



# **SNS COLLEGE OF ENGINEERING**

**Coimbatore-35**

**An Autonomous Institution**

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## **DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

**19EC701- AdHoc Networks**

IV ECE / VII SEMESTER

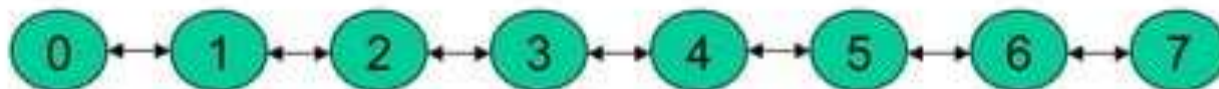
**UNIT 1 –INTRODUCTION**

**TOPIC 3 –Challenges and features of ADHOC**



# Advent of Ad hoc Wireless Networks

- The principle behind ad hoc networking is multi-hop relaying in which messages are sent from the source to the destination by relaying through the intermediate hops (nodes).
- In multi-hop wireless networks, communication between two end nodes is carried out through a number of intermediate nodes whose function is to relay information from one point to another. A static string topology is an example of such network:



- In the last few years, efforts have been focused on multi-hop "ad hoc" networks, in which relaying nodes are in general mobile, and communication needs are primarily between nodes within the same network.



# Evolution of Ad hoc Wireless Networks

- An examples of such developments is the Bluetooth standard that is one of the first commercial realizations of ad hoc wireless networking developed by Bluetooth Special Interest Group (SIG):
  - A piconet formed by a group of nodes establishes a single-hop (master node) point-to-point wireless link.
  - A scatternet formed by multiple piconets (master nodes) can establish a multi-hop wireless network.
- Though the IEEE 802.11 protocols have developed for the wireless networks, they don't function well in multi-hop networks.
- Realizing the necessity of open standards in this emerging area of computer communication, the mobile ad hoc networks (MANET) standards are being developed by the Internet Working Tasking Force (IETF) MANET working group.





