full one-shot videos on :**JK Coding Pathshala YouTube channel**

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Unit III	ADHOC AND WSN	(06 hrs)
Infrastructure Network and Infrastructure-less Wireless Networks, Issues in Adhoc Wireless Network, Adhoc Network MAC Layer: Design Issues, Design Goal, Classification, MACAW, **Adhoc Network Routing Layer:** Issues in Designing a Routing Protocol for Ad-hoc Wireless Networks – Classifications of Routing Protocols, DSDV, AODV, DSR, **Applications of Sensor Network**, Comparison with Ad Hoc Wireless Network, Sensor node architecture Issues and Challenges in Designing a Sensor Network, Classification of sensor network protocols, SENSOR NETWORK ARCHITECTURE: Layered Architecture, Clustered Architecture		

Q1)	a)	Explain Adhoc Network MAC Layer with Design Issues, Design Goal & Classification.	**[9]**
	b)	Classify protocols used in Sensor Network.	**[9]**
		OR	
Q2)	a)	Explain AODV and DSR protocol in detail.	**[9]**
	b)	Explain the issues in designing a Routing Protocol for Ad-hoc Wireless Networks.	**[9]**

Q1) a) Explain DSDV & AODV protocol in detail. **[9]**

b) Write a short note on sensor network with classification of protocols used. **[9]**

OR

Q2) a) Explain design issues and design goal in adhoc network MAC layer. **[6]**

b) Compare sensor network with adhoc wireless network. **[6]**

c) Explain with diagram clustered architecture for sensor network. **[6]**

Q1) a) Explain the connection establishment and data transfer phase in the following routing protocols with suitable diagram. **[9]**

i) AODV

ii) DSDV

b) Explain with diagram Layered Architecture for Sensor Network. **[9]**

OR

Q2) a) Differentiate between infrastructure network and infrastructure less network. **[6]**

b) What are hidden station and exposed station problem in WLAN. **[6]**

c) Explain Distributed Denial of Service attacks. **[6]**

4) *Assume suitable data if necessary.*

Q1) a) Explain MACAW protocol in details. **[9]**

b) Explain with diagram Layered Architecture for Sensor Network. **[9]**

OR

Q2) a) Explain the issues in designing a routing protocol for Ad-hoc Wireless Network. **[6]**

b) What are hidden station and exposed station problem in WLAN. **[6]**

c) Explain different issues and Challenges in Designing a Sensor Network. **[6]**

Q1) a) Explain with diagram layerd architecture & clustered architecture for sensor network. **[9]**

b) Comment on Adhoc Netwrok MAC layer with design issues, Design goal. **[9]**

OR

Q2) a) Explain the issues in designing a Routing protocol for adhoc wirless network. **[9]**

b) Explain different issues and challenges in designing sensor network. **[9]**

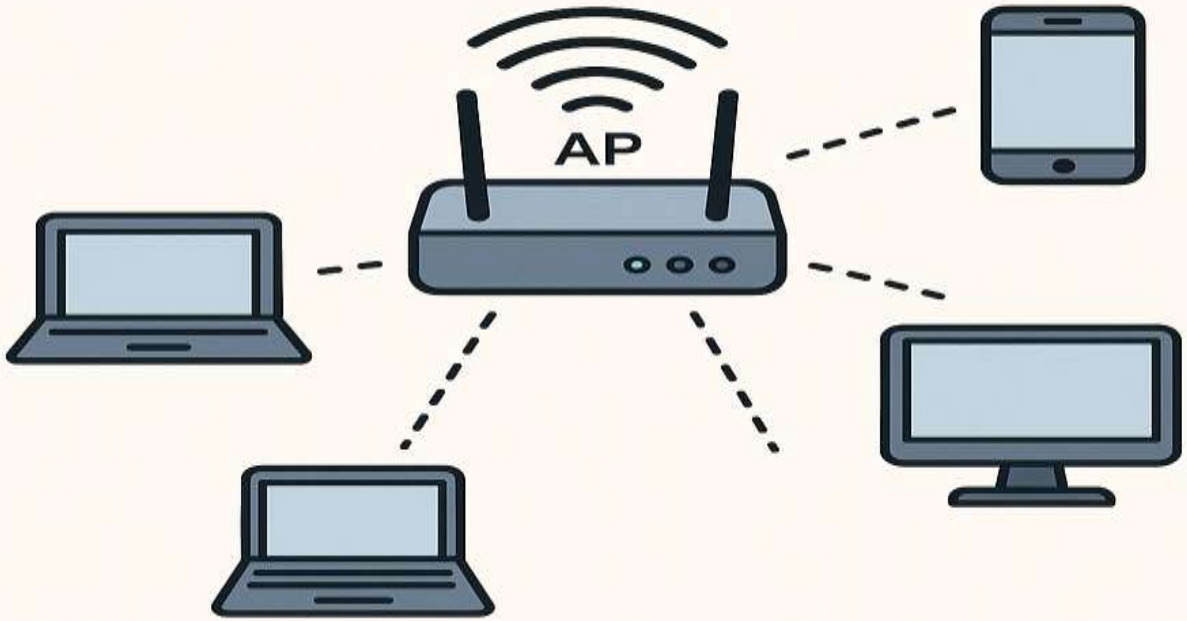
Infrastructure Network
and
Infrastructure-less Wireless Networks

1. Infrastructure Wireless Network – (Jisme Tower ya Access Point Hota Hai)

📌 **Simple Language Mein:**
Yeh aise network hote hain jisme ek **center device** hota hai, jaise **Wi-Fi router, mobile tower ya access point**, jo sab devices ko connect karta hai.

Socho Jaise:
Tumhare ghar ka Wi-Fi router. Sab phones, laptops, TV isi router se judte hain. Agar router band ho gaya, toh sabka net chala jaata hai.

Infrastructure Wireless Network



Features:

- Ek **central device** sab kuch control karta hai.
- Devices **direct ek dusre se baat nahi karte**, wo router ke through communicate karte hain.
- **Reliable** hota hai (agar setup sahi ho).
- **Range** zyada hoti hai, especially cellular networks mein.

🔎 **Examples:**

- Ghar ka Wi-Fi
- Office ka wireless LAN
- Mobile network (4G/5G)

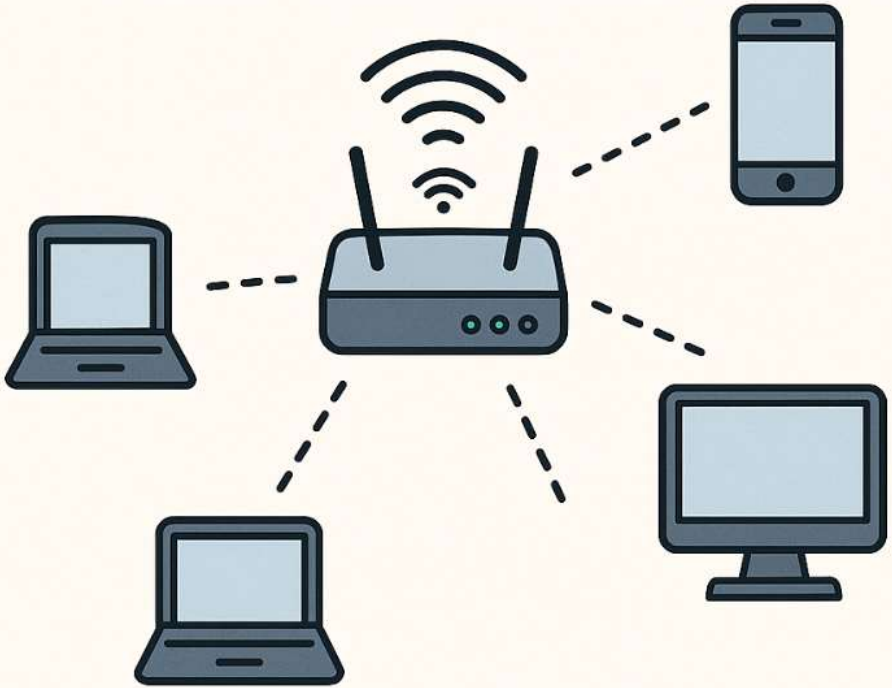
🔄 2. Infrastructure-less Network (Ad Hoc Network) – (Jisme Koi Fixed Device Nahi Hota)

📌 **Simple Language Mein:**
Yeh aise network hote hain jisme **koi center ya router nahi hota**, sab devices **directly ek dusre se connect** karte hain.

 Socho Jaise:
Tum aur tumhara doston ka phone Bluetooth se connect ho gaya, bina kisi router ke. Sab ek dusre se files bhej rahe ho — bas wahi hai **ad hoc network**.

Infrastructure-less Wireless Network

(Ad Hoc Network)



Features:

•Koi fixed tower ya router nahi hota.
•Devices **apne aap network banate hain**.
•**Temporary** ya emergency ke liye perfect hota hai.
•Thoda unstable ho sakta hai — agar koi device hat gaya toh network toot sakta hai

🎤 **Examples:**

- Bluetooth file sharing
- Army communication during war (without network towers)
- Natural disaster ke time temporary network setup

Feature	Infrastructure Network	Infrastructure-less Network (Ad Hoc)
Central Coordination	Yes (Access Point/Base Station)	No
Setup Time	Longer	Quick
Cost	Higher (equipment needed)	Lower (no infrastructure)
Scalability	High	Limited
Reliability	High	Variable
Use Case Example	Office Wi-Fi, Cellular Networks	Disaster recovery, sensor networks

Ad Hoc Wireless Network – Main Issues

⚠ 1. Lack of Central Control

📌 Kya hota hai:

Is network mein koi router ya server nahi hota, sab devices apne aap connect hote hain.

- **Problem:**

Koi ek device sabko manage nahi karta, isliye network **confused ya unstable** ho sakta hai.

📱 Example:

5 log Bluetooth se files share kar rahe hain. Agar ek phone off ho gaya, to beech ke connections toot sakte hain.

🔋 2. Battery Drain and Resource Usage

📌 **Kya hota hai:**

Devices khud routing ka kaam karte hain (data dusre tak pahunchate hain), isliye unka **battery aur processing power zyada use** hota hai.

 Problem:

Jiska phone ya device routing mein zyada kaam karta hai, uska battery jaldi drain ho jata hai.

📱 **Example:**

Agar ek device 3-4 devices ke beech mein hai, to woh zyada data forward karega aur jaldi dead ho sakta hai.

🔁 **3. Unstable Connections**

📌 **Kya hota hai:**

Devices kabhi bhi move kar sakte hain, switch off ho sakte hain — network dynamic hota hai.

 Problem:

Connection **bar bar break** ho sakta hai, especially jab log move kar rahe ho ya signal weak ho.

📱 **Example:**

Agar aap car mein ho aur kisi ke sath direct file share kar rahe ho, to thoda move hote hi link toot sakta hai.

4. Scalability Problem

📌 **Kya hota hai:**

Chhoti group ke liye sahi hai, lekin **bahut zyada devices connect karein to problem hoti hai**.

Problem:

Routing complex ho jata hai, aur data transfer slow ya fail ho sakta hai.

📱 **Example:**

Agar ek classroom mein 30 students Bluetooth sharing karte hain — kisi ko file nahi milegi easily.

