth le lete hain
❌ **Limited Users** → Spectrum limited hai, isliye zyada users handle nahi kar sakta
❌ **Poor Spectrum Efficiency** → Fixed allocation hone se unused slots waste ho jate hain
❌ **Interference Issue** → Proper filtering required hoti hai

8. Applications of FDMA

- **1G Mobile Communication** → FDMA hi primary access method tha
- **Satellite Communication Systems**
- **Two-way Radio Systems**
- **Analog TV & FM Broadcasting**

1. TDMA (Time Division Multiple Access) –

•**Definition**:

TDMA ek **multiple access technique** hai jahan **same frequency channel** ko **time slots** me divide karke **multiple users** ko allocate kiya jata hai.

•Har user **apne time slot** me data bhejta hai.

•Jab ek user ka slot khatam hota hai, doosra user transmit karta hai.

•Ye technique **digital communication systems** me kaafi popular hai.

Used In:
•2G GSM Networks
•Satellite Communication
•Wireless LANs

2. Working of TDMA

TDMA me **time** ko small parts me divide kiya jata hai, jinhe **time slots** kehte hain. Har user apne dedicated slot me data send/receive karta hai.

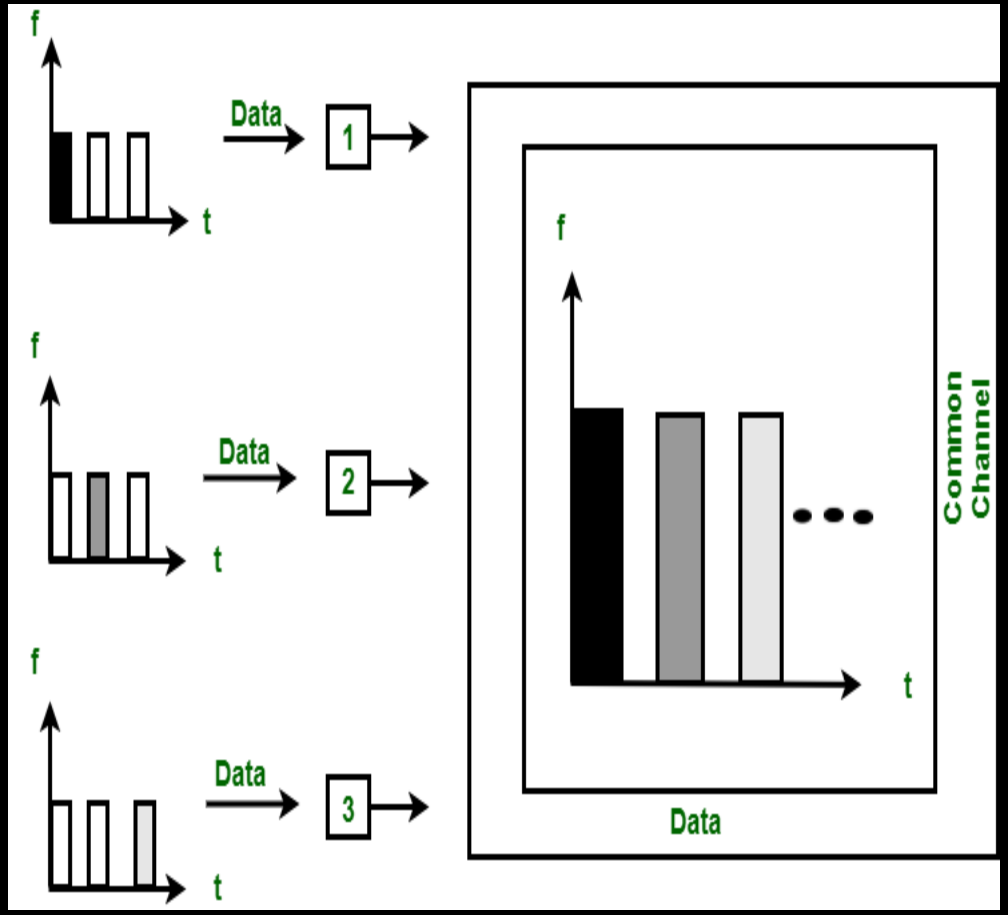
Steps:
1.Single Frequency Channel → Sab users ek hi frequency share karte hain.
2.Time Slot Allocation → Time ko slots me divide karke users ko assign kiya jata hai.
3.Round-Robin Transmission → Har user sequentially apne slot me transmit karta hai.
4.Synchronization → Accurate timing required hoti hai taaki data overlap na ho.

3. TDMA Example

Maan lo ek **5 MHz** frequency band hai aur 5 users hain:
•Har user ko **1 ms** ka **time slot** milta hai.
•Ek **frame** = 5 slots = 5 ms.
•Har user har frame me apna ek slot use karke data send/receive karega.

Example:
•**Slot 1** → User A
•**Slot 2** → User B
•**Slot 3** → User C
•**Slot 4** → User D
•**Slot 5** → User E

Is tarah **sabhi users same frequency** par communicate karte hain, **lekin alag-alag time slots me**.



- Ek hi frequency channel hai.
- Us channel ko multiple **time slots** me divide kiya gaya hai.
- Har user apne slot me data bhejta hai.
- Slots repeat hote hain har frame ke baad.

5. Characteristics of TDMA

- **Shared Frequency** → Same frequency sab users share karte hain.
- **Dedicated Time Slots** → Har user ko ek fixed time slot milta hai.
- **High Synchronization Needed** → Accurate clock synchronization zaruri hai.
- **Frame-based Structure** → Slots combine hoke frame banate hain.