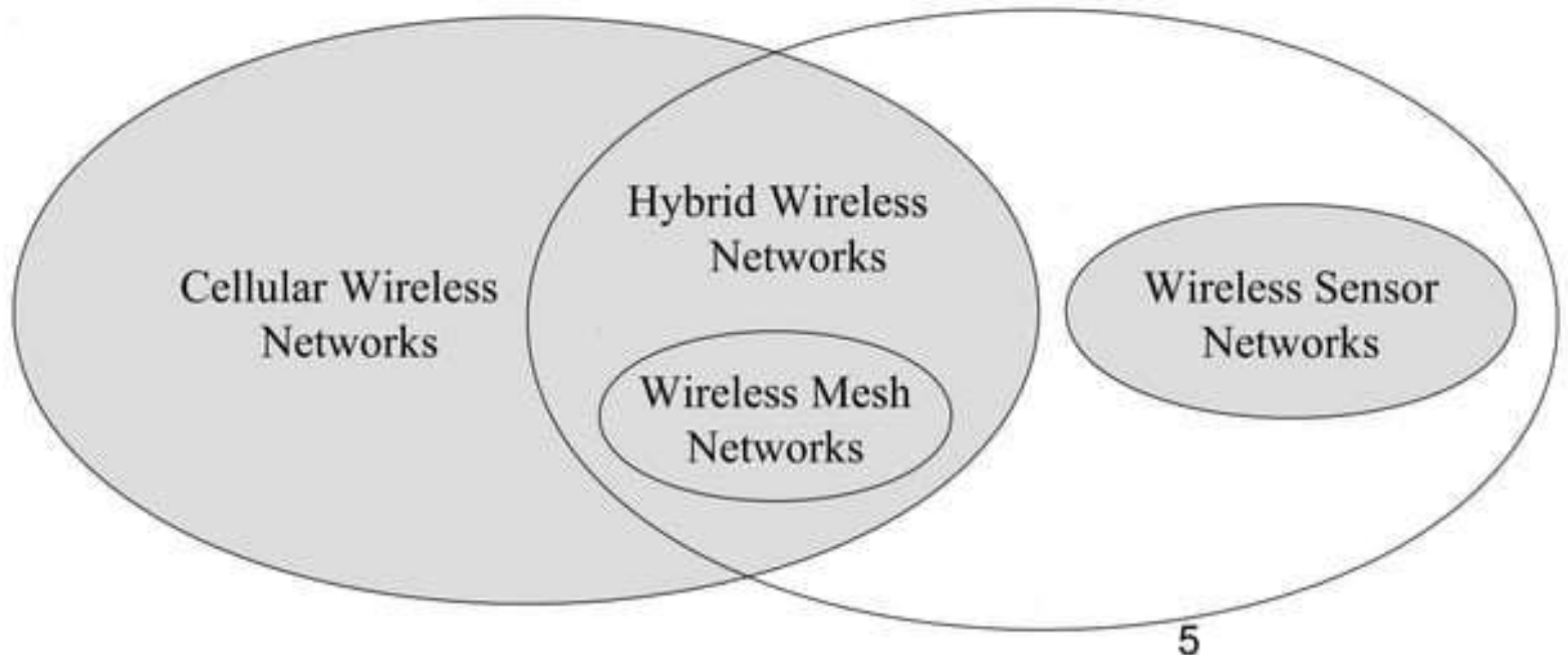
# Invent of Ad hoc Wireless Networks

- Even though ad hoc wireless networks are expected to work in the absence of any fixed infrastructure, recent advances in wireless network architectures enable the mobile ad hoc nodes to function in the presence of infrastructure
- Multi-hop cellular networks (MCNs), self-organizing packet radio ad hoc networks with overlay (SOPRANO), and mesh networks are examples of such types of networks.
- Mesh networks serve as access networks that employ multi-hop wireless forwarding by non-mobile nodes to relay traffic to and from the wired Internet. In such an environment, hybrid technologies and/or hierarchical network organization can be used for ad hoc and infrastructure wireless links.



# ular and Ad Hoc Wireless Networks

- The following figure represents different wireless networks.
  - Infrastructure: cellular wireless networks
  - Ad hoc: wireless sensor networks
  - Hybrid: mesh networks



# Comparisons between Cellular and Ad Hoc Wireless Networks (I)



## Cellular Networks

Fixed infrastructure-based

Guaranteed bandwidth (designed for voice traffic)

Centralized routing

Circuit-switched (evolving toward packet switching)

Seamless connectivity (low call drops during handoffs)

High cost and time of deployment

Reuse of frequency spectrum through geographical channel reuse

Easier to employ bandwidth reservation

## Ad Hoc Wireless Networks

Infrastructureless

Shared radio channel (more suitable for best-effort data traffic)

Distributed routing

Packet-switched (evolving toward emulation of circuit switching)

Frequent path breaks due to mobility

Quick and cost-effective deployment

Dynamic frequency reuse based on carrier sense mechanism

Bandwidth reservation requires complex medium access control protocols



# Comparisons between Cellular and Ad Hoc Wireless Networks (II)



## Cellular Networks

Application domains include mainly civilian and commercial sectors

High cost of network maintenance (backup power source, staffing, etc.)

Mobile hosts are of relatively low complexity

Major goals of routing and call admission are to maximize the call acceptance ratio and minimize the call drop ratio

Widely deployed and currently in the third generation of evolution

## Ad Hoc Wireless Networks

Application domains include battlefields, emergency search and rescue operations, and collaborative computing

Self-organization and maintenance properties are built into the network

Mobile hosts require more intelligence (should have a transceiver as well as routing/switching capability)

Main aim of routing is to find paths with minimum overhead and also quick reconfiguration of broken paths

Several issues are to be addressed for successful commercial deployment even though widespread use exists in defense