🔐 5. Security Issues

📌 Kya hota hai:

Kyunki centralized firewall ya security system nahi hota, to **koi bhi data sniff kar sakta hai**.

⚠ Problem:

Sensitive data easily **hack ya misuse** ho sakta hai.

📱 Example:

Agar tum kisi unknown ad hoc network se connect ho jao, toh wo tumhara data copy kar sakta hai.

📡 **6. Limited Range**

📌 **Kya hota hai:**

Har device ki wireless range limited hoti hai.

 Problem:

Agar devices door ho gaye to data forward karna mushkil ho jata hai.

📱 **Example:**

Ek device se dusre tak signal tabhi pahunchta hai jab beech mein aur devices ho. Agar beech ka device hat gaya to signal nahi jaayega.

Issue	Problem in Simple Words	Real-life Example
No Central Control	Network manage karne wala koi nahi	Devices khud route karte hain
Battery Usage	Devices zyada kaam karte hain	Middle device ka battery jaldi khatam
Unstable Network	Devices move karte hain	Moving car mein file sharing fail
Scalability	Zyada users se network slow	Classroom mein 30 students ka sharing
Security	Easy to hack	Unknown network se data leak
Limited Range	Range chhoti hoti hai	Beech ka device hata, data ruk gaya

Adhoc Network MAC Layer: Design Issues, Design Goal, Classification, MACAW

Ad hoc Network me **MAC Layer** (Medium Access Control Layer) kaafi important hoti hai, kyunki isse hi decide hota hai ki wireless medium par kaun, kab, aur kaise data bhejega bina kisi conflict ke.

❖ What is Ad hoc Network?

•**Ad hoc Network** ek aisa wireless network hota hai jisme koi fixed infrastructure (jaise router, access point) nahi hota.

•Devices (ya nodes) directly ek dusre se baat karte hain.

•Example: Aapke mobile phones bina kisi tower ke ek dusre se directly connect ho jayein (jaise Bluetooth file transfer, military communication, disaster area communication).

❖ MAC Layer in Adhoc Network

➤ Role:

MAC Layer ka kaam hota hai:

•Wireless medium pe kis node ko kab bolna hai ye decide karna.

•Collision avoid karna (jab 2 ya zyada devices ek hi time pe bolne lagein).

•Fair access dena sabhi nodes ko.

◈ MAC Layer Design Issues

1.No Centralized Control:

1. Koi fixed base station nahi hoti, sab nodes equal hote hain.
2. Sabko self-control karna hota hai.

2.Hidden Terminal Problem:

1. Jab 2 nodes (A aur C) ek hi node (B) se connected hain par ek dusre ko nahi dekh pa rahe.
2. Jab A aur C ek hi time B ko message bhejenge to collision hoga.

3.🖼 **Image Search Tip**: Google par search karo **"** Hidden Terminal Problem diagram**“**

4.Exposed Terminal Problem:

1. Jab ek node dusre node ki communication sun kar chup reh jaata hai, jabki wo actually transmit kar sakta tha.

5.Mobility:

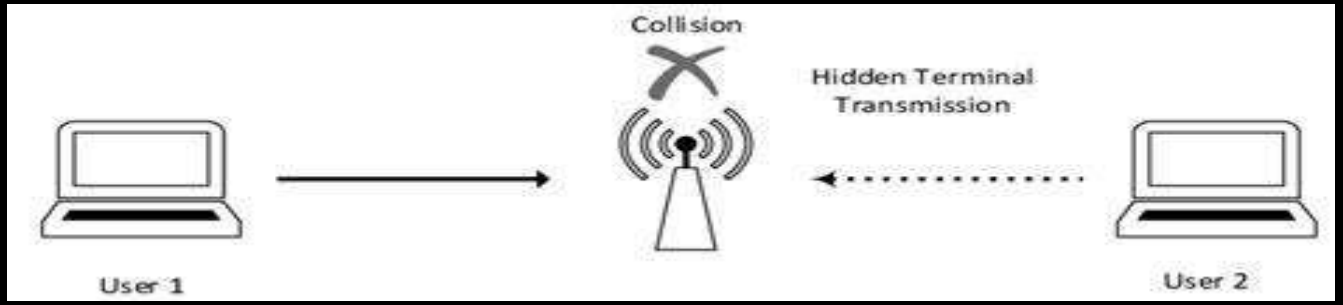
1. Nodes move karte hain, isliye topology frequently change hoti hai.

6.Energy Constraint:

1. Nodes battery pe chal rahe hote hain, isliye energy-efficient protocol chahiye.

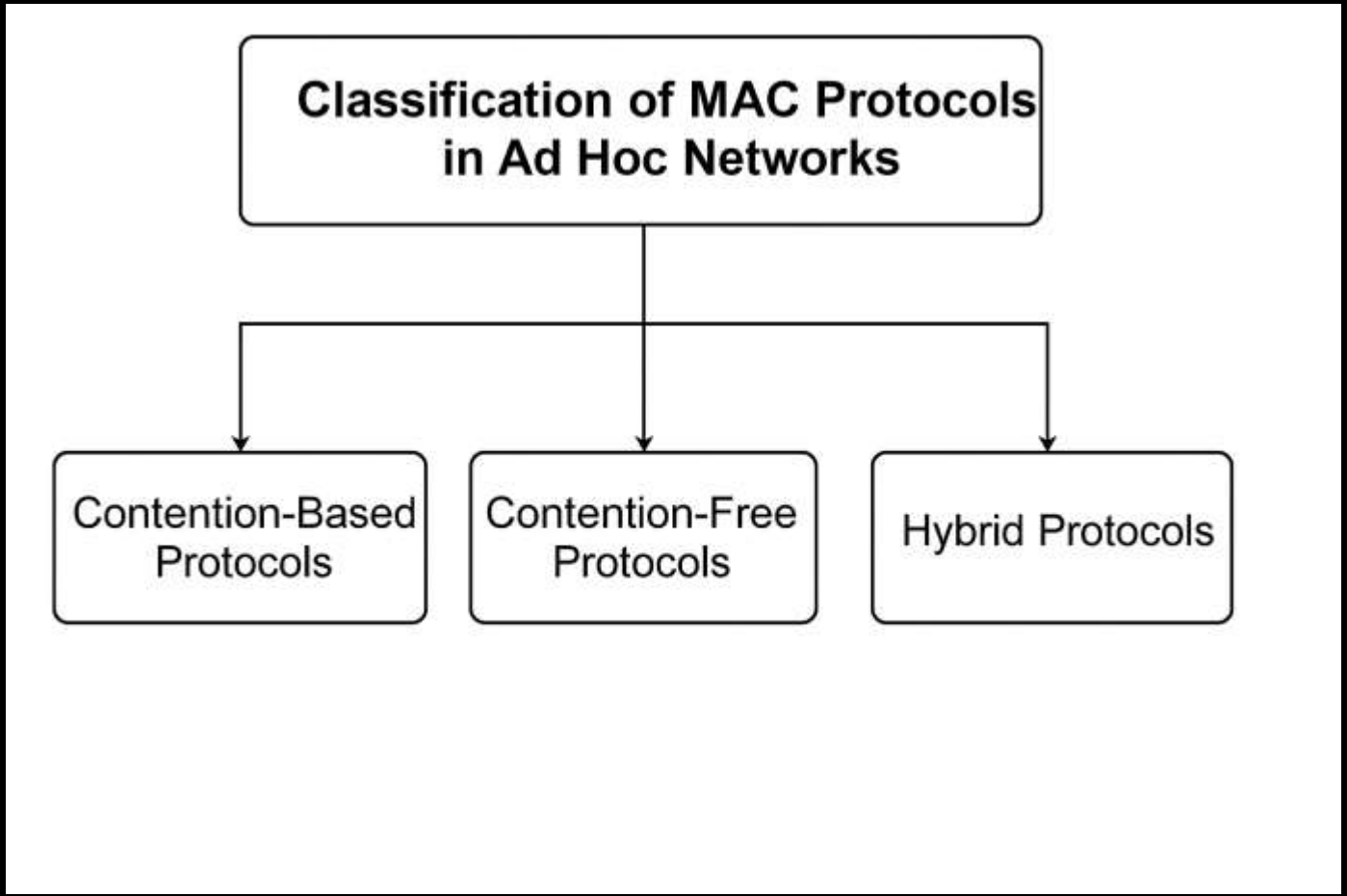
❖ Design Goals of MAC Layer in Adhoc Networks

1.Efficient Medium Access – Collision kam ho aur bandwidth ache se use ho.
2.Fairness – Sabko equal chance mile transmit karne ka.
3.Low Latency – Delay kam ho.
4.Low Overhead – Control messages kam bhejne padein.
5.Scalability – Jab network bada ho jaye to bhi sahi kaam kare.
6.Power Efficiency – Battery bachaye.


Collision
Hidden Terminal
Transmission
User 1
User 2

 Classification of MAC Protocols in Adhoc Network

MAC protocols 3 categories me divide hote hain:


Classification of MAC Protocols in Ad Hoc Networks
Contention-Based Protocols
Contention-Free Protocols
Hybrid Protocols

1. Contention-Based Protocols

•Medium par data bhejne se pehle check kiya jata hai ki wo **free hai ya nahi**.

•Agar free hai to send karo, warna wait karo.

✳ **Example:**

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

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

✓ **Pros:**

•Simple aur flexible

✕ **Cons:**

•Collision ho sakta hai

•Delay zyada ho sakta hai

2. □ Contention-Free Protocols

•Data bhejne ka **fixed time slot** hota hai.

•Koi collision nahi hota.

✳ **Example:**

•**TDMA (Time Division Multiple Access)**

•**FDMA (Frequency Division Multiple Access)**

✓ **Pros:**

•No collision

•Better for real-time data

✕ **Cons:**

•Complex synchronization

•Time waste ho sakta hai agar node data na bheje

3. 🔄 Hybrid Protocols

•**Contention-based + Contention-free** ka combination.

•Flexible and adaptive protocol.

✳ **Example:**

•**Z-MAC (Zebra MAC)**

✓ **Pros:**

•Good performance in all conditions

❌ **Cons:**

•More complex design

Topic	Details
MAC Layer Role	Manage medium access in wireless ad hoc networks
Design Issues	No central control, hidden/exposed terminal, mobility, power, bandwidth
Design Goals	Efficiency, fairness, low delay, scalability, power saving
Protocol Types	Contention-based, Contention-free, Hybrid
Examples	CSMA/CA, TDMA, MACA, MACAW, Z-MAC

❖ MACAW Protocol – Deep Explanation with Example

MACAW = Multiple Access with Collision Avoidance for Wireless
Yeh ek improved version hai **MACA** ka.

MACA kya karta tha?

•RTS (Request to Send)

•CTS (Clear to Send)

MACAW ne kya add kiya?

