Unit 5

Mobile Ad-hoc network and wireless sensor network

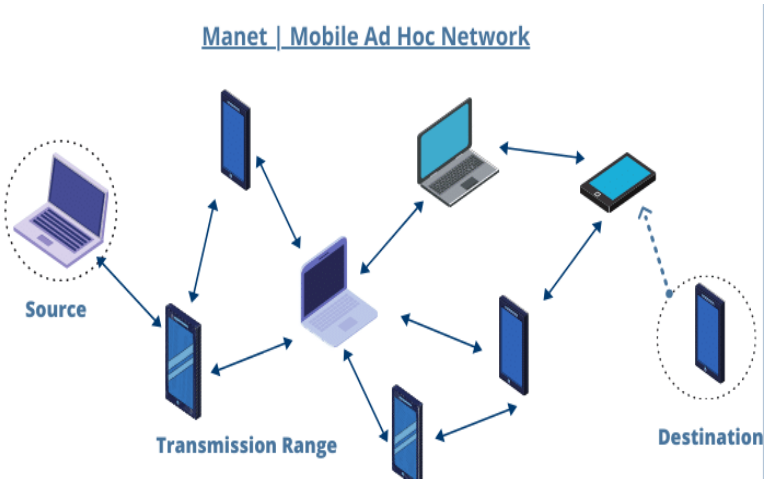
Unit –V Mobile Ad-hoc Networks and Wireless Sensor Networks	5a. Explain the feature of given component in MANET architecture. 5b. Explain characteristics of the given WSN architecture. 5c. Describe the given design challenges in WSN 5d. Classify the given clustering algorithm. 5e. State the procedure of scheduled maintenance of the given system	5.1 MANET, MANET topologies, Features of MANET, Applications, types of MANET Architecture, Design challenges in MANET, 5.2 Mesh Networking; Wireless sensor network, Applications, Clustering of WSN, Characteristics of WSN; Sensor node: Block diagram, Different types of WSN Architecture, Energy efficiency in WSN 5.3 WSN, MANET and IOT; ISO equivalent protocol layer architecture for WSN, Classification of clustering algorithms, Components of WSN Architecture

❖ MANET

(All topics are Important in MANET)

1) A MANET is a collection of mobiles nodes which are independent. Mobile nodes in the MANET communicate to each other via radio waves.*
2) The mobile nodes can directly communicate with each other if and only if that are in radio range.*
3) For communication with each other each mobile node has wireless interface *
4) A mobile ad hoc network (MANET) is a collection of mobile nodes that act as both routers and hosts in an ad hoc wireless network and that dynamically self-organize in a wireless network without using any pre-established infrastructure.*
5) MANET consists of a number of mobile devices that come together to form a network as needed, without any support from any existing internet infrastructure or any other kind of fixed stations.
6) A MANET can be defined as an autonomous system of nodes or MSs(also serving as routers) connected by wireless links, the union of which forms a communication network modeled in the form of an arbitrary communication graph.*
7) This is in contrast to the well-known single hop cellular network model that supports the needs of wireless communication between two mobile nodes relies on the wired backbone and fixed base stations.

M – Mobile (Moving)
A – Ad- Hoc – (Temporary)
NET – Network



❖ Characteristics of MANET

1. Dynamic Topologies:
2. Autonomous – Self Independent
3. Less security – Central firewall is absent
4. Energy Constraint
5. Manet Nodes acts as Both – Host and router

❖ Features/Characteristics of MANET

1) **Distributed operations** -As there is no central control on network operation, control of network is distributed among the node
2) **Dynamic topology –** Nodes in the MANET move freely in network with different speeds, hence n/w topology may change randomly. They establish their own network
3) **Multi-hop Routing –** When a node sends information to other node in MANET which is not in communication range, the packet should be forwarded via one or more intermediate node.
4) **Acts as autonomous terminal-** In MANET each mobile node is an independent node, which acts as a host and a router.
5) **Light weight terminal –** In MANET, nodes are mobile with less capability of CPU, less memory size and low storage of power
6) **Shared physical medium** – In MANET, access to the channel cannot be restricted because in MANET the wireless communication medium is accessible to any node

❖ Advantages of MANET

1) MANET is **scalable** as it accommodate additional nodes in the network
2) MANET is **less expensive** as compared to the wired network
3) There is **no need of central network administration** in MANET. Due to this, MANET is self-configuring network.