6. Advantages of TDMA

✅ **Efficient Spectrum Usage** → Same frequency ko multiple users efficiently share karte hain.
✅ **No Interference** → Alag-alag time slots hone ki wajah se overlap nahi hota.
✅ **Flexible** → Different data rates ke liye slot size adjust kiya ja sakta hai.
✅ **Lower Power Consumption** → User apne slot ke alawa rest kar sakta hai.

7. Disadvantages of TDMA

❌ **Strict Synchronization Required** → Time mismatch se collisions ho sakti hain.
❌ **High Latency** → User ko apne slot ka wait karna padta hai.
❌ **Limited Data Rates** → Har user ka slot fixed hone ki wajah se bandwidth limited hoti hai.
❌ **Complex Hardware** → Accurate timing circuits ki requirement hoti hai.

8. Applications of TDMA

- **2G GSM Networks** (Global System for Mobile Communication)
- **Satellite Communication**
- **Digital Enhanced Cordless Telecommunication (DECT)**
- **Military & Defense Communication Systems**

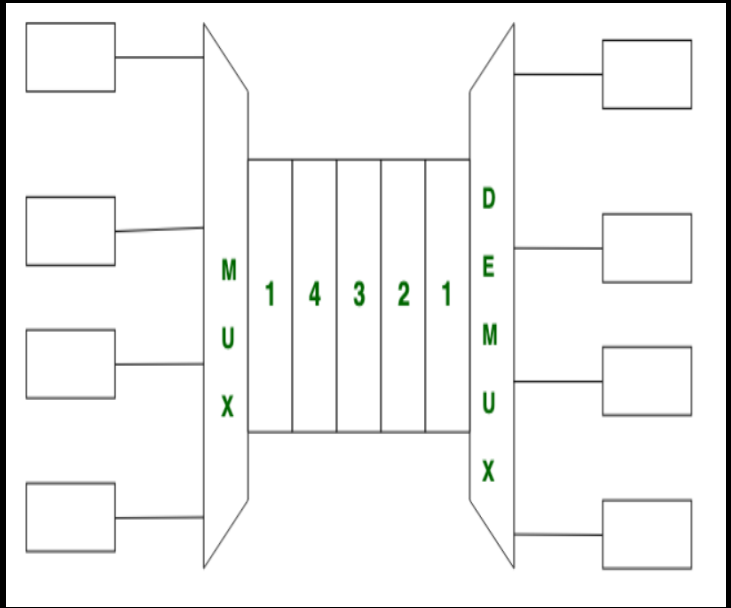
Point	FDMA	TDMA	CDMA	SDMA
1. Basic Concept	Bandwidth ko **frequency bands** me divide kiya jata hai	Same frequency ko **time slots** me divide kiya jata hai	Same frequency & time, lekin **unique codes** assign kiye jate hain	Same frequency & time, lekin **different spatial beams** use kiye jate hain
2. Resource Sharing	**Frequency-based** sharing	**Time-based** sharing	**Code-based** sharing	**Space-based** sharing
3. Synchronization	**Not required**	**Required** (time slots ke liye)	**Not required**	**Required** (beamforming ke liye)
4. Efficiency	**Moderate** (guard bands waste hoti hain)	**High** (spectrum utilization better)	**Very High** (spread spectrum)	**Very High** (spatial reuse)
5. Interference	Low (different frequencies)	Low (different time slots)	Minimal (codes separate users)	Minimal (beams separate users)
6. Complexity	**Low** (simple filters)	**Medium** (timing circuits needed)	**High** (code generation)	**Very High** (smart antennas required)
7. Applications	**1G**, FM Radio, Satellites	**2G GSM**, DECT Phones	**3G, 4G LTE, GPS**	**5G, MU-MIMO, Radar**

What is Fixed TDM?

•Fixed TDM me **time slots predefined** hote hain aur **har user** ko **fixed slot** assign kiya jata hai, chahe user data bhej raha ho ya nahi.

•Isko **Synchronous TDM** bhi kehte hain, kyunki **slot allocation fixed hota hai**.

•Agar koi user apne slot me data nahi bhejta, toh wo **slot waste ho jata hai**.



Example of Fixed TDM

Maan lo 4 users hain: **A, B, C, D**

•Har frame me **4 slots** honge.

•**Slot 1 → A**, **Slot 2 → B**, **Slot 3 → C**, **Slot 4 → D**.

•Har user ka **fixed slot** har frame me repeat hota rahega.

Case:

•Agar **B** data nahi bhejta, toh bhi **Slot 2 empty** chala jayega.

ALOHA Protocol
ALOHA ek **random access protocol** hai jo **medium access control (MAC)** layer me use hota hai, mainly **wireless communication** me.
Ye originally **University of Hawaii** me develop hua tha satellite aur radio communication ke liye.

ALOHA ke **do main types** hain:

1.Pure Aloha (Classical Aloha)
2.Slotted Aloha

1. Pure Aloha (Classical Aloha)

Concept

- Isme koi **time slot** nahi hota.
- Jab bhi koi station data bhejna chahta hai, wo **turant transmit** karta hai.
- Agar **collision** hoti hai, toh station **random time** wait karke dobara transmit karta hai.