MACAW ne 5 messages ka system use kiya:

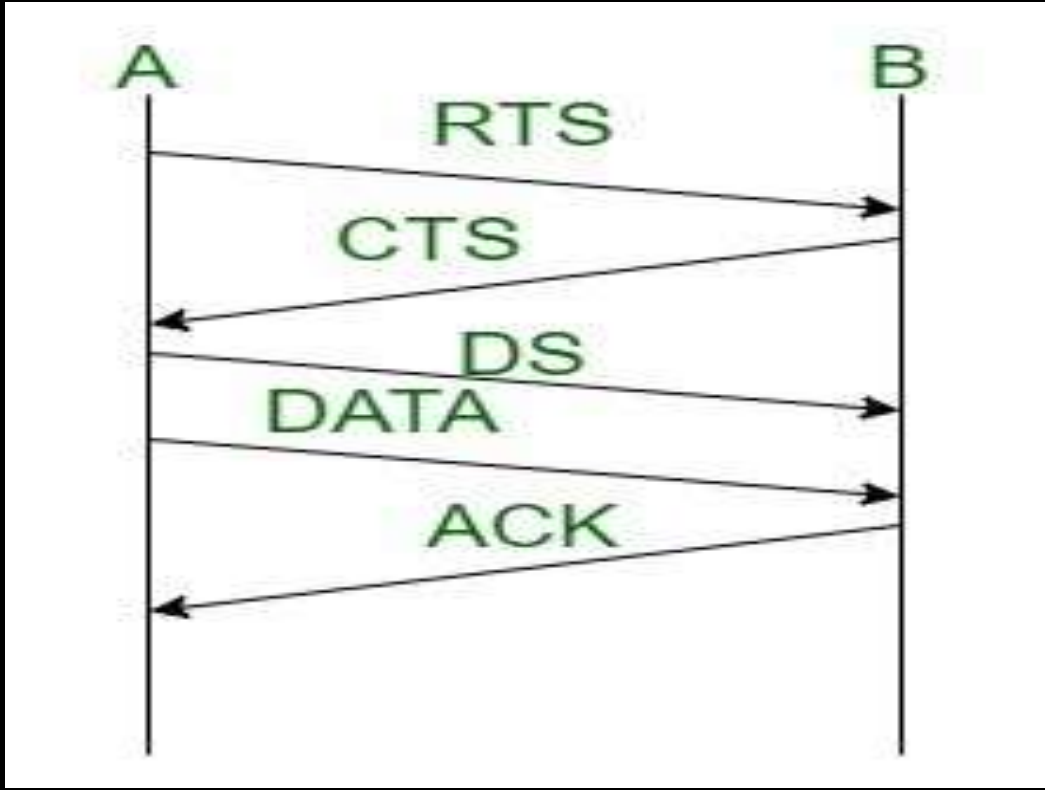
1.RTS – Sender node pehle request bhejta hai.

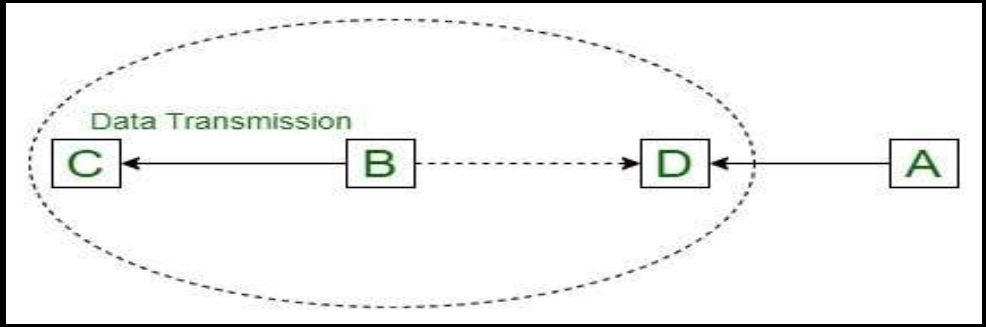
2.CTS – Receiver agar ready hai to clear signal bhejta hai.

3.DS (Data Sending) – RTS-CTS ke baad, sender data bhejne se pehle DS bhejta hai.

4.DATA – Actual data send hota hai.

5.ACK – Receiver data milne ke baad acknowledgement bhejta hai.


A
B
RTS
CTS
DS
DATA
ACK



Example:
Maan lo:
•Node A → Node B ko data bhejna chahta hai

Step by Step:
1.A → RTS → B
2.B → CTS → A
3.A → DS → B (Others sun ke chup ho jaate hain)
4.A → DATA → B
5.B → ACK → A

MACAW ke Advantages:

- Hidden/exposed terminal problem ka solution.
- Fairness maintain hoti hai (sabko chance milta hai).
- Reliable communication (ACK ke through).

◆ 1. Hidden Station Problem (Hidden Terminal Problem)

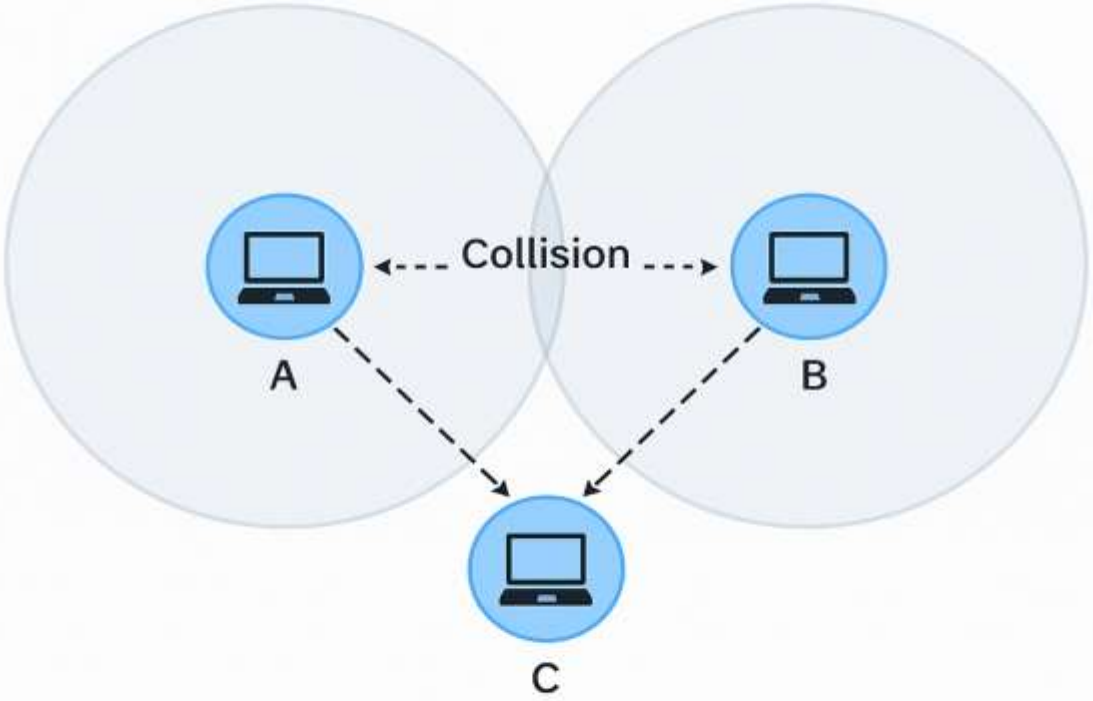
❖ Explanation:

•Jab **do nodes (A & C)** ek **common node (B)** ke sath connected hote hain,
•Lekin **A aur C ek dusre ko detect nahi kar sakte** (because of range),
•Dono sochte hain medium free hai, aur ek hi time par **B ko data bhej dete hain**,
•Isse **collision** hoti hai.

📌 Real-Life Analogy:

Maan lo tumhare 2 friends ek hi ladki ko propose kar rahe hain, lekin dono ko nahi pata ki doosra bhi propose kar raha hai. Girl confused ho jaati hai (jaise receiver B).

Hidden Terminal Problem in WLAN



◆ 2. Exposed Station Problem

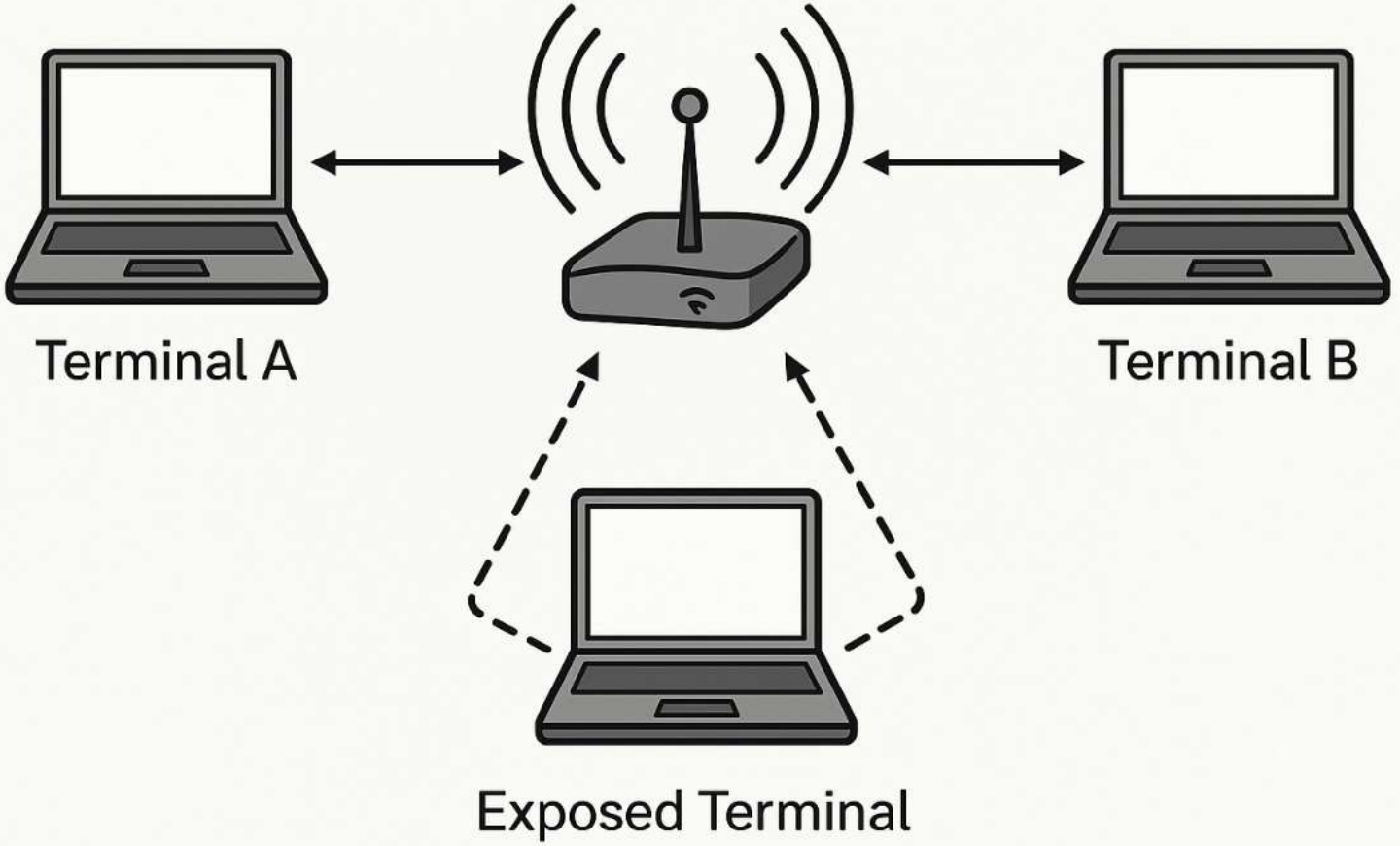
◈ Explanation:

•Maan lo **node B** data bhej raha hai **node A** ko.
•Uske paas wala node **C** ye sun leta hai aur sochta hai ki usse data nahi bhejna chahiye (galat soch).
•Jabki wo **apne target node D** ko bina interfere kiye bhej sakta tha.
•Is wajah se channel **under-utilized** ho jaata hai.