# Applications of Ad hoc Wireless Networks

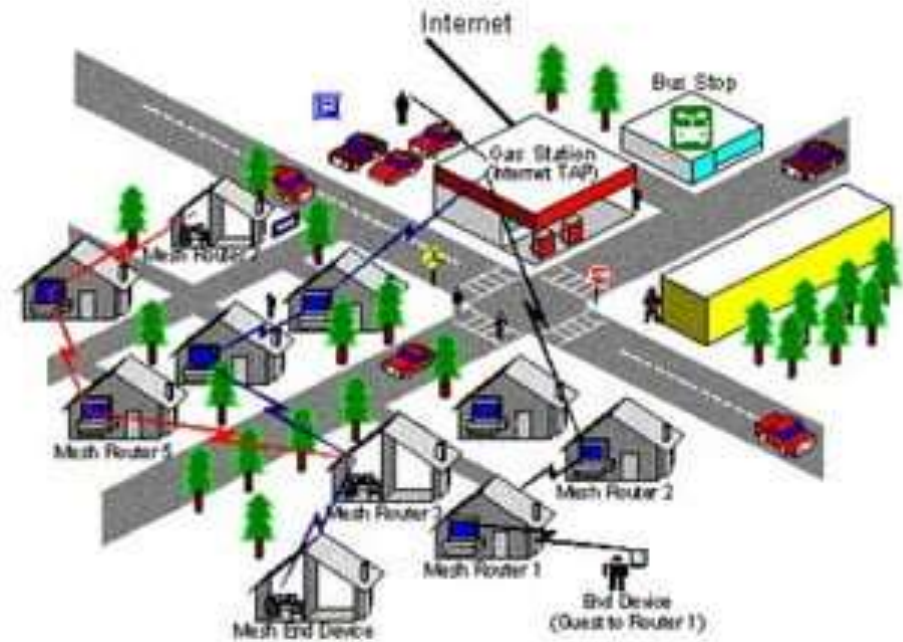
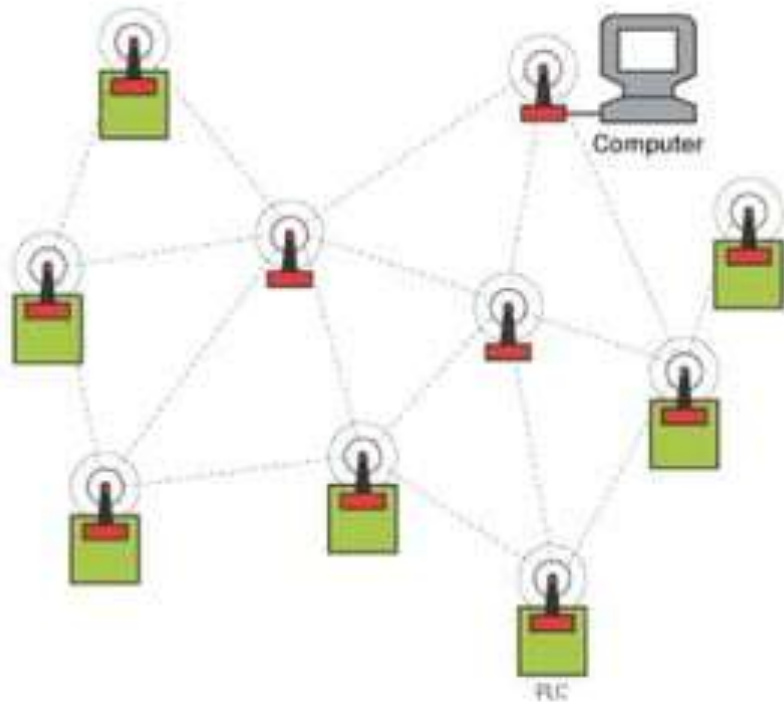
## Military applications

- Ad hoc wireless networks is useful in establishing communication in a battle field.
- Collaborative and Distributed Computing
  - A group of people in a conference can share data in ad hoc networks.
  - Streaming of multimedia objects among the participating nodes.
- Emergency Operations
  - Ad hoc wireless networks are useful in emergency operations such as search and rescue, and crowd control.
- A **Wireless Mesh Network** is a mesh network that is built upon wireless communications and allows for continuous connections and reconfiguration around blocked paths by "hopping" from node to node until a connection can be established.