Working Steps

1. Station data bhejna chahta hai → **turant transmit karega**.
2. Agar **collision** hoti hai → Packet **destroy** ho jata hai.
3. Station **random backoff time** wait karta hai.
4. Dobara **retransmit** karta hai.

Throughput

- Maximum throughput ≈ **18.4%**.
- Bahut low efficiency kyunki **collision probability high** hoti hai.

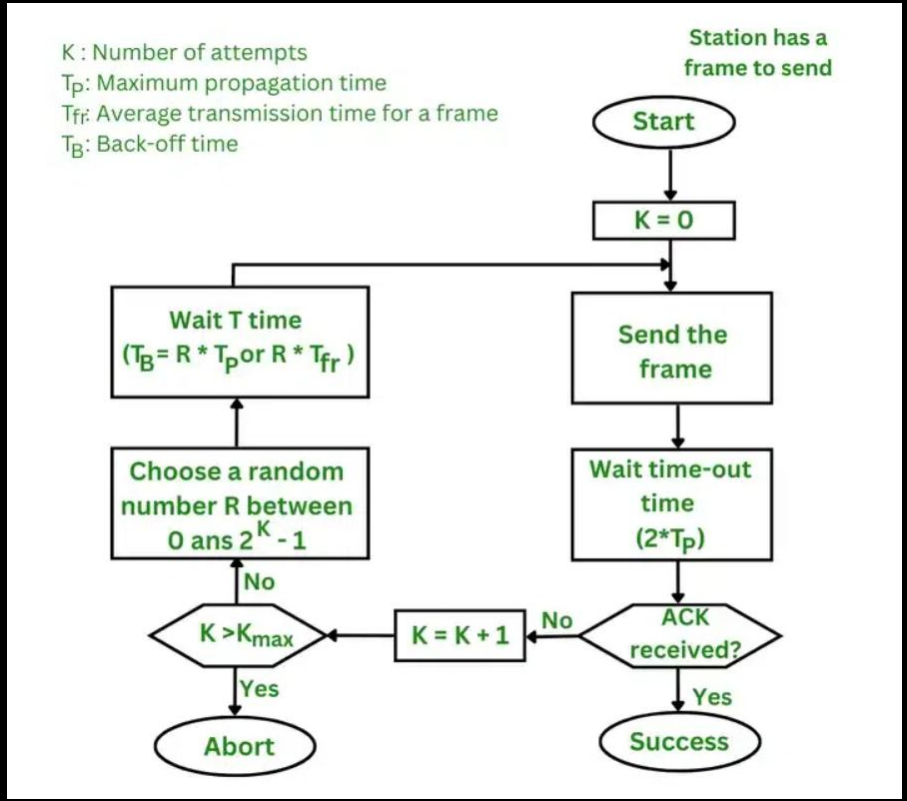
•**Start:** Station ke paas frame bhejne ke liye hai, initially **K = 0** hota hai (number of attempts).

•**Send Frame:** Frame bhejna hota hai aur **ACK** (Acknowledgment) ka wait kiya jata hai.

•**ACK Check:** Agar ACK mil jata hai → **Success**, warna **collision** maan kar retry process start hota hai.

•**Backoff Time:** Station ek random number **R** choose karta hai between **0 to 2^K – 1**, aur $T^B = R \times T_p$ wait karke dobara bhejne ki koshish karta hai.

•**Retry or Abort:** Agar **K > Kmax** ho jata hai toh transmission **abort** ho jata hai, warna **K = K + 1** karke dobara try hota hai.



2. Slotted Aloha
Concept
•Slotted Aloha, **Pure Aloha** ka **improved version** hai.
•Yaha **time slots** hote hain, aur stations **sirf slot ke starting point pe hi transmit kar sakte hain**.
•Collision chances **kam ho jate hain**.

Working Steps
1.Time ko **equal slots** me divide kiya jata hai.
2.Station sirf **slot start hone par transmit** kar sakta hai.
3.Agar collision hoti hai → Station **next slot** me random backoff ke baad retransmit karega.

Throughput
•Maximum throughput ≈ **36.8%**.
•Pure Aloha se **double efficiency** deta hai.

Example
•Agar slot 1 = 1 sec hai → Station A sirf **slot start** pe bhejega.
•Agar B same slot me bhejta hai → Collision.
•Agar B next slot me bhejta hai → Successful transmission.

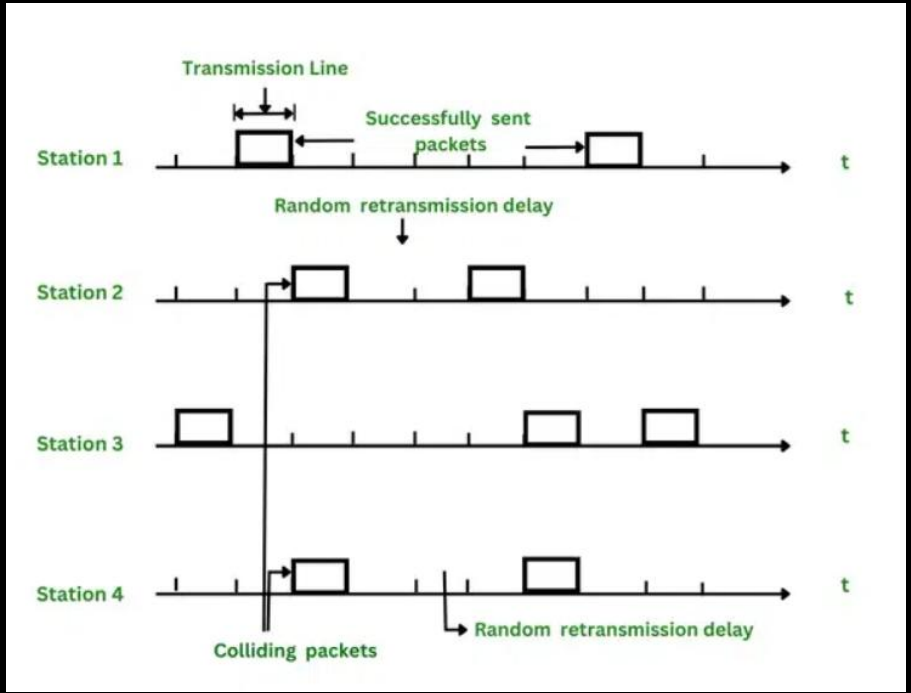
•**Stations Data Send Karte Hain:** Multiple stations (Station 1, 2, 3, 4) same transmission line par apne packets bhejte hain.