📌 Real-Life Analogy:

Maan lo koi dusra banda baat kar raha hai phone pe, aur tum sochte ho ki tumhe bhi chup rehna chahiye — jabki tum alag line pe ho aur asani se baat kar sakte ho.

Exposed Terminal in WLAN



Problem Type	Description	Consequence
Hidden Terminal	Nodes can't hear each other, send to same node at same time	Collision
Exposed Terminal	Node unnecessarily stays quiet due to nearby transmission	Wasted bandwidth

Adhoc Network Routing Layer

📡 What is Routing in Ad Hoc Networks?

Ad hoc network me koi **fixed router** nahi hota.
Har node **khud router ka kaam karta hai**.
Routing ka kaam hai **source se destination tak path dhoondhna aur maintain karna**.

⚠️ Issues in Designing Routing Protocol for Adhoc Networks

1.Dynamic Topology:

1. Nodes move karte hain, isliye **links bar-bar toot jaate hain**.
2. Har waqt naye routes banane padte hain.

2.Limited Bandwidth:

1. Wireless channels me bandwidth limited hoti hai, isliye routing protocol ko **efficient** hona chahiye.

3.Energy Constraint:

1. Devices battery pe chal rahe hote hain.
2. Routing protocol ko **energy-saving** hona chahiye.

4.Scalability:

1. Protocol chhote aur bade network me bhi **sahi kaam kare**.

5.Route Maintenance:

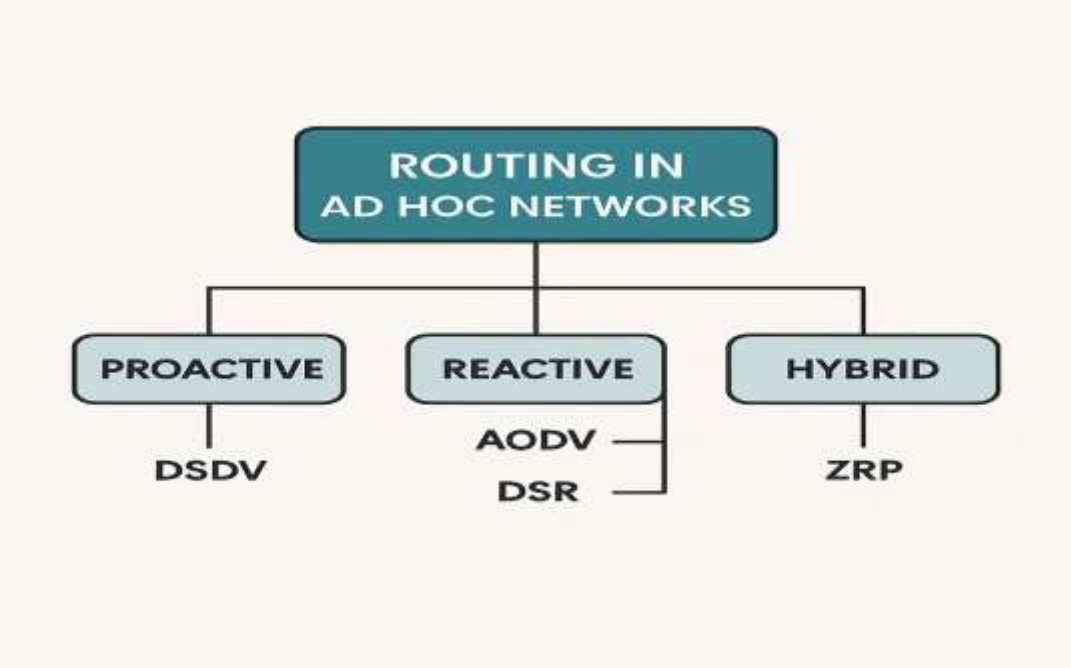
1. Jab path break ho jaaye, to **jaldi se naye route** banaye jayein.

6.Security:

1. Wireless medium open hota hai, isliye routing secure hona chahiye (e.g. packet hijacking, spoofing).

 Classification of Routing Protocols

Routing protocols 3 main categories me divide hote hain:



1. 🗄️ Proactive (Table-Driven)
•Har node ek **routing table** maintain karta hai.
•Table me har destination ka shortest path hota hai.
•Routes **pehle se hi available** hote hain.

✅ **Advantage:**
•Data transfer me delay kam.

❌ **Disadvantage:**
•**High overhead** due to frequent updates.
🔹 **Example: DSDV (Destination-Sequenced Distance Vector)**

2. 🔲 Reactive (On-Demand)

•Jab data bhejna hota hai, tabhi **route discover** hota hai.
•Pehle route search hota hai, phir data bheja jata hai.

✅ **Advantage:**
•**Bandwidth save** hota hai.
❌ **Disadvantage:**
•**Initial delay** hota hai route banane me.
🔹 **Example: AODV, DSR**

3. ▧ Hybrid

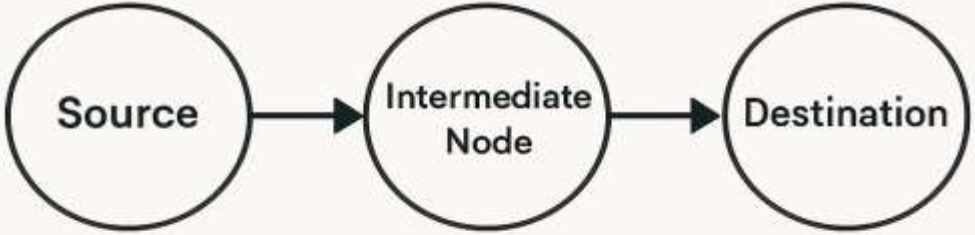
- **Proactive + Reactive** ka combination.
- Nearby nodes ke liye proactive, distant nodes ke liye reactive.

◈ **Example: ZRP (Zone Routing Protocol)**

DSDV – Destination-Sequenced Distance Vector

DSDV

DESTINATION-SEQUENCED DISTANCE VECTOR



DSDV (Destination-Sequenced Distance Vector)

DSDV Kya Hai?

DSDV ek **Proactive (table-driven)** routing protocol hai jo **Mobile Ad hoc Networks (MANETs)** ke liye banaya gaya hai.

Ye protocol **Bellman-Ford algorithm** pe based hai, lekin isme ek extra feature hota hai – **sequence number** – jo routing loops ko avoid karta hai.

⚙️ **Kaam kaise karta hai?**

1. **Har node ek routing table rakhta hai**:
    1. Table mein har destination ke liye:
        1. **Next hop (next node)**
        2. **Distance (number of hops)**
        3. **Sequence number (latest update ke liye)** likha hota hai.
2. **Sequence number**:
    1. Har destination ka ek unique number hota hai jo batata hai ki information kitni **fresh ya recent** hai.
    2. Agar koi naya route mile jiska sequence number zyada ho, to node apna table update kar leta hai.
3. **Regular updates**:
    1. Routing table ko har kuch time baad **periodically broadcast** kiya jata hai sabhi neighbors ko.

DSDV Ko Samajhne Wala Simple Real-Life Example:

Socho tumhare 10 dost hain jo alag-alag streets mein rehte hain.

•Tumhare paas ek **diary** hai jisme likha hai ki kis dost tak kaunsa rasta shortest hai, aur kab last update mila.

•Har thodi der mein, sab dost apne-apne diaries update karte hain aur ek dusre ko latest route bata dete hain.

Is tarah, kisi bhi time pe tum kisi bhi dost tak **asani se pahuch sakte ho** bina wait kiye, kyunki route pehle se pata hota hai.

Table Maintenance in DSDV (Destination-Sequenced Distance Vector)

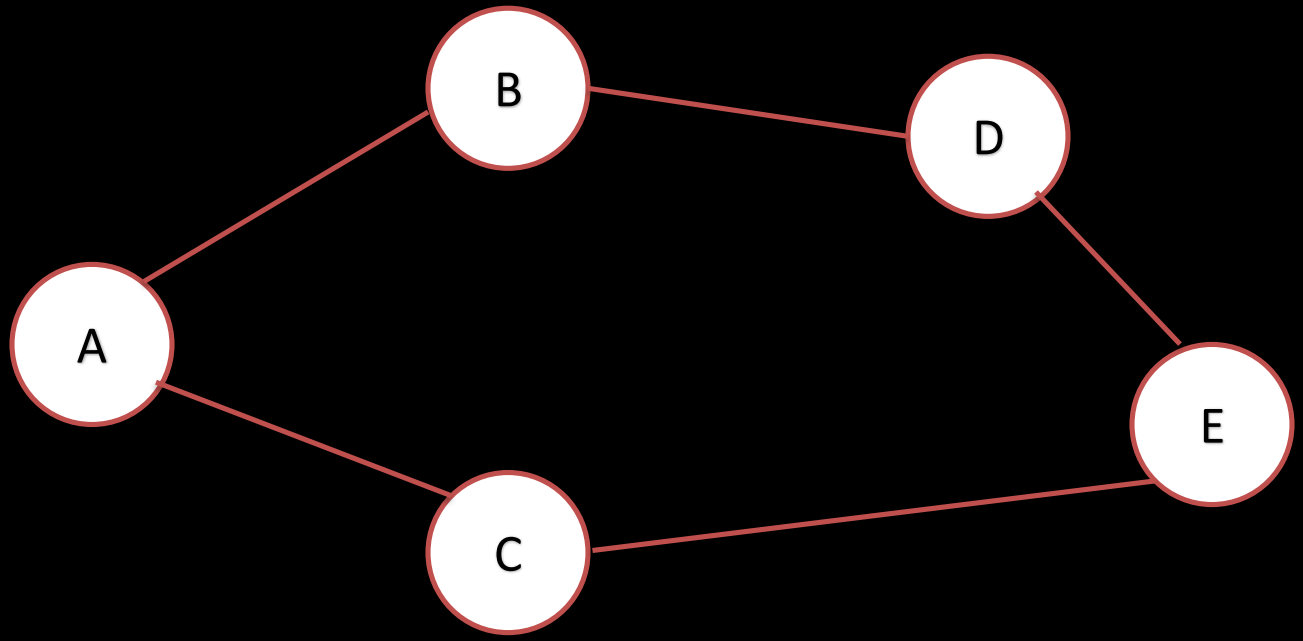
•**Har node route info receive karta hai**:
•Dusri nodes se **latest sequence number** ke saath route info milta hai.
•Agar sequence number purane se **naya ya zyada ho**, tabhi table update hoti hai.

•**Node apni routing table check karta hai**:
•Taaki **shortest path** find kar sake sabhi destinations ke liye.