4) MANET is robust due to decentralized administration.
5) Set up of MANET can be done **at any place** and at any time

Limitation/Disadvantages of MANET

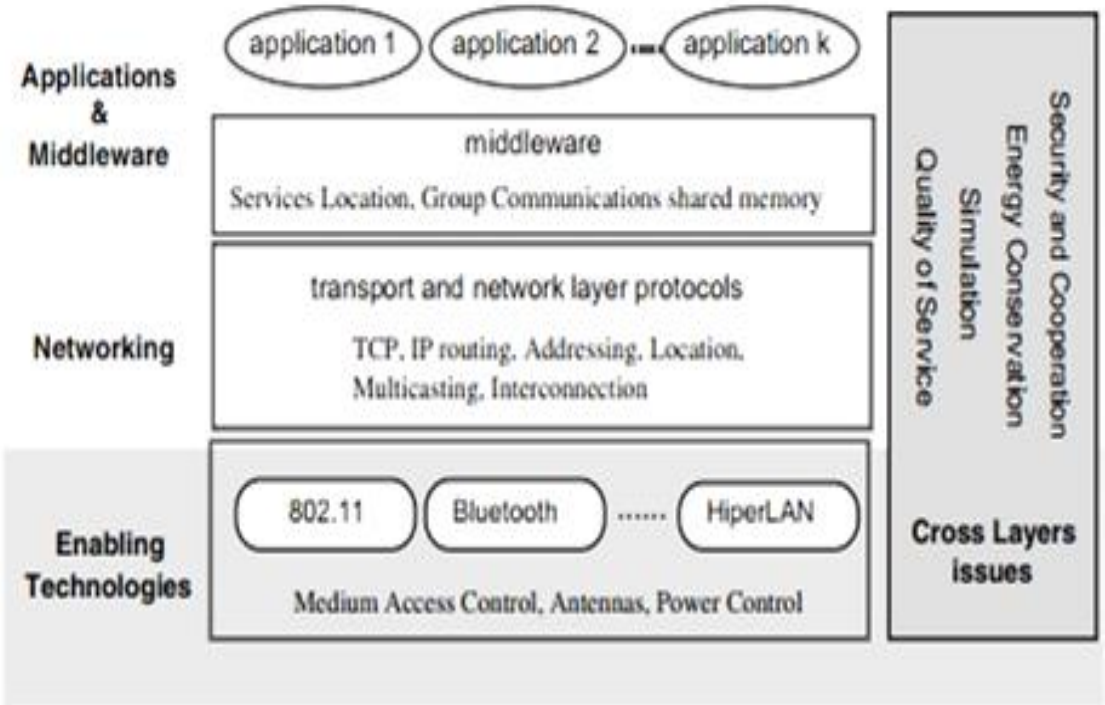
1) Lack of centralized network administration.
2) In MANET there is no system of verification of user's identity before allowing data access.
3) Can't define physical boundary of the network

Applications of MANET

1) In military applications to keep updated information network between the soldiers, vehicles etc.
2) In collaborative work, to exchange information on a given project in business.
3) In emergency services, to search and rescue operation, supporting doctors and nurses in hospitals.
4) Education through internet

MANET Architecture

(Important)



- The Architecture of Mobile Ad Hoc Network (MANET) is shown in the figure below and it is grouped into three main classifications which are as follows:*

1. **Enabling Technologies**
2. **Networking**
3. **Middleware and applications**

1. Enabling Technologies: Considering the coverage area, these are further divided into various classes like-*

i. **BAN (Body Area Network):** The communication range is 1-2 meters and the BAN provides the connectivity to devices that may be attached to wearable computers

ii. **PAN (Personal Area Network):** The communication range is up to 10 meters and the PAN helps to connect the mobile devices to another mobile devices or stationary devices.

iii. **WLANs (Wireless Local Area Networks):** The communication range is 100-500 meters for single building or the group of buildings.

iv. **WAN (Wide Area Network)** and **MAN (Metropolitan Area Network)** are mobile multi-hop wireless networks that still faces various challenges like security, addressing, location management etc.

2. Networking:

In MANET, the greater part of the principle functionalities of the Networking protocols should be redesigned for the self-configuring, dynamic, unstable, peer-to-peer communication environment. *

The primary focus of networking protocols is to utilize the one-hop transmission services which are given by the enabling technologies to develop end-to-end reliable services, from a sender to one receiver(s). *

3. Middleware and applications:

The presentation of new innovations like WiFi, Bluetooth, IEEE 802.11, WiMAX and HyperLAN enormously encourages the deployment of ad hoc technology.*

The new ad hoc networking applications mainly in specific fields like emergency services, disaster recovery and environment monitoring. *

Types of MANET

1. Vehicular Ad hoc Network (VANETs) –

Enable effective communication with another vehicle or with the roadside equipment. Intelligent vehicular ad hoc networks (InVANETs) deals with another vehicle or with the roadside equipment.