•**Successful Transmission:** Agar kisi station ka packet bina overlap ke bheja jata hai, toh woh **successfully deliver** hota hai.

•**Collision Hoti Hai:** Jab do ya zyada stations **ek hi time** par data bhejte hain, toh **packets collide** karte hain.

•**Random Retransmission Delay:** Collision ke baad stations **random delay** wait karke dobara packets bhejte hain, taki dubara collision na ho.

•**Efficiency Improve Hoti Hai:** Random delay ki wajah se network me **throughput improve** hota hai aur data loss kam hota hai.



Feature	Pure Aloha (Classical)	Slotted Aloha
Time Division	No time slots	Time slots used
Transmission	Station kabhi bhi transmit kar sakta hai	Station sirf **slot ke starting point** pe transmit karega
Collision	High probability	Lower probability
Efficiency	~18.4%	~36.8%
Throughput	Low	Better than Pure Aloha
Complexity	Simple implementation	Slightly more complex
Delay	Higher	Lower
Applications	Early satellite communication	Ethernet, modern wireless networks

Carrier Sense Multiple Access (CSMA)

Definition:

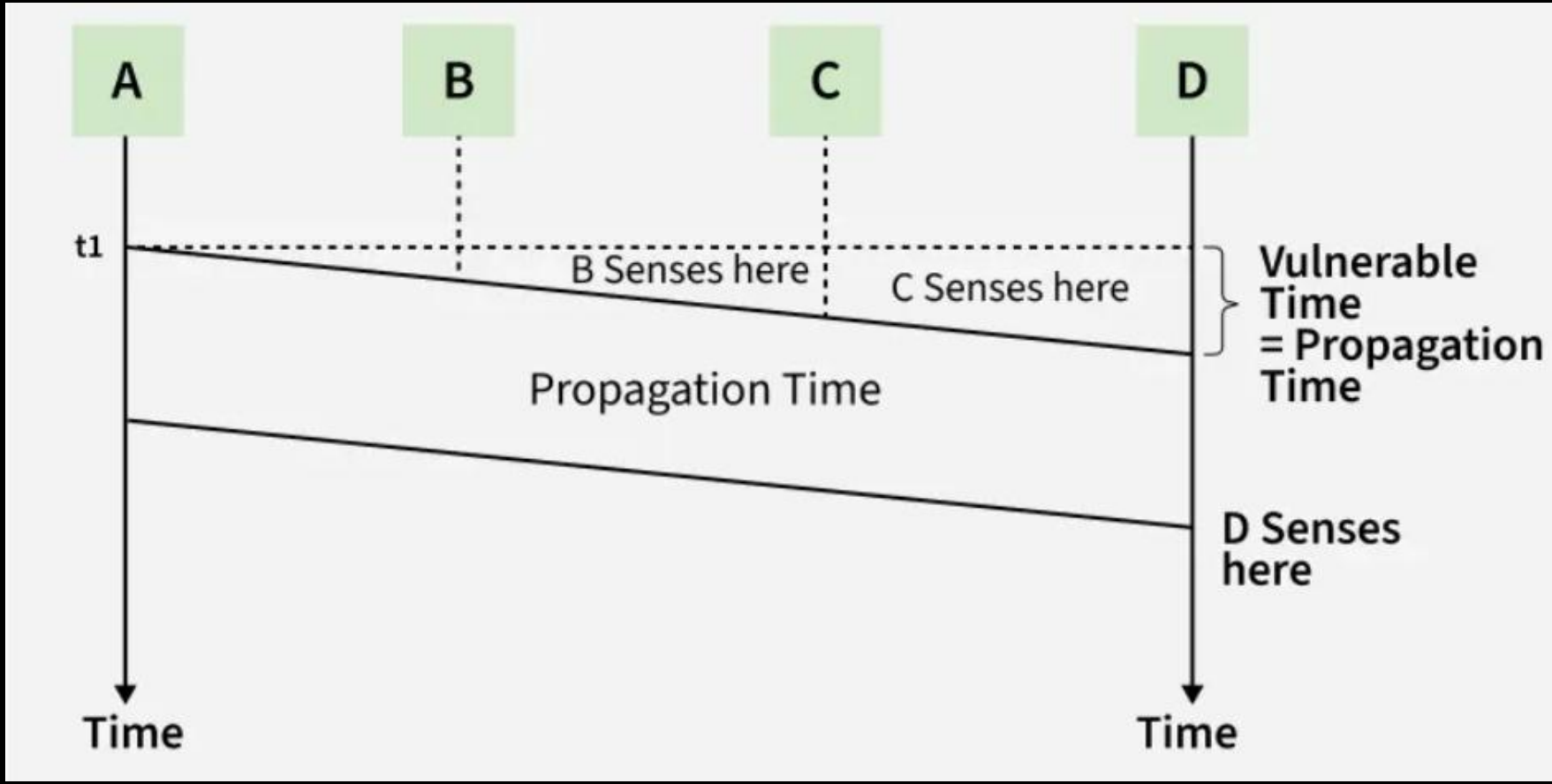
CSMA ek network protocol hai jisme device **pehle channel check karta hai** aur fir data bhejta hai. Agar channel free hai → data bhejo, agar busy hai → wait karo.