# Wireless Mesh Networks



- In a wireless mesh network, multiple nodes cooperate to relay a message to its destination. The mesh topology enhances the overall reliability of the network, which is particularly important when operating in harsh industrial environments.



# Wireless Mesh Networks

Investment required in wireless mesh networks is much less than in the cellular network counterparts.

- Such networks are formed by placing wireless replaying equipment spread across the area to be covered by the network.
- The possible deployment scenarios include:
  - Residential zones (where broadband Internet connectivity is required)
  - Highways (where a communication facility for moving automobiles is required)
  - Business zones (where an alternate communication system to cellular networks is required)
  - Important civilian regions (where a high degree of service availability is required)
  - University campuses (where inexpensive campus-wide network coverage can be provided)



# Wireless Mesh Networks

Wireless mesh networks should be capable of self-organization and maintenance.

## ■ Advantages

- High data rate
  - Quick and low cost of deployment
  - Enhanced services
  - High scalability
  - Easy extendability
  - High availability
  - Low cost per bit
  - High availability
  - Low cost per bit
- It operates at 2.4 GHz or 5 GHz
- Data rates of 2 Mbps to 60 Mbps can be supported<sub>1</sub>





# Wireless Sensor Networks

Wireless Sensor Networks are a special category of ad hoc networks that are used to provide a wireless communication infrastructure among the sensors deployed in a specific application domain.

- A sensor network is a collection of a large number of sensor nodes that are deployed in a particular region.
- Distinct properties of wireless sensor networks:
  - Mobility of nodes are not needed in all cases in wireless sensor networks.
  - The size of the network is much larger than that in a typical ad hoc wireless network.
  - The density of nodes in a sensor network varies with the domain of application.
  - The power constraints in sensor networks are much more stringent than those in ad hoc wireless networks.



# Wireless Sensor Networks

Distinct properties of wireless sensor networks:

- The power source can be classified into three categories:
  - Replenishable power resource
  - Non- Replenishable power source
  - Regenerative power source
- Data/information fusion aims at processing the sensed data at the intermediate nodes and relaying the outcome to the monitor node.
- The communication traffic pattern varies with the domain of applications.



# Hybrid Wireless Networks

## Hybrid Wireless Networks

- Multi-hop cellular networks (MCNs) allows the transmission through the base stations or multi-hop of mobile nodes.
  - Integrated cellular ad hoc relay (iCAR) is a system that combines conventional cellular technology with Ad hoc Relay Station (ARS) technology. In this system cellular stations will relay or reroute calls from the congested cell to an adjacent one that is not congested.
- Advantages
- Higher capacity than cellular networks
  - Increased flexibility and reliability in routing
  - Better coverage and connectivity





# Issues in Ad hoc Wireless Networks

## Medium access scheme

- **Distributed operation** is required.
- **Synchronization** is required in TDMA-based systems.
- **Hidden terminals** are nodes hidden from a sender.
- **Exposed terminals** are exposed nodes preventing a sender from sending.
- **Throughput** needs to be maximized.
- **Access delay** should be minimized.
- **Fairness** refers to provide an equal share to all competing nodes.
- **Real-time traffic support** is required for voice, video, and real-time data.
- **Resource reservation** is required for QoS.
- **Ability to measure resource availability** handles the resources.
- **Capability for power control** reduces the energy consumption.
- **Adaptive rate control** refers to the variation in the data bit rate.
- **Use of directional antennas** has advantages including increased spectrum reuse, reduced interference, and reduced power consumption.