2. Smart Phone Ad hoc Network (SPANC) –

To create peer-to-peer network without relying on cellular carrier networks, wireless access points or traditional network infrastructure. Here peer can join or leave the network without destroying it.

3. Internet based Mobile Ad hoc Network (iMANETs) –
It supports internet protocols such as TCP/UDP and IP. To link mobile nodes and establish routes distributed and automatically.

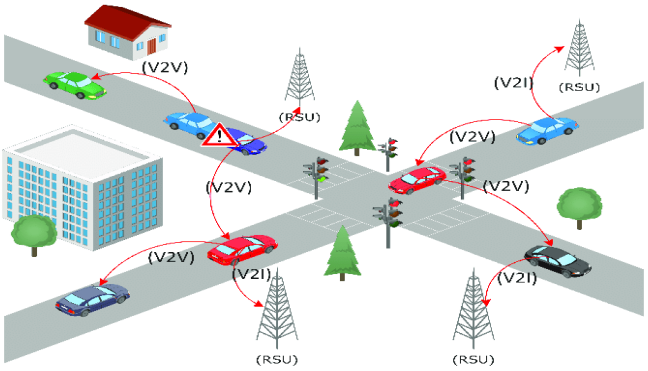
4. Hub-Spoke MANET:
Multiple sub MANET's may be connected in hub-spoke VPN to create a geographically distributed MANET. Normal Ad-hoc routing algorithm does not apply directly.

5. Military or Tactical MANETs –
This is used by the military units. Emphasis on data rate, real time demand, fast re-routing during mobility, security, radio range, etc.

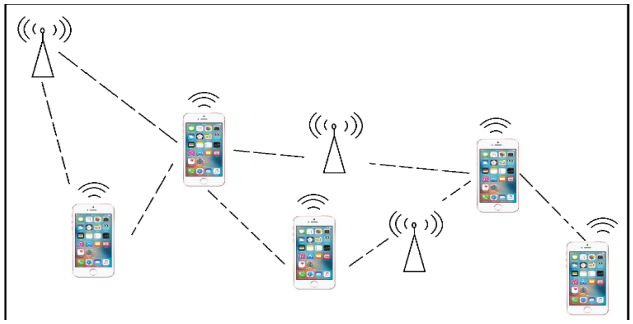
6. Flying Ad hoc Network (FANETs) –
This is composed of unmanned aerial vehicle (commonly known as drone). Provides links to remote areas and mobility.

(For understanding purpose)

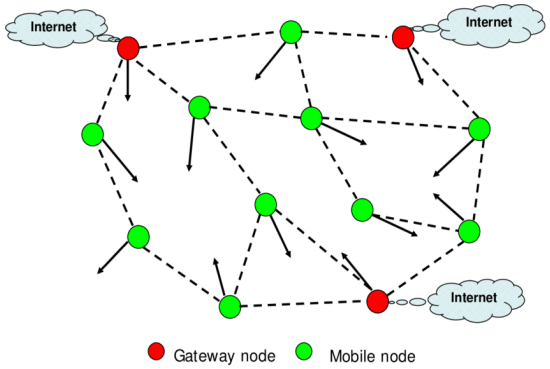
- **Vehicular Ad hoc Network (VANETs) –**
- Enable effective communication with another vehicle or with the roadside equipments. Intelligent vehicular ad hoc networks(InVANETs) deals with another vehicle or with roadside equipments.
- Intelligent vehicular ad hoc networks (InVANETs)are a kind of artificial intelligence that helps vehicals to behave in intelligent manners during vehicle-to-vehicle collisions, accidents.



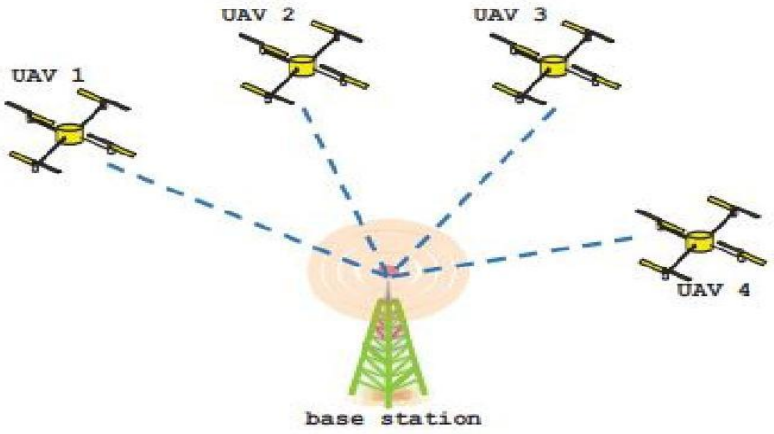
- **Smart phone ad hoc networks (SPANs)—**
  To create peer-to-peer networks without relying on cellular carrier networks, wireless access points, or traditional network infrastructure. Here peers can join or leave the network without destroying it.