•**Shortest path info se naye routing table banta hai**:
•Har node khud ka **naya table** banata hai based on updated info.

•**Naya table neighbors ko broadcast hota hai**:
•Har node apna updated routing table apne **neighbors ko bhejta** hai.

•**Neighbor nodes table update karte hain**:
•Jab unhe naya info milta hai, to wo bhi apna table update kar lete hain.


B
D
A
E
C

□ Routing Table Format (Node A ke liye):

Destination	Next Hop	Distance	Sequence No.
B	B	1	340
C	C	1	164
D	B	2	115 (discarded if old)
E	C	2	20

- Agar kisi node ka distance **infinity (∞)** ho jaye (jaise D ka jab disconnect ho gaya), to uska entry **discard** kar diya jata hai.

✅ **Pros of DSDV:**

- 🔁 **Always available routes** – Ready-made path, koi delay nahi.
- 🔁 **Loop prevention** – Sequence number ke through avoid hota hai loop.

❌ **Cons of DSDV:**

- 📡 **High overhead** – Har waqt update bhejna padta hai, even jab route use nahi ho raha.
- 📉 **Bandwidth waste** – Jab network stable ho, tab bhi updates jaate rehte hain.
- 🕒 **Slow in highly mobile environments** – Frequent topology change se stability loose hoti hai.

DSR – Dynamic Source Routing Protocol

Type: Reactive Routing Protocol (On-demand)

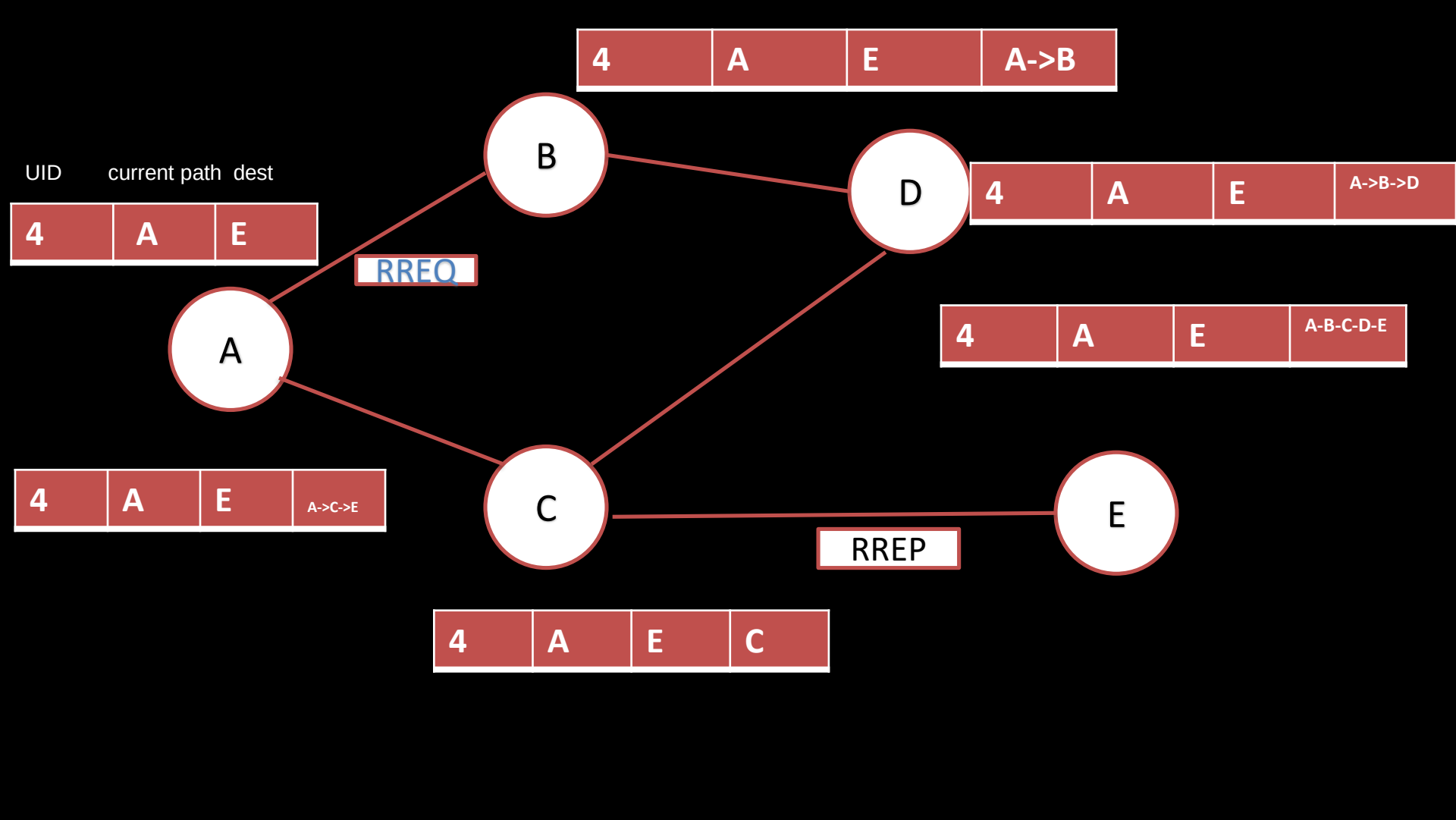
Working of DSR

Phase	Details
1. Route Discovery	- Jab source node ko kisi destination se baat karni hoti hai aur route nahi pata hota, tab RREQ (Route Request) packet bheja jata hai. - RREQ me har hop (node) ka address add hota hai. - Ye packet broadcast hota hai. - Jab destination ko RREQ milta hai, to wo RREP (Route Reply) packet bhejta hai source ko via unicast. - RREP me complete path hota hai.
2. Route Maintenance	- Agar beech ka link toot jaye to RERR (Route Error) message bheja jata hai source node ko. - Source fir naye route ke liye RREQ bhej sakta hai.
Route Cache	- Har node ke paas ek route cache hota hai jisme previously known routes store hote hain. - Multiple route options store ho sakte hain.

📌 **Real-Life Example**
"Maan lo aapko ek jagah ka poora raasta paper pe likh kar milta hai, jisme har turn aur road ka naam likha hota hai. Aap wahi follow karte ho, bina kisi se puchhe."

✓ **Advantages (Pros)**
•Routing table ki zarurat nahi hoti.
•Multiple routes cache ki form me store ho sakte hain.
•Intermediate nodes ko route maintain nahi karna padta.
•Network overhead kam hota hai.

✕ **Disadvantages (Cons)**
•Packet size bada ho jata hai kyunki full path har packet ke sath jata hai (source routing).
•Route discovery me delay hota hai.


4 A E A->B
B
D
4 A E A->B->D
UID current path dest
4 A E
RREQ
A
4 A E A-B-C-D-E
4 A E A->C->E
C
E
RREP
4 A E C

🔄 Dynamic Source Routing (DSR) Table

Step	UID	Current Path	Node Processing	Action Taken	Remarks
1	4 A E	A	A	Start Route Request (RREQ)	Source initiates request
2	4 A E	A → B	B	Forwards RREQ	Path updated
3	4 A E	A → B → D	D	Forwards RREQ	Path updated
4	4 A E	A → B → D → C → E	E	Reached Destination	❌ Path is long → Discard
5	4 A E	A → C	C	Forwards RREQ	Alternate shorter path starts
6	4 A E	A → C → E	E	Reached Destination	✅ Path accepted
7	4 A E	A → C → E	A	RREP (Route Reply) sent to A	Reverse shortest path used

✓ Final Selected Path

A → C → E (Shortest Path)

✗ Discarded Path:

A → B → D → C → E (Too long)

● AODV – Adhoc On-Demand Distance Vector Routing Protocol

📌 **Definition:**
AODV ek **reactive routing protocol** hai jo **Mobile Adhoc Networks (MANETs)** mein use hota hai.
(Ye tabhi route create karta hai jab zarurat ho – that's why it's called *on-demand*.)

⚙️ Working (Kaise kaam karta hai AODV?):

✌️ Two Main Phases:

1.Route Discovery :

Jab source ko destination tak data bhejna ho, tab wo RREQ (Route Request) message broadcast karta hai.

2.Route Maintenance :

Agar route break ho jaye, to RERR (Route Error) message se source notify hota hai, and fir se naye route ki discovery hoti hai.

 Important Points:

•Source node **पूरा path carry nahi karta**, bas next hop ki info hoti hai.

•**Each node maintains a Route Cache.**

•Har node ko **previous aur next hop** ki info hoti hai.

 RREQ Packet mein kya hota hai?

Field	Description
Source Node ID	Jis node ne RREQ bheja hai ✓
Destination Node ID	Jisko data bhejna hai ✓
Recent Seq. No.	Latest data track karne ke liye
Broadcast ID	Duplicate RREQ avoid karne ke liye
Hop Count	Number of nodes passed so far

✅ Advantages (Fayde):

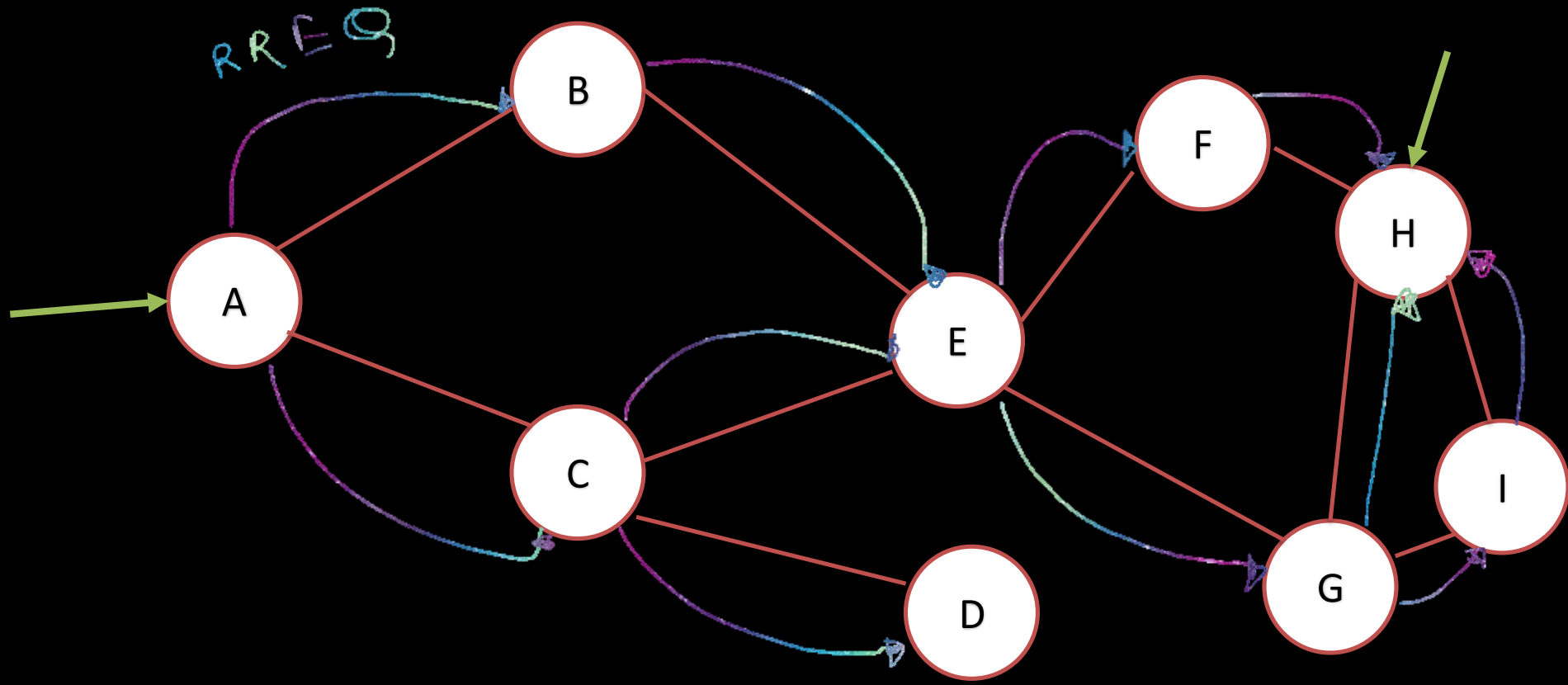
Point	Explanation
✅ On-demand	Kam bandwidth use hoti hai
✅ Loop-free	No routing loops
✅ Fresh Routes	Updated info ke saath path milta hai