Steps (Kaise kaam karta hai):

1. **Listen karo channel ko** – Device dekhta hai koi aur data bhej raha hai ya nahi.
2. **Check karo agar free hai:**
   - Agar **idle** → data bhej do.
   - Agar **busy** → thodi der wait karo (backoff) aur phir try karo.
3. **Collision handle karna** – Agar do devices ek saath bhejenge → collision hoga. Devices random time wait karke dobara try karte hain.

Types of CSMA:

1. **1-Persistent CSMA:**
   - Agar channel idle → turant send karo.
   - Agar busy → wait karo jab tak free na ho.
2. **Non-Persistent CSMA:**
   - Agar channel idle → turant send karo.
   - Agar busy → random time wait karo, phir check karo.
3. **p-Persistent CSMA:** (slotted channel ke liye)
   - Agar idle → data bhejo **probability p** ke saath.
   - Agar nahi bheja → next time slot wait karo.


A
B
C
D
t1
B Senses here
C Senses here
Vulnerable Time = Propagation Time
Propagation Time
D Senses here
Time
Time

2. Demand Assigned Multiple Access (DAMA)

•**Definition:** DAMA me channels ko **user ki demand ke hisaab se allocate** kiya jata hai.

•Jab user ko data bhejna hai → wo request karta hai.

•Agar channel free hai → usko assign kar diya jata hai.

•Jab data transmission complete hota hai → channel wapas pool me chala jata hai.

👉 **Working:**

1.User → request send karta hai.

2.Central controller → check karta hai free channel.

3.Channel allocate hota hai → data transmit hota hai.

4.Kaam complete hone ke baad → channel release hota hai.

👉 **Advantages:**

•Resources waste nahi hote.

•Efficient for bursty traffic (jaise internet browsing).

👉 **Disadvantages:**

•Delay ho sakta hai agar demand zyada ho.

•Complex implementation.

👉 **Example:**

Satellite communication systems jaha ek centralized controller hota hai jo slots allocate karta hai.

📌 **PRMA – Packet Reservation Multiple Access**

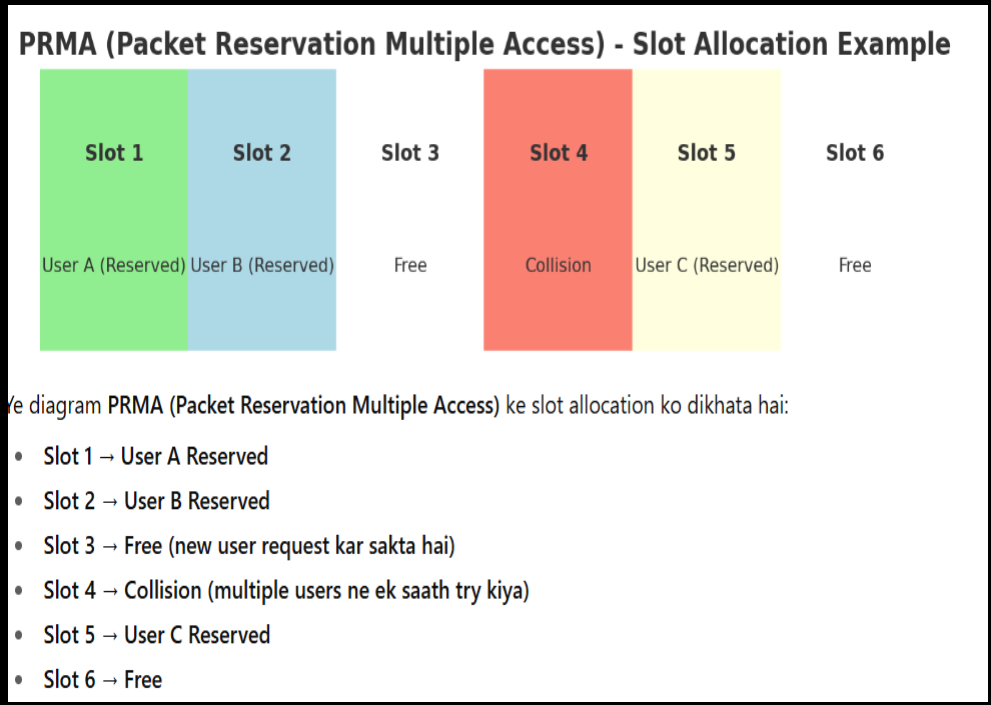
•**Definition:** PRMA ek hybrid technique hai jo **TDMA + Reservation** ka use karti hai.