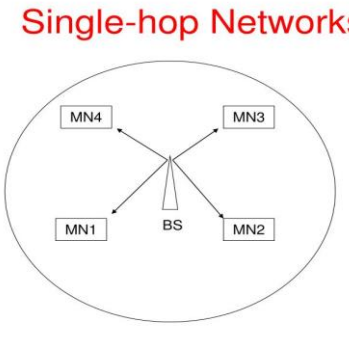


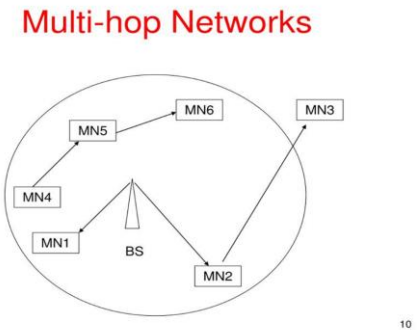
- **Internet based Mobile Ad hoc Network (& Hub-Spoke MANET**
- Are ad hoc networks that link Mobile node and fixed iinternet-gateway node.
- Multiple sub MANET's may be connected in hub-spoke VPN to create a geographically distributed MANET. Normal Ad-hoc routing algorithm does not apply directly.



- **Flying Ad hoc Network (FANETs) –** This is composed of unmanned aerial vehicles that means UAV (commonly known as drones). Provides links to remote areas and mobility.
- A Flying Ad hoc Networks (FANETs) is such kind of network that consists of a group of small UAVs connected in ad-hoc manner, which are integrated into a team to achieve high level goals







Design challenges in MANET

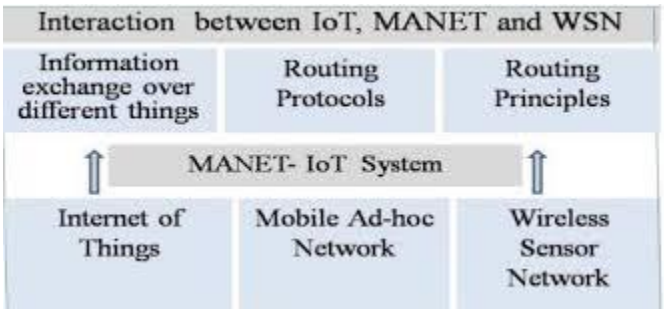
(Write any min 4 5 points with full description in your own words)

1. **Autonomous**- No centralized administration entity is available to manage the operation of the different mobile nodes. *
2. **Dynamic topology-** Nodes are mobile and can be connected dynamically in an arbitrary manner. Links of the network vary timely and are based on the proximity of one node to another node.*

3. **Bandwidth optimization-** The limited transmission range also imposes a constraint on routing protocols in maintaining the topological information. Especially in MANETS due to frequent changes in topology, maintaining the topological information at all nodes involves more control overhead which, in turn, results in more bandwidth wastage.
4. **Limited resources** - Mobile nodes rely on battery power, which is a scarce resource. Also storage capacity and power are severely limited. *
5. **Scalability**- Scalability can be broadly defined as whether the network is able to provide an acceptable level of service even in the presence of a large number of nodes
6. **Limited physical security-** Mobility implies higher security risks such as peer-to- peer network architecture or a shared wireless medium accessible to both legitimate network users and malicious attackers. *
7. I**nfrastructure**-less and self-operated- Self healing feature demands MANET should realign itself to blanket any node moving out of its range.*
8. **Poor Transmission Quality-** This is an inherent problem of wireless communication caused by several error sources that result in degradation of the received signal. *
9. **Ad hoc addressing-** Challenges in standard addressing scheme to be implemented. *
10. **Network configuration-** The whole MANET infrastructure is dynamic and is the reason for dynamic connection and disconnection of the variable links.
11. **Topology maintenance**- Updating information of dynamic links among nodes in MANETs is a major challenge. *
12. **Device discovery-** Identifying relevant newly moved in nodes and informing about their existence need dynamic update to facilitate automatic optimal route selection.