❌ Disadvantages (Nuksan):

Point	Explanation
❌ High Delay	Route discovery mein time lagta hai
❌ Frequent Breaks	Dynamic network mein route bar-bar fail ho sakta hai
❌ Broadcast Storm	Bahut zyada RREQ messages se congestion ho sakta hai

🌍 Real-Life Applications:

Application	Description
🚨 Disaster Recovery	Earthquake, flood jese situations mein communication
🪖 Military Network	No centralized structure needed
🚗 Vehicular Networks	Vehicle-to-Vehicle communication (VANETs)


RREQ
A
B
C
D
E
F
G
H
I

Route Selection Example :

🔁 RREQ = Route Request
🔁 RREP = Route Reply

📋 Route Table from Diagram:

Route No.	Path	Hop Count	Status
Route 1	A → B → E → F → H	4	✅ Selected
Route 2	A → C → E → G → H	4	❌ Not Selected
Route 3	A → C → E → G → I → H	5	❌ Not Selected

📌 **Note:** Shortest path with **minimum hop count** is chosen: **Route 1**.

📡 What is a Sensor Network?
(Sensor Network kya hota hai?)

🔍 Definition:

Sensor Network ek aisa **network hota hai jo kai chhote-chhote sensors se bana hota hai**.

Ye sensors environment ke different parameters jaise:

- 🌡 Temperature
- 💧 Humidity
- 🌫 Pollution
- 🔊 Sound
- 🎁 Pressure
- 🚶 Motion

...ye sab **sense** karke data ek central device (base station) tak bhejte hain.

- **Working (Kaise Kaam Karta Hai)**

1.Sensor Nodes environment se data collect karte hain.
2.Ye data **wireless network** ke through ek **Base Station (Sink)** tak pahuchta hai.
3.Base station ya to **data store** karta hai ya **cloud/server** par bhej deta hai for further analysis.

🎯 Real-Life Examples of Sensor Networks:

Scenario	Explanation (HiEnglish)
🔥 **Forest Fire Detection**	Jungle mein kai jagahon par fire sensors lagaye jaate hain. Agar kahi temperature aur smoke level badh jaata hai, to sensors turant signal bhejte hain fire alert system ko.
🛡️ **Health Monitoring**	Hospital mein patient ke body par sensors lage hote hain (like heart rate, BP). Ye sensor network doctor ko real-time health status dikhata hai.
🚜 **Smart Farming**	Kheton mein soil moisture aur temperature check karne ke sensors lagaye jaate hain. Ye farmer ko batata hai kab aur kitna paani dena hai.
🏙️ **Smart Cities**	Traffic, pollution aur noise level sensors poore city mein lage hote hain. Ye data central system mein jaata hai for monitoring and decision making.

🔋 Features of Sensor Network:

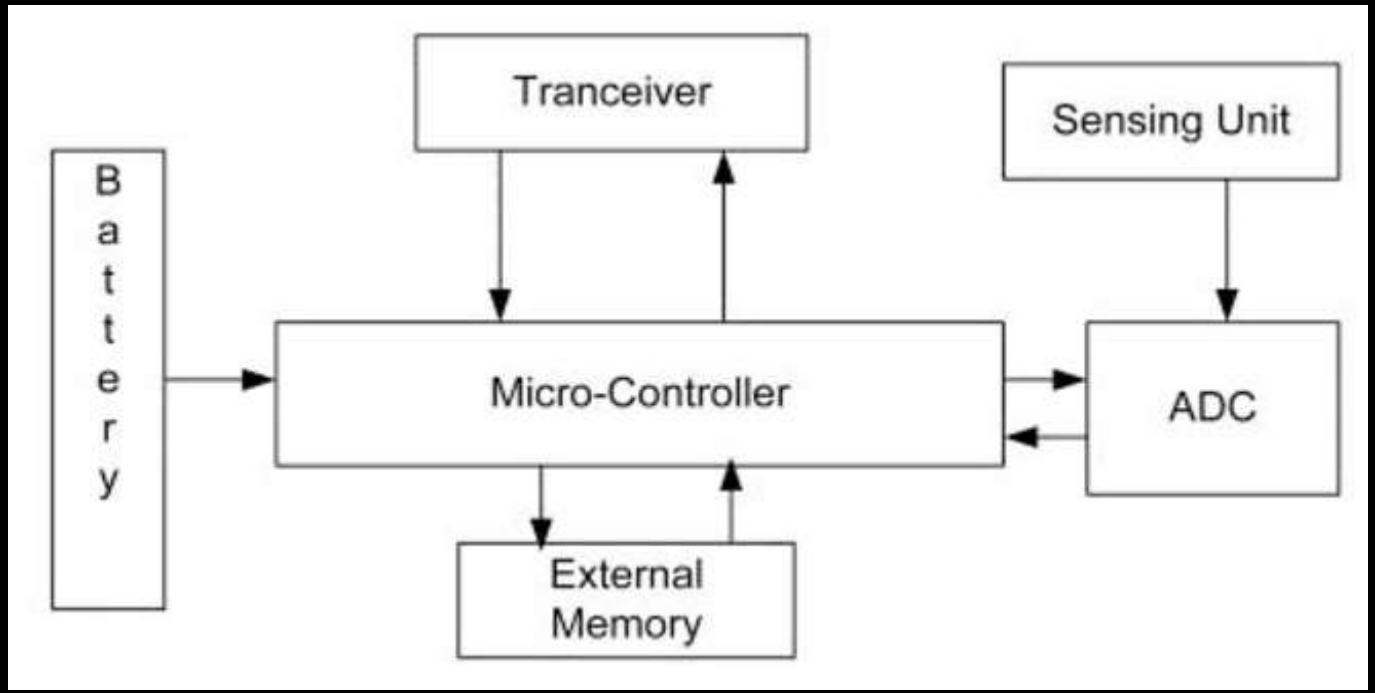
🔧 Feature	📝 Description
⚡ Low Power	Battery operated nodes
📏 Small Size	Chhote aur cheap sensors
🔗 Wireless	Cables ki zarurat nahi hoti
🤝 Cooperative Work	Multiple sensors ek saath kaam karte hain
📡 Remote Monitoring	Dur se monitoring possible hoti hai

Applications of Sensor Network

Application	Use Case Example
Environmental	Forest fire detection, air pollution
Healthcare	Remote patient monitoring
Industry	Equipment fault detection
Agriculture	Smart irrigation, soil sensing
Smart Cities	Traffic, pollution, waste monitoring
Military	Enemy tracking, surveillance
Home Automation	Smart lights, security sensors
Disaster Management	Earthquake & flood alerts

Category	Sensor Network (WSN)	Ad Hoc Wireless Network
Purpose	Data collect karna environment se (like temperature, motion, etc.)	Communication between mobile devices without infrastructure
Node Type	Sensor nodes (small, cheap, low power)	General mobile nodes (like laptops, phones)
Data Flow	Mostly **many-to-one** (sensors → base station)	**Many-to-many** communication
Power Source	Battery powered (limited energy)	Battery powered but usually higher energy than sensor nodes
Mobility	Mostly static nodes	Nodes are mobile
Scalability	Large scale (hundreds/thousands of nodes)	Medium scale (10s to 100s nodes)
Processing Power	Limited (simple data processing)	Better processing capability
Deployment Area	Often harsh, remote, or large outdoor environments	Military, disaster recovery, or tactical environments

✓ Sensor Node Architecture



Sensor node ek chhota electronic device hota hai jo physical environment se data collect karta hai (like temperature, pressure, motion), aur usse transmit karta hai kisi base station ya sink tak.

🎁 **Components of Sensor Node:**

1.Sensing Unit

1. Ye physical signal (jaise light, temperature, vibration) ko detect karta hai.
2. Example: Temperature sensor in a weather monitoring system.

2.Analog-to-Digital Converter (ADC)

1. Ye analog signals ko digital format me convert karta hai so that microcontroller use samajh sake.

3.Processing Unit (Microcontroller)

1. Ye unit data ko process karta hai aur communication decisions leta hai.
2. Example: Arduino ya ARM controller.

4.Transceiver Unit

1. Ye data ko receive aur transmit karta hai (wireless communication).
2. Example: Zigbee, LoRa, Bluetooth module.

5.Power Supply Unit

1. Usually ek battery hoti hai jo poore node ko power deti hai.
2. Power efficient design is crucial kyunki nodes remote jagah pe hote hai.

6.Memory

1. Data aur program store karne ke liye.

🔧 Issues and Challenges in Designing a Sensor Network

1. Power Constraint (Battery Life)

- ⚠ Challenge: Sensor nodes limited battery pe kaam karte hain.
- 💡 Example: Jungle me deployed nodes jo solar charge nahi kar sakte, wahan battery bachana zaruri hai.

2. Limited Computation and Memory

- ⚠ Challenge: Microcontroller low power hota hai, heavy processing possible nahi hoti.
- 💡 Example: Video processing sensor node karna mushkil hai.

3. Communication Reliability

- ⚠ Challenge: Wireless signals weak ho sakte hain, interference ho sakta hai.
- 💡 Example: Urban area me wireless signals dusre electronic devices se interfere ho sakte hain.

4. Scalability

- ⚠ Challenge: Agar 1000+ sensor nodes hain, to unka coordination aur data routing mushkil hota hai.
- 💡 Example: Agriculture field me thousands of sensors deploy karne hain.