•**Working:**

- Channel ko **time slots** me divide kiya jata hai.
- User apne packets bhejne ke liye slot **request** karta hai.
- Agar ek hi user bhejta hai → slot usko **reserve** mil jata hai.
- Agar multiple users bhejte hain → **collision** hota hai, aur fir retry karna padta hai.
- Jab tak user ke packets khatam nahi hote, wahi reserved slot use karta hai.

•**Advantages:** Efficient bandwidth use, continuous traffic (voice/data) ke liye best, reservation ke baad collision nahi.

•**Disadvantages:** Slot capture ke time pe collision ho sakta hai, thoda complex system.



Ye diagram **PRMA (Packet Reservation Multiple Access)** ke slot allocation ko dikhata hai:

- Slot 1 → User A Reserved
- Slot 2 → User B Reserved
- Slot 3 → Free (new user request kar sakta hai)
- Slot 4 → Collision (multiple users ne ek saath try kiya)
- Slot 5 → User C Reserved
- Slot 6 → Free

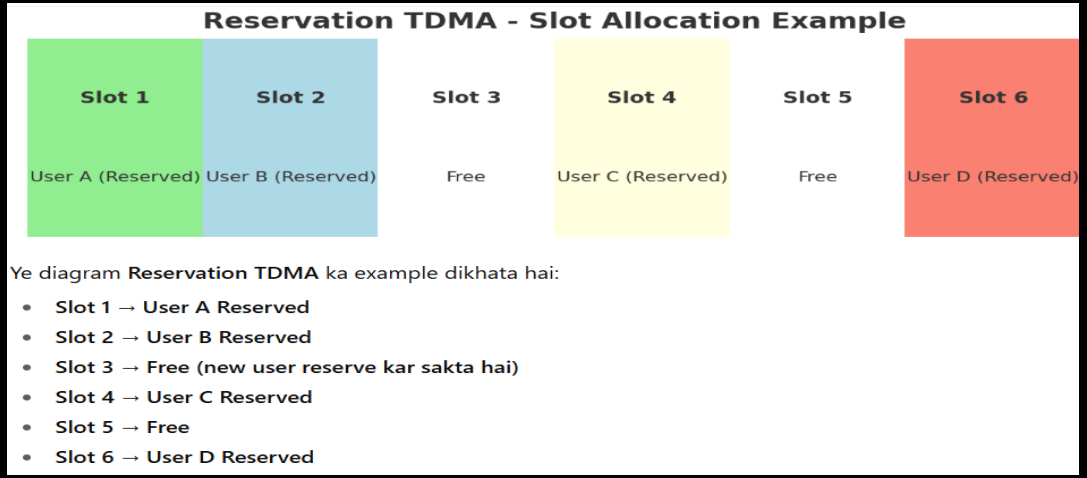
📌 Reservation TDMA

•**Definition:** Reservation TDMA ek **improved TDMA** hai jisme **users demand ke hisaab se slots reserve** karte hain. Normal TDMA me slots fix hote hain chahe use ho ya na ho, lekin Reservation TDMA me waste nahi hota.

•**Working:**

- Frame me slots divide hote hain.
- Jo user ko data bhejna hai → slot reserve karta hai.
- Reserved slot me data transmit hota hai.
- Jab data khatam hota hai → slot free ho jata hai.

•**Advantages:** Efficient bandwidth use, waste nahi hoti.
•**Disadvantages:** Reservation ke liye extra signalling lagta hai.



Ye diagram **Reservation TDMA** ka example dikhata hai:

- **Slot 1 → User A Reserved**
- **Slot 2 → User B Reserved**
- **Slot 3 → Free (new user reserve kar sakta hai)**
- **Slot 4 → User C Reserved**
- **Slot 5 → Free**
- **Slot 6 → User D Reserved**

📌 **MACA (Multiple Access with Collision Avoidance)**

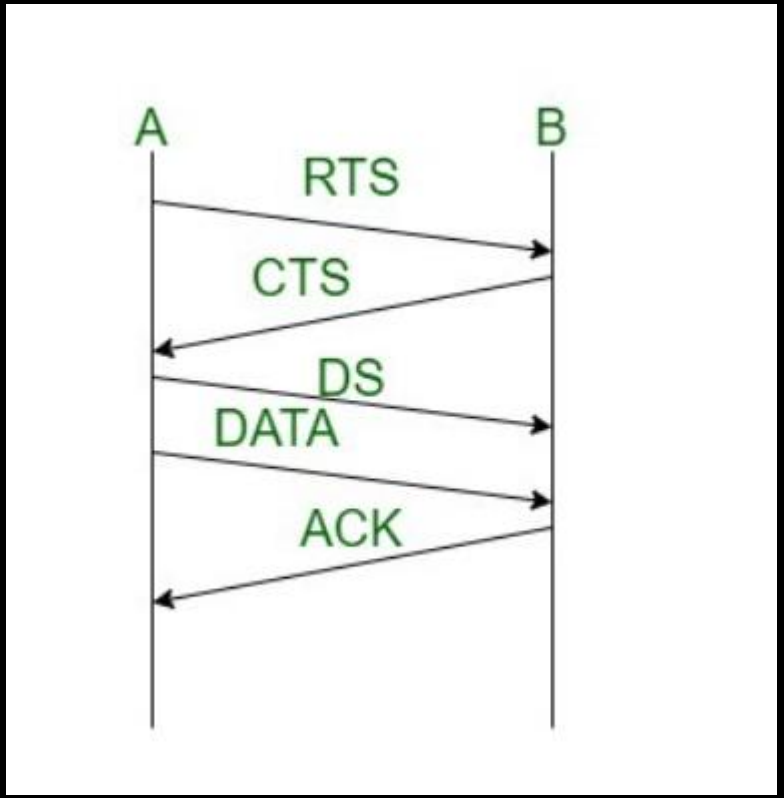
•**Definition:** MACA ek protocol hai jo wireless networks me **collision avoid** karne ke liye use hota hai.