Comparison of cellular Networks and MANET

Cellular network	MANET
Cellular networks are based on fixed infrastructure	In MANET , no need of fixed infrastructure
Single hop wireless links are used	Multihop wireless links are used
Routing in cellular network is centralized	Routing in MANET is distributed
Time synchronization is easy	Time synchronization is difficult
Circuit switching technology is used	Packet switching technology is used
Maintenances of network cost is high	Maintenance cost is low because self organization is inbuilt in MANET

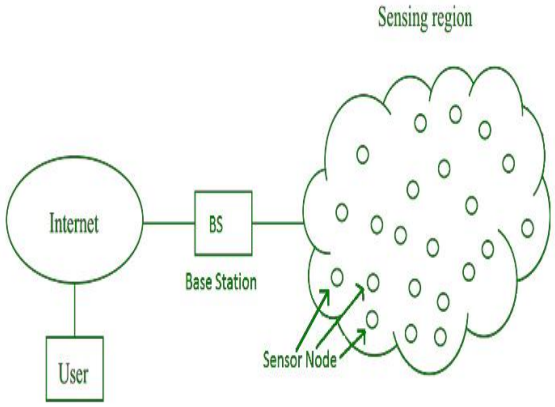


5.2 Wireless sensor network (WSN)

1. A wireless sensor network (WSN) can be defined as a network of small embedded devices, called sensors, which communicate wirelessly following an ad hoc configuration.*
2. **Wireless sensor networks** (WSNs) refer to networks of spatially dispersed and dedicated sensors that monitor and record the physical conditions of the environment and forward the collected data to a central location.
3. A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations.*
4. WSN is a collection of sensing devices that can communicate wirelessly.*
5. Even though wireless sensors has limited resources in memory, computation power, bandwidth, and energy, With small physical size, It can be embedded in the physical environment. Self-organizing multi-hop ad-doc networks.

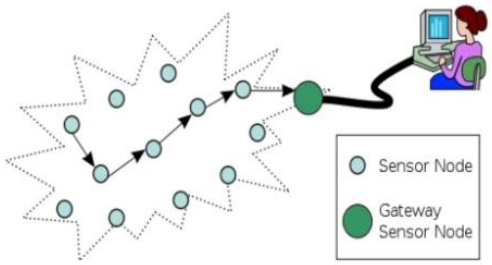
Wireless sensor network (WSN) Architecture

1. A Wireless Sensor Network can be described as the network of devices that can communicate the information gathered from monitored filed through wireless links.
2. It consists of base stations and number of node (wireless sensors) and cooperatively pass data through the network to the main location.



3. WSN are self-configured,without infrastructure and distributed network. WSN contains small, lightweight, large number of sensor nodes, which observe the system or environment.
4. Each node of WSN consist of three subsystems:
    a. **Sensor subsystem**
    b. **Processing subsystem**
    c. **Communication subsystem**
5. Sensor subsystem senses the environment. On sensed data, local computations are performed by processing subsystem.
6. For exchanging message with neighboring sensor node communication subsystem is responsible.
7. Data circulation and data gathering are two most important operations performed in sensor network.
8. Sensor nodes used in WSN, monitor environmental conditions like temperature, sound, humidity, pressure etc.
9. WSN is a collection of sensor nodes which are homogeneous and self-organized.
10. These nodes have abilities such as event sensing and data processing.

Wireless Sensor Network Architecture



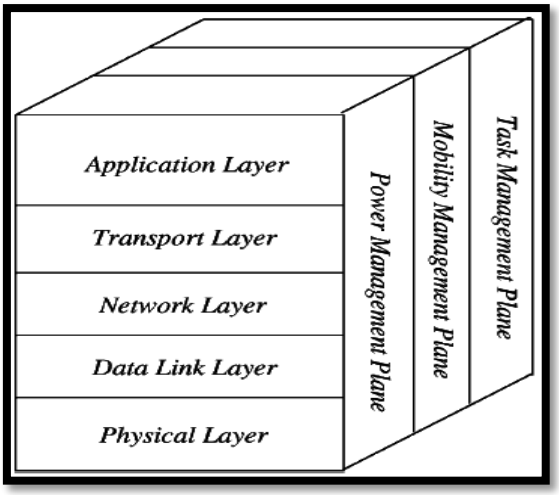
Applications of WSN

1. Internet of Things (IOT)
2. Surveillance and Monitoring for security, threat detection
3. Environmental temperature, humidity, and air pressure
4. Noise Level of the surrounding
5. Medical applications like patient monitoring

Resource constraints of WSN

1. Power Consumption-As WSN have limited power supply, designer have to consider conservation constraint while designing the protocol.
2. Communication-Due to limited bandwidth of WSN, network may be forced to use noisy channel. This effects on quality of services, security and capacity of network.
3. Computation-Limited computing power and memory resources of WSN restrict on the type of data processing algorithm

ISO Equivalent Protocol Layer Architecture of WSN:



Layered Network Architecture

The five layers in the architecture are:

1. **Application layer-** traffic management, offers software for numerous applications.
2. **Transport layer-** deliver congestion avoidance, reliability, contact other networks. STCP (Sensor Transmission Control Protocol), PORT (Price-Oriented Reliable Transport Protocol and PSFQ (pump slow fetch quick).
3. **Network layer-** routing, to explain reliable lane & redundant lanes.
4. **Data link layer-** multiplexing data frame detection, data streams, error control, and reliability of point-to-point or point-to-multipoint.
5. **Physical layer-** selection of frequency, generation of a carrier frequency, signal detection, Modulation & data encryption.
6. The three cross layers include the following:

- Power Management Plane
- Mobility Management Plane
- Task Management Plane

7. These three cross layers are mainly used for controlling the network as well as to make the sensors function as one in order to enhance the overall network efficiency

Design Issues of WSN Architecture

Energy Consumption	The energy consumption is very high.
Localization	The difficulty of determining the sensor's physical location once they have been arranged is known as localization.
Coverage	To cover the whole network, the sensor nodes should be chosen.
Clocks	Clocks must be synchronized within some applications like monitoring as well as tracking.
Computation	The main issue within computation is that it must reduce the utilization of resources.
Cost of Production	The price of every sensor node within the wireless sensor network is a demanding problem.
Design of Hardware	When designing any sensor network's hardware must be energy-efficient.
Quality of Service(QoS)	Data must be distributed in time.

Challenges of WSN

Quality of Service

The quality of service or QoS is nothing but, the data must be distributed in time. Because some of the real-time sensor-based applications mainly depend on time. So if the data is not distributed on time toward the receiver then the data will turn useless.

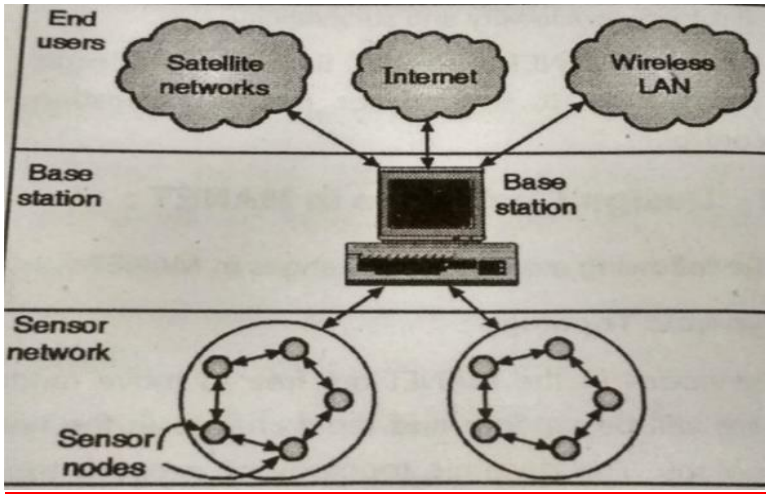
Energy Efficiency

In WSN, power consumption is one of the main issues. As an energy source, the battery is used by equipping with sensor nodes. The sensor network is arranged within dangerous situations so it turns complicated for changing otherwise recharging batteries.

Security

Security is very important parameter in sensor network since sensor networks are data centric so there is no particular id associated with sensor nodes and attacker can easily inserted himself into the network and stole the important data by becoming the part of network without the knowledge of sensor nodes of the network.

Components of WSN:



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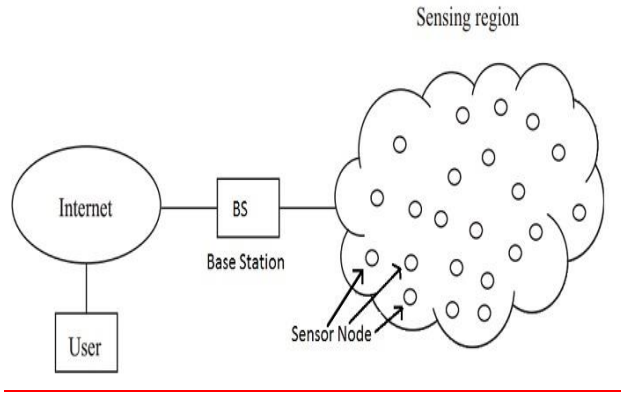


Wireless Sensor Node

- sensor
  - A transducer
  - converts physical phenomenon e.g. heat, light, motion, vibration, and sound into electrical signals
- sensor node
  - basic unit in sensor network
  - contains on-board sensors, processor, memory, transceiver, and power supply
- sensor network
  - consists of a large number of sensor nodes
  - nodes deployed either inside or very close to the sensed phenomenon