5. Security Issues

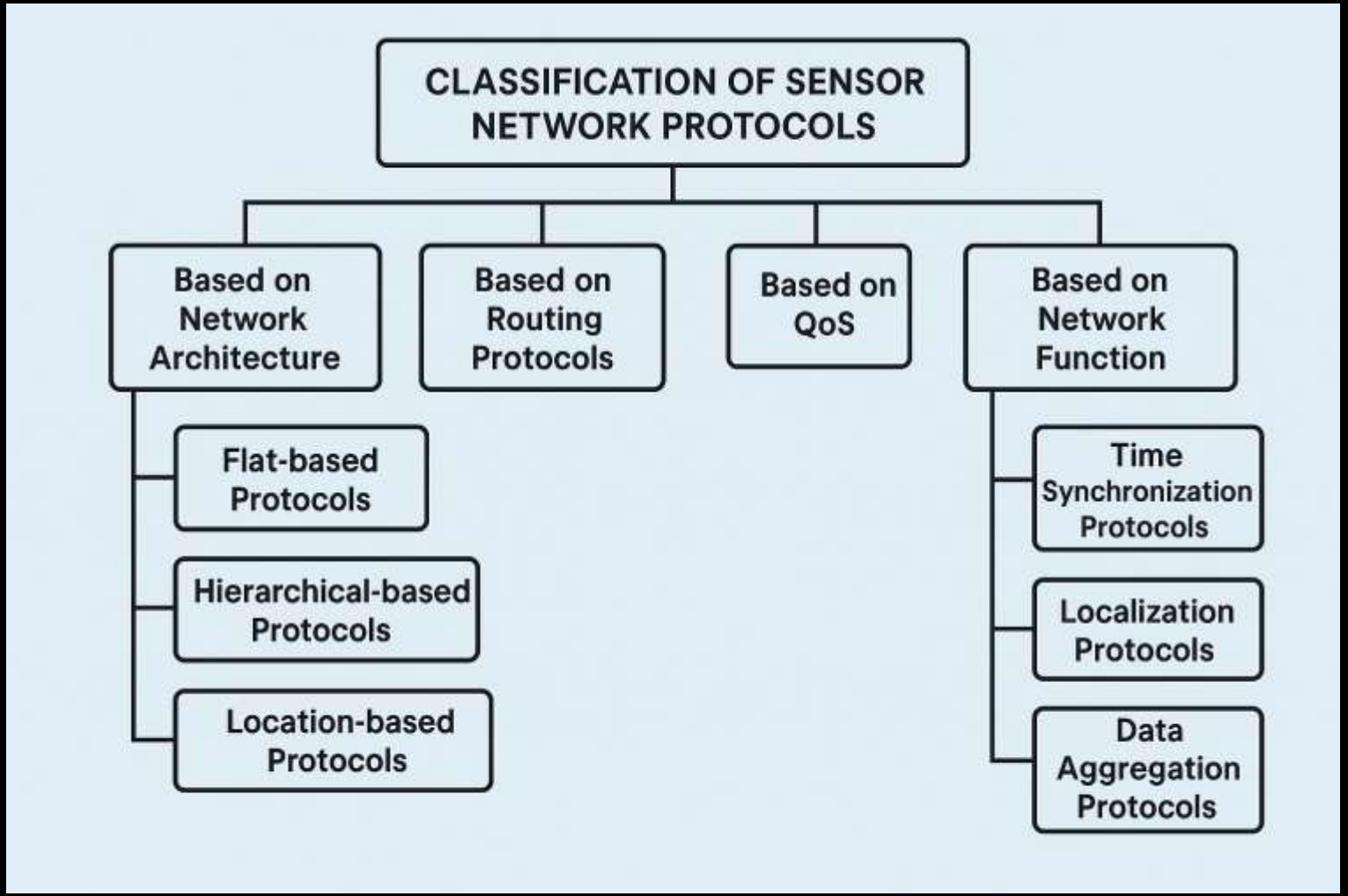
- ⚠ Challenge: Sensor networks open environment me hote hain, kisi bhi attacker ka target ban sakte hain.
- 💡 Example: Kisi attacker ne sensor data ko tamper kar diya – fake temperature values bhej raha hai.

6. Fault Tolerance

- ⚠ Challenge: Agar ek node fail ho gaya, to network ka kaam rukna nahi chahiye.
- 💡 Example: Smart home me agar ek sensor fail ho jaye, to backup system hona chahiye.

7. Cost and Deployment

- ⚠ Challenge: Large-scale deployment me cost important factor hai.
- 💡 Example: Har ek sensor me GPS lagana expensive ho sakta hai.


CLASSIFICATION OF SENSOR NETWORK PROTOCOLS
Based on Network Architecture
Based on Routing Protocols
Based on QoS
Based on Network Function
Flat-based Protocols
Hierarchical-based Protocols
Location-based Protocols
Time Synchronization Protocols
Localization Protocols
Data Aggregation Protocols

1. Based on Network Architecture

Isme protocols decide karte hain ki data kaise flow karega aur nodes kaise organize honge.

- **Flat-based Protocols**
  - Sabhi nodes equal hote hain, data collaboratively forward hota hai.
  - Example: **Flooding, Gossiping**
    - Flooding: Ek node apna data sabko broadcast karta hai.
    - Problem: High energy consumption.
- **Hierarchical-based Protocols** (Cluster-based)
  - Nodes groups mein divided hote hain, har group ka ek leader hota hai (Cluster Head).
  - Example: **LEACH (Low Energy Adaptive Clustering Hierarchy)**
    - Cluster head data aggregate karta hai aur base station ko bhejta hai, isse energy save hoti hai.
- **Location-based Protocols**
  - Nodes apne location ke basis pe communication karte hain.
  - Example: **GPSR (Greedy Perimeter Stateless Routing)**
    - Node apne aur destination ke location ko use karta hai best path select karne ke liye.

2. Based on Routing Protocols

Routing protocols decide karte hain ki data packets network mein kaise route honge.

- **Data-centric Routing**
  - Data request ke basis pe routing hota hai, data aggregation important hoti hai.
  - Example: **Directed Diffusion**
    - Sink node interest broadcast karta hai, nodes data provide karte hain based on interest.
- **Hierarchical Routing**
  - Routing cluster heads ke through hota hai.
  - Example: Again **LEACH** fits here.
- **Location-based Routing**
  - Routing based on node geographic location.
  - Example: GPSR as above.

3. Based on QoS (Quality of Service)
Protocols jo data ki delivery guarantee karte hain with certain latency, reliability, etc.
•Example: Protocols ensuring real-time data transmission in health monitoring systems.

4. Based on Network Function
Protocols designed for specific tasks like:
•**Time Synchronization Protocols**
    •Synchronize clocks between nodes.
    •Example: **TPSN (Timing-sync Protocol for Sensor Networks)**
•**Localization Protocols**
    •Nodes apni location estimate karte hain.
    •Example: **DV-Hop Localization**
•**Data Aggregation Protocols**
    •Multiple data packets ko combine karte hain to reduce transmission.
    •Example: Tree-based data aggregation.

Protocol Classification	Description	Example
Flat-based	All nodes equal	Flooding, Gossiping
Hierarchical-based	Cluster-based communication	LEACH
Location-based	Routing based on location	GPSR
Data-centric Routing	Data request-based routing	Directed Diffusion
QoS-based	Ensures latency/reliability	Real-time health monitoring protocols
Time Synchronization	Clock sync among nodes	TPSN
Localization	Node location estimation	DV-Hop
Data Aggregation	Combine data to save energy	Tree-based aggregation

Example Scenario:

Agriculture Monitoring Network:

- Sensor nodes (soil moisture sensors) deployed in a field.
- Use **Hierarchical Protocol (LEACH)** to form clusters for energy-efficient data transfer.
- Data aggregation protocol used to combine soil moisture data from nearby nodes.
- GPSR used if nodes are mobile and location info needed.
- Time synchronization ensures all nodes report data simultaneously.

1. Layered Architecture:

Overview:

Layered architecture sensor networks mein traditional network models (jaise OSI model) se inspired hota hai. Pure network ko alag-alag layers mein divide kar dete hain, jismein har layer apna specific kaam karti hai.

LAYERED ARCHITECTURE

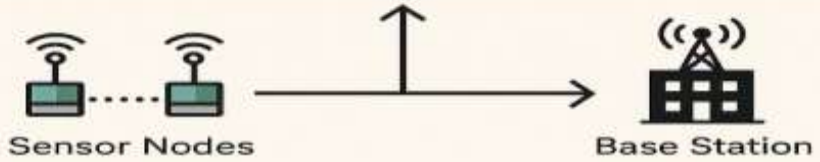
TRANSPORT LAYER
Ensures reliable data transfer between nodes, error aggregation, event detection, and monito-

APPLICATION LAYER
Ensures reliable data transfer between nodes, error recovery, and congestion control

NETWORK LAYER
Manages routing of data packets across sensor network from source nodes to sink

DATA LINK LAYER
Responsible for node-to-node data transfer, framing, error detection, and MAC

PHYSICAL LAYER
Deals with transmission and reception of raw bits over physical medium (e.g. r.io waves)



Layer	Function (Hinglish)
Physical Layer	Raw data bits ko wireless medium (radio waves) ke through bhejna aur receive karna. Modulation, signal processing, aur energy consumption handle karta hai.
Data Link Layer	Node se node tak data transfer, framing, error detection, aur collision avoid karne ke liye MAC protocols chalata hai.
Network Layer	Sensor network mein data packets ka routing manage karta hai — matlab data ko source sensor se base station/sink tak pahunchana.
Transport Layer	Data transfer ko reliable banata hai, errors recover karta hai, aur network congestion control karta hai (kuch sensor networks mein optional).
Application Layer	Sensor applications ke liye interface provide karta hai — jaise data aggregation, event detection, monitoring, etc.

Advantages:

- **Modular design:** Har layer alag-alag function handle karti hai, isse system maintain aur upgrade karna asaan hota hai.
- **Separation of concerns:** Har layer apna specific kaam karti hai, jisse design simple hota hai.
- **Reusable protocols:** Network ke har layer mein standard protocols use kar sakte hain.

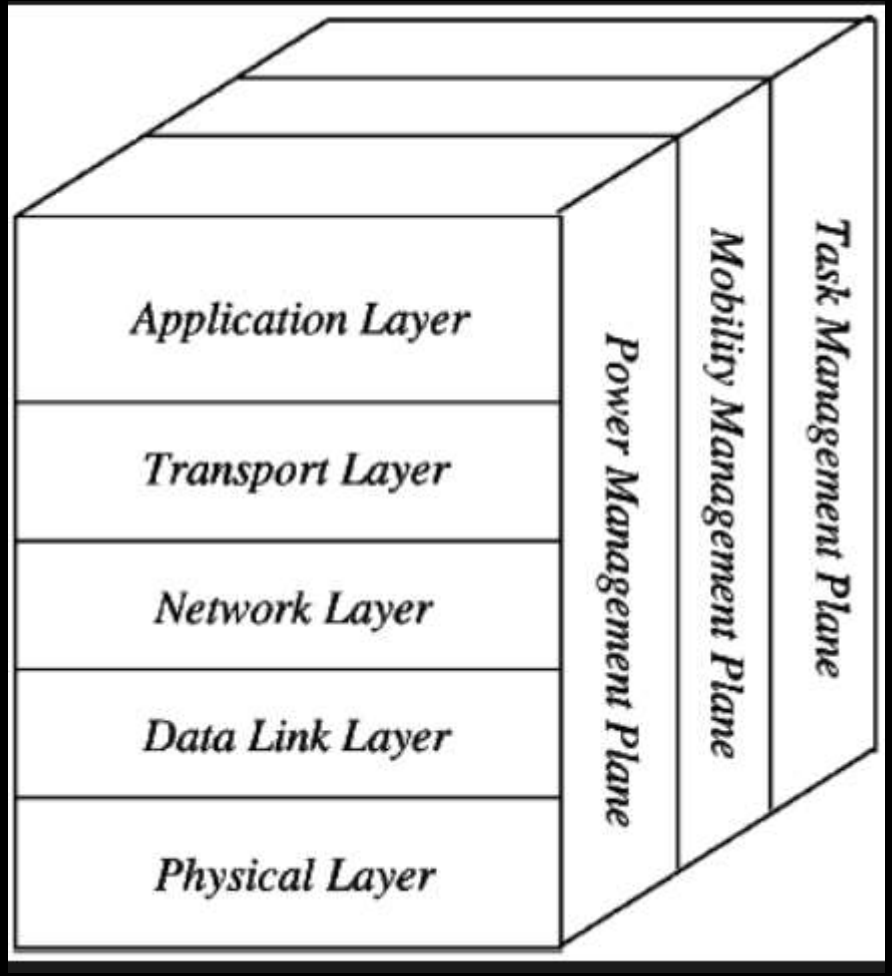
Real Life Example (Smart Home System):
1.Physical Layer: Ghar ke andar lage sensors jaise temperature sensor aur light sensor environment se data lete hain (jaise room ka temperature).