•**Working:**

- Sender pehle **RTS (Request to Send)** bhejta hai.
- Receiver agar free hai to **CTS (Clear to Send)** bhejta hai.
- Sender phir **data** bhejta hai.
- Receiver finally **ACK** deta hai.

•**Advantages:** Collision kam, hidden terminal problem solve hota hai.

•**Disadvantages:** Extra RTS/CTS messages ke wajah se delay aur overhead.



📌 Polling

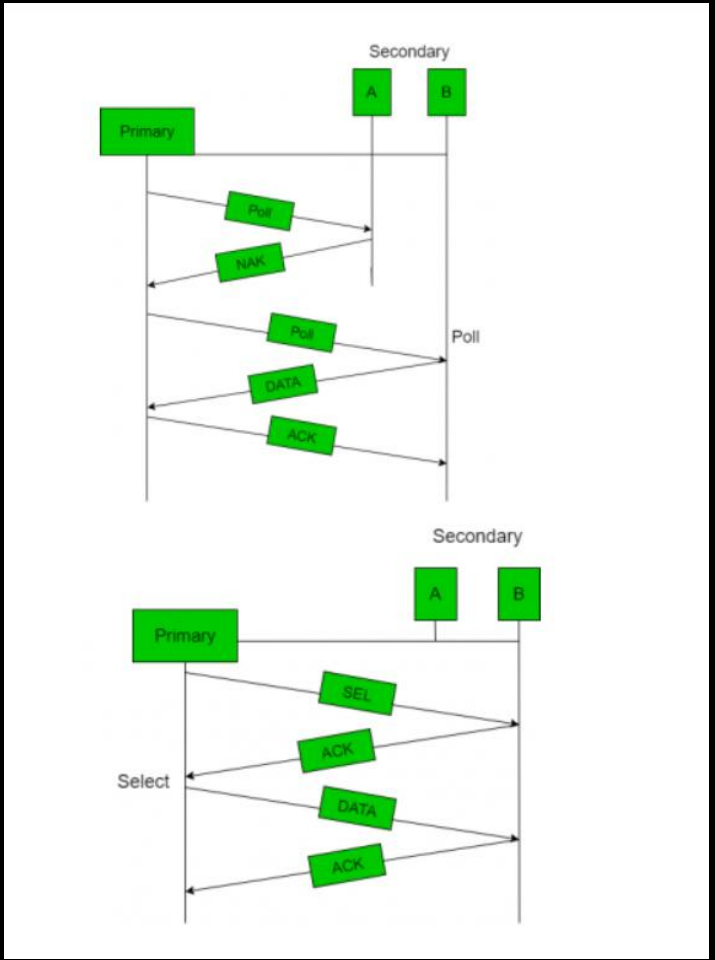
•**Definition:** Polling ek access method hai jisme ek **master device** sequentially sabhi users ko check karta hai: *“Kya tumhe data bhejna hai?”*

•**Working:**

- Master ek-ek karke users ko poll karta hai.
- Jis user ke paas data hai → wo transmit karta hai.
- Agar data nahi hai → master next user ko check karta hai.

•**Advantages:** Collision nahi hota, orderly communication.

•**Disadvantages:** Delay zyada, master fail ho to system band.



📌 Inhibit Sense Multiple Access (ISMA)

🔹 Definition

ISMA ek **random access protocol** hai jo mainly **cellular mobile communication systems** (jaise **ALOHA-based systems**) mein use hota hai.
Iska main purpose **uplink channel ke access ko control karna** hai.

🔹 Working Principle

- Ye **ALOHA principle** pe based hai.
- Jab ek mobile station (MS) ko data bhejna hota hai → wo **uplink channel** ke free hone ka wait karta hai.
- Agar uplink channel **busy hai**, to **transmission inhibit** ho jaati hai (matlab MS apna data nahi bhejta).
- Agar channel **idle hai**, tabhi MS apna data transmit karta hai.

♦ Steps (Simple Flow)

1. MS channel ko sense karta hai.
2. Agar **busy** → transmission inhibit.
3. Agar **idle** → MS data transmit kar deta hai.
4. Agar collision hota hai → random back-off karke fir se try karta hai.

♦ Advantages

- Channel ka **efficient utilization** hota hai.
- **Collisions kam** hote hain as compared to pure ALOHA.

♦ Disadvantage

- Agar channel zyada **busy** ho → stations ko wait karna padta hai (delay increase hota hai).

1. **Base Station (BS):**

   Beech me jo tower hai wo **base station** hai.

   Base station ka kaam hai uplink channel ki **status information** dena (Busy/Idle).