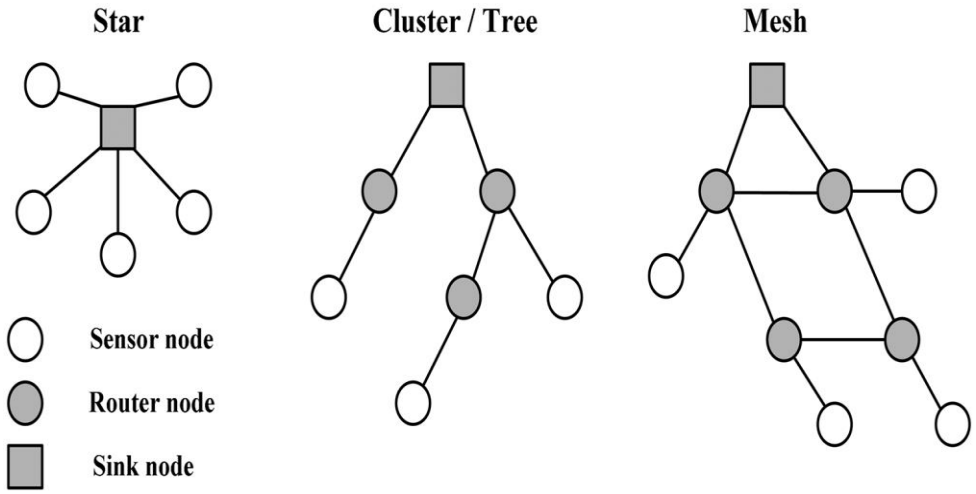
1. Sensors
2. Radio Nodes
3. WLAN Access Point
4. Evaluation Software

The base station sends commands to the sensor nodes and the sensor node perform the task by collaborating with each other. After collecting the necessary data, the sensor nodes send the data back to the base station.

A base station also acts as a gateway to other networks through the internet. After receiving the data from the sensor nodes, a base station performs simple data processing and sends the updated information to the user using internet.

If each sensor node is connected to the base station, it is known as Single-hop network architecture. Although long distance transmission is possible, the energy consumption for communication will be significantly higher than data collection and computation

WSN Topologies



Star topology

1. In star topology, sink node is central device
2. The sensing e sense the data and pass it to the gateway
3. It looks like a star, hence the name star topology.

Advantages-

- ✓ Simplicity
- ✓ It has a ability to keep minimum power consumption of nodes.
- ✓ It allow low latency communication bet the remote node and the base station

Disadvantages

The disadvantages of star topology is, the base station should be within radio transmission range of all the individual nodes.

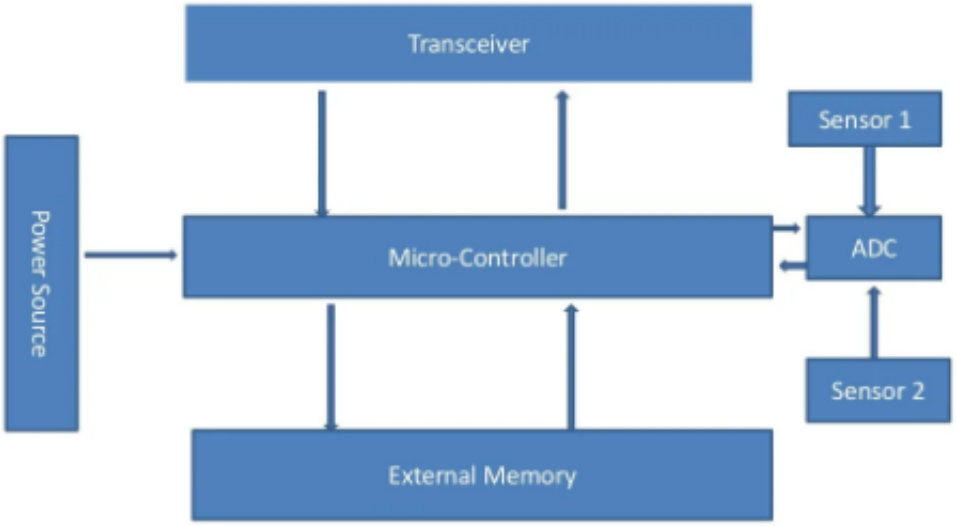
Tree topology

- In a tree topology, sink is the root of a tree and the routers are the branches of the tree that are connected to the sensing nodes.
- It looks like a tree, hence the name tree topology

Mesh Topology

- In the mesh topology, the nodes are interconnected to each other.
- A mesh network allow data transmission from one node to other nodes in the network within its radio transmission range. This is known as multihop communication.
- If a node wants to send some data to another node, which is present outside of a radio communications range, it can use as intermediate node to forward the data to the preferred node.
- The advantages of mesh topology is redundancy and scalability
- The disadvantage of mesh is more power consumption.