2.Data Link Layer: Ye ensure karta hai ki ye data WiFi ya Bluetooth ke through ghar ke router tak bina problem ke pahunch jaye.

3.Network Layer: Router decide karta hai ki data smart home controller (base station) tak kaise jayega.

4.Transport Layer: Agar data transfer mein error aaye to ye layer usko dobara bhejne ka kaam karti hai taaki data accurate mile.

5.Application Layer: Jab aap apne phone se app kholte ho to yeh layer aapko ghar ke temperature ya light status dikhata hai.

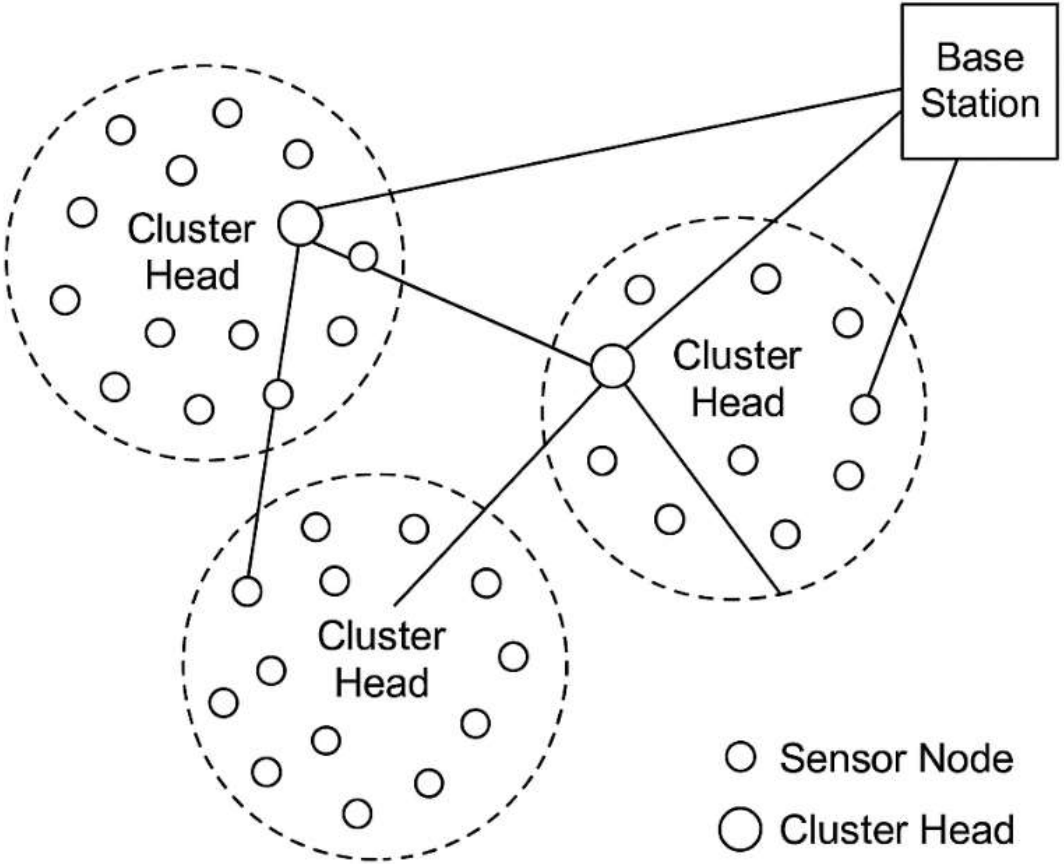

Application Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer
Power Management Plane
Mobility Management Plane
Task Management Plane

2. Clustered Architecture :

Overview:

Clustered architecture mein poore sensor network ko **chhoti-chhoti clusters (groups)** mein divide kiya jata hai. Har cluster ka ek **Cluster Head (CH)** hota hai jo baaki sensor nodes se data collect karta hai aur fir woh data base station tak bhejta hai.

CLUSTERED ARCHITECTURE



Component	Function (Hinglish)
Sensor Nodes	Data sense karte hain jaise temperature, humidity, etc. Aur CH ko bhejte hain.
Cluster Head (CH)	Cluster ke andar ke sensor nodes se data collect karta hai, data compress karta hai aur fir base station tak bhejta hai.
Base Station	Final destination hota hai jahan saara sensor data aata hai aur process hota hai.

Advantages:

- **Energy Efficient:** Har node directly base station se communicate nahi karti, isse energy save hoti hai.
- **Scalability:** Bade networks ko easily manage kar sakte ho kyunki clusters ban jaate hain.
- **Data Aggregation:** CH data ko filter/compress karta hai, jisse bandwidth save hoti hai.

Real Life Example (Smart Agriculture System):

1.Ek kheti ke field mein kai sensors lage hain jo soil moisture aur temperature detect karte hain.
2.Har field region mein ek **Cluster Head (CH)** hota hai jo apne aas-paas ke sensors se data collect karta hai.
3.CH wo saara data ek saath process karke farm ke control center (base station) ko bhejta hai.
4.Control center data dekh ke irrigation system ko control karta hai — jaise kab aur kitna paani dena hai.

Point	Layered Architecture	Clustered Architecture
Basic Concept	Network ko layers mein divide kiya jata hai (jaise OSI model).	Network ko chhoti-chhoti clusters mein divide kiya jata hai.
Structure	Har layer ka apna specific kaam hota hai.	Har cluster mein ek **Cluster Head (CH)** hota hai jo data collect karta hai.
Data Transfer	Data layer se layer hota hua destination tak jata hai.	Data pehle CH ko bheja jata hai, fir CH se Base Station tak.
Energy Consumption	Har node active hoti hai, zyada energy use hoti hai.	Normal nodes sirf CH ko data dete hain → energy saving hoti hai.
Efficiency	Moderate efficient.	Zyada efficient due to data aggregation.
Scalability	Large network handle karna mushkil ho sakta hai.	Easily scalable — naye clusters bana sakte ho.
Example	Smart Home (jaise lights, fan sensors layered system).	Smart Farming (har field ka cluster bana ke monitoring).
Communication Type	Layer-by-layer communication (protocol stack style).	Cluster Head based communication (peer-to-peer inside cluster).
Maintenance	Layer-wise protocol changes karne padte hain.	CH change karne se cluster maintain ho jata hai.
Fault Tolerance	Agar koi layer fail ho jaye to pura system effect hota hai.	Agar CH fail ho jaye to us cluster ka communication ruk jata hai.

Explain Distributed Denial of Service attacks.

🔍 **What is a DDoS Attack?**
DDoS (Distributed Denial of Service) attack ek aisa cyber-attack hota hai jisme attacker **multiple systems**
(bots/computers) ka use karke ek target server ya website ko itna **traffic bhejta hai** ki wo crash ho jaye ya users
ke liye unavailable ho jaye.

🔧 **Simple Explanation in Hinglish:**
Socho ek restaurant hai jisme 10 log ki baithne ki jagah hai. Agar 100 log bina order kiye andar ghus jayein aur sirf jagah ghair lein, to jo asli customer order dena chahta hai wo andar hi nahi ja paayega.
➡️ Yehi hota hai **DDoS attack** mein. Bot systems milkar target server pe traffic ka flood karte hain.

💡 **Real-Life Example:**

Maan lo ek popular shopping website (jaise Flipkart) pe Big Billion Day chal raha hai.

•Ek attacker 1000 zombie computers ka network banata hai.

•Sab bots ek saath us website pe fake requests bhejte hain.

•Result: Server overload ho jata hai, website **down ho jati hai ya slow** chalne lagti hai.

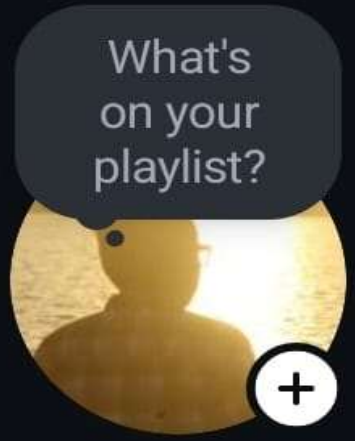
•Genuine customer kuch kharid hi nahi paate.

 Goal of DDoS Attack:

- Website ko **crash** karna
- Business ka **nuksan** karna
- Reputation ko **damage** karna
- Kabhi-kabhi ransom bhi demand kiya jata hai ("DDoS hatane ke paise do").

Point	DDoS Attack Description
Full Form	Distributed Denial of Service
Attackers Use	Botnets (infected devices)
Main Target	Website, Server, Network
Result	Slowdown ya complete shutdown
Example	Flipkart down during sale due to fake traffic

jayesh_kande_



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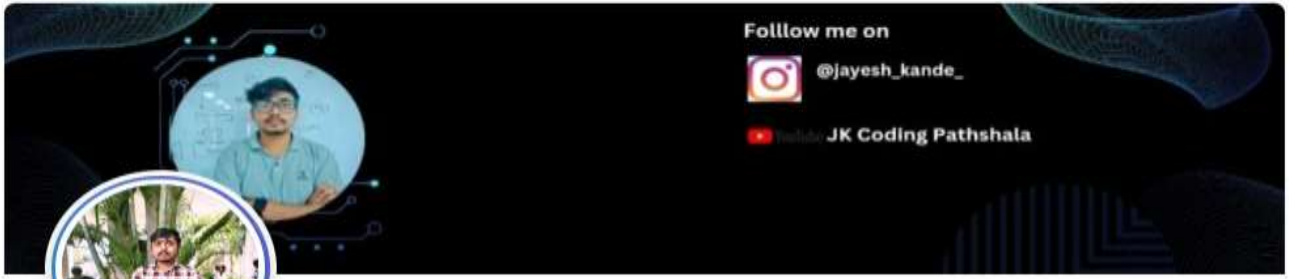

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