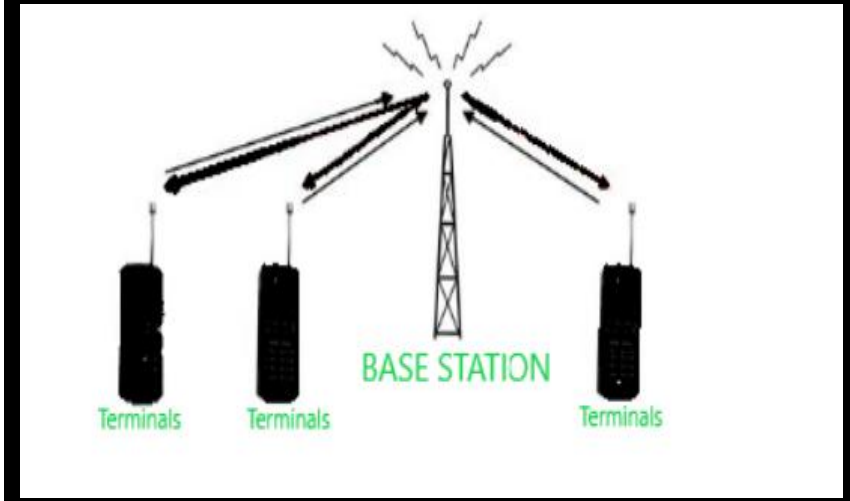
2. **Terminals (Mobile Stations):**

   Side me jo chhote-chhote phones dikh rahe hain wo **terminals (MS)** hain.

   Har terminal channel ko use karna chahta hai data bhejne ke liye.

3. **Working Flow:**

   - Jab koi terminal data bhejna chahta hai → pehle wo **uplink channel ko sense karta hai**.
   - Agar **Base Station busy signal bhej raha hai** → terminal apna transmission **inhibit (rokti)** hai.
   - Agar **Base Station idle signal bhej raha hai** → terminal apna data transmit kar deta hai.
   - Agar ek hi time pe multiple terminal transmit karein → collision ho sakta hai → terminals **random back-off** karke fir try karte hain.



b) Write a short note of CSMA/CD and CSMA/CA.

c) Write short note on : Telecommunication generations. **[5]**

Which are different method to access the channel based on their time. Explain in Details. **[5]**

(b) Short Note on CSMA/CD and CSMA/CA

🔹 CSMA/CD (Carrier Sense Multiple Access with Collision Detection)

- Ye **wired LANs (Ethernet)** me use hota hai.
- Station pehle channel ko **sense** karta hai → agar free hai to transmit karta hai.
- Agar **collision hota hai**, station usse detect karke transmission **abort** kar deta hai aur fir **random back-off** ke baad dobara try karta hai.

✅ Use: Ethernet networks me.

🔹 CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance)

- Ye mainly **wireless LANs (Wi-Fi)** me use hota hai.
- Station channel ko sense karta hai aur collision avoid karne ke liye **acknowledgement (ACK), RTS/CTS (Request To Send / Clear To Send)** mechanism use karta hai.
- Isme collision detect karna mushkil hai isiliye system pehle se hi **avoidance** karta hai.

✅ Use: Wireless networks me.

Short Note on Telecommunication Generations
1.1G: Analog voice communication (1980s), sirf voice call support.
2.2G: Digital voice + SMS, GSM/CDMA, zyada security.
3.3G: Voice + Data (internet access, video calls), UMTS/WCDMA.
4.4G: High-speed data (LTE), HD video streaming, VoIP.
5.5G: Ultra-fast data, IoT support, low latency, smart devices connectivity.

(d) Different Methods to Access the Channel Based on Time
Channel access methods mainly **time-based multiple access** hote hain:
1.FDMA (Frequency Division Multiple Access):
1. Har user ko ek **frequency band** allocate hota hai.
2. Example: Radio channels.

2.TDMA (Time Division Multiple Access):
1. Same frequency par alag-alag users ko **time slots** diye jate hain.
2. Example: GSM (2G).

3.CDMA (Code Division Multiple Access):
1. Saare users ek hi frequency use karte hain but alag-alag **codes** se differentiate hote hain.
2. Example: 3G networks.

4.SDMA (Space Division Multiple Access):
1. Users ko alag-alag **geographical areas (cells/antenna sectors)** assign kiye jate hain.

✅ In methods ka purpose hota hai channel ko efficiently share karna aur interference/collision avoid karna.

Explain carrier sense Multiple access with collision avoidance (CSMA/CA). **[5]**

What is the Reason for implementing CSMA with CA strategy in wireless networks?

- **Definition:**

CSMA/CA ek **wireless medium access control protocol** hai jo transmission ke time **collision avoid karne** ke liye use hota hai.

- **Working:**

1.Station channel ko **sense** karta hai.
2.Agar channel free hai → station data bhejne se pehle **back-off time** wait karta hai.
3.Agar channel busy hai → station wait karta hai aur baad me dobara try karta hai.
4.Collision avoid karne ke liye **RTS (Request to Send) / CTS (Clear to Send)** aur **ACK (Acknowledgement)** use hota hai.

- **Example:** Wireless LANs (Wi-Fi, IEEE 802.11).

✅ Isse **data loss kam hota hai** aur wireless communication zyada reliable ban jata hai.

📌 **Q2: Reason for Implementing CSMA/CA in Wireless Networks**

•Wireless me **collision detect karna (CD)** mushkil hai (jaise wired Ethernet me hota hai).

•Agar do devices ek sath transmit karein, to signals overlap hote hain aur dono data **loss** ho jata hai.

•CSMA/CA ka purpose hai:

- **Collision ko avoid karna** (detect nahi).
- **Hidden terminal problem** ko kam karna.
- Wireless channel ka **efficient utilization** ensure karna.

✅ Isliye wireless networks me CSMA/CA strategy implement hoti hai.