Architecture of Sensor Node



Applications

- Military Applications
- Environmental Applications
- Health Applications
- Home and Office Applications
- Automotive Applications
- Other Commercial Applications

Advantages

- It avoids a lot of wiring .
- It can accommodate new devices at any time .
- It's flexible to go through physical partitions .
- It can be accessed through a centralized monitor

WSN Applications

1. **Using in military**

Battlefield surveillance and monitoring, guidance systems of intelligent missiles, detection of attack by weapons of mass destruction such as chemical, biological, or nuclear

2. **Using in nature**

Forest fire, flood detection, habitat exploration of animals

3. **Using in health**

Monitor the patient's heart rate or blood pressure, and sent regularly to alert the concerned doctor, provide patients a greater freedom of movement

4. **Using in home (smart home)**

Sensor node can built into appliances at home, such as ovens, refrigerators, and vacuum cleaners, which enable them to interact with each other and be remote-controlled

5. **Using in office building**

Airflow and temperature of different parts of the building can be automatically controlled

6. **Using in warehouse**

Improve their inventory control system by installing sensors on the products to track their movement

Energy efficiency in WSN

Energy efficiency must be optimization goal in which following aspects are considered…

1. Energy per correctly received bits
2. Energy per reported event
3. Delay/energy trade-offs
4. Network lifetime

1. **Energy per correctly received bits**

i. For periodic monitoring applications this is very useful metric.
ii. How much energy spent on an average to transfer one bit of information from the transmitter to the receiver

2. **Energy per reported event**

i. It is important that how much average energy spent to report one event
ii. Sometimes the same event is reported from various sources.
iii. Time metric is always normalized to only unique events

3. **Delay/energy trade-offs**

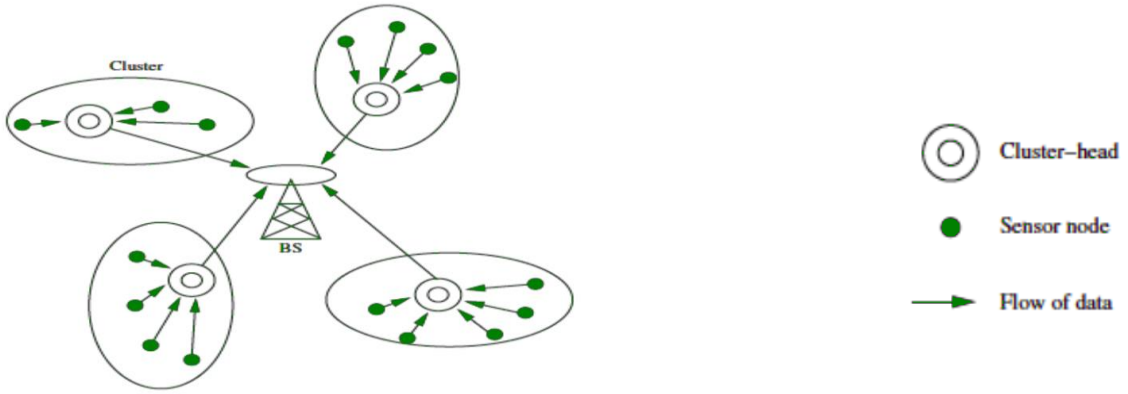
There is a concept of "urgent" events in some applications which can justify increased investment of energy for reporting such events with speed.

4. **Network lifetime**

It is time for which network is operational and the time duration in which network able to fulfill its work beginning from a given amount of stored energy .But when time will end is not clear

Clustering In Wireless Sensor Node

Clustering is **one of the most popular techniques for WSN topology management**. A clustering technique organizes nodes into a set of groups called clusters based on a set of pre-defined criteria such as supporting Quality of Service (QoS), optimizing resource consumption, network load balancing, etc.



How are Clusters Formed?

- Nodes are organized into clusters, each of which has a cluster head; the rest of the nodes become cluster members. We focus on the behavior of a given cluster. To form the clusters, **all nodes transmit a packet directly to the sink node and continue to transmit that packet until it is successfully received**

Advantages of Clustering

- Various advantages of cluster-based WSN are
- **energy efficiency,**
- **better network communication,**
- **efficient topology management,**
- **Minimized delay**, and so forth.

Consequently, clustering has become a key research area in WSN

WSN	IOT
Nodes are not directly connected to the Internet, nodes route traffic to reach sink node. WSN are not necessarily connected to the Internet.	Sensors send their data directly to the internet because they have internet connection
In WSN there is one kind of devices gathering information called sensors.	Things may be anything sensors, humans, cameras, pcs and phones. these devices may upload thier data to the internet so other users may use them.

WSN is sometimes referred to as subset of IoT.

Note- For IoT concepts, refer given PPTs and refer data whatever s suitable for you in understanding the topic.
Introduction
Working
Architecture or block diagram
Advantages Dis Applications (Topic is general***)***

----------All the Best----------