# Issues in Ad hoc Wireless Networks

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- Mobility
- Bandwidth constraint
- Error-prone and shared channel: wireless channel ( $10^{-5}$  to  $10^{-3}$ ), wired channel ( $10^{-12}$  to  $10^{-9}$ )
- Location-dependent contention depends on the number of nodes.
- Other resource constraints such as computing power, battery power
- Minimum route acquisition delay
- Quick route reconfiguration
- Loop-free routing
- Distributed routing approach
- Minimum control overhead
- Scalability
- Provisioning of QoS
- Support for time-sensitive traffic: hard real-time and soft real-time traffic
- Security and privacy



# Issues in Ad hoc Wireless Networks

Formation of multiple links among the nodes in an ad hoc network results in a mesh-shaped structure. The mesh-shaped multicast routing structure work well in a high-mobility environment.

- The issues in multicast routing protocols are:
  - **Robustness:** It must be able to recover and reconfigure quickly.
  - **Efficiency:** It should make a minimum number of transmissions to deliver a packet.
  - **Control overhead:** It demands minimal control overhead.
  - **Quality of service:** QoS support is essential.
  - **Efficient group management** needs to be performed with minimal exchange of control messages.
  - **Scalability:** It should be able to scale for a large network.
  - **Security** is important.





# Issues in Ad hoc Wireless Networks

- The objectives of the transport layer protocols include:
  - Setting up and maintaining end-to-end connections
  - Reliable end-to-end delivery of data packets
  - Flow control
  - Congestion control
- Connectionless transport layer protocol (UDP), unaware of high contention, increases the load in the network.
- Pricing Schemes need to incorporate service compensation.
- Quality of Service Provisioning
  - QoS parameters based on different applications
  - QoS-aware routing uses QoS parameters to find a path.
  - QoS framework is a complete system that aims at providing the promised services to each users.



# Issues in Ad hoc Wireless Networks

- Self-Organization is required in ad hoc wireless networks:
  - Neighbor discovery
  - Topology organization
  - Topology reorganization
- Security
  - Denial of service
  - Resource consumption
    - Energy depletion: deplete the battery power of critical nodes
    - Buffer overflow: flooding the routing table or consuming the data packet buffer space
  - Host impersonation: A compromised node can act as another node.
  - Information disclosure: a compromised node can act as an informer.
  - Interference: jam wireless communication by creating a wide-spectrum noise.



# Issues in Ad hoc Wireless Networks

- Addressing and Service Discovery is essential because of absence of a centralized coordinator.
- Energy Management
  - Transmission power management: The radio frequency (RF) hardware design should ensure minimum power consumption.
  - Battery energy management is aimed at extending the battery life.
  - Processor power management: The CPU can be put into different power saving modes.
  - Devices power management: Intelligent device management can reduce power consumption of a mobile node.
- Scalability is expected in ad hoc wireless networks.





# Issues in Ad hoc Wireless Networks

## ■ Deployment considerations

- Low cost of deployment
- Incremental deployment
- Short deployment time
- Reconfigurability
- Scenario of deployment
  - Military deployment
  - Emergency operations deployment
  - Commercial wide-area deployment
  - Home network deployment
- Required longevity of network
- Area of coverage
- Service availability
- Operational integration with other infrastructure
- Choice of protocols at different layers should be taken into consideration.



# Issues of Ad hoc Wireless Internet

## ■ Gateways

- Gateway nodes are the entry points to the wired Internet and generally owned and operated by a service provider.
- Perform the following tasks: keeping track of the end users, band-width fairness, address, and location discovery.

## ■ Address mobility

- Solutions such as Mobile IP can be used.

## ■ Routing

- Specific routing protocols for ad hoc networks are required.

## ■ Transport layer protocol

- Split approaches that use traditional wired TCP for the wired part and a specialized transport layer protocol for the ad hoc wireless network part.

## ■ Load balancing

- Load balancing techniques are essential to distribute the load so as to avoid the situation where the gateway nodes become bottleneck nodes.



# Issues of Ad hoc Wireless Internet

## g/billing

- It is important to introduce pricing/billing strategies for the ad hoc wireless internet.
- Provisioning of security
  - It is essential to include security mechanisms in the ad hoc wireless Internet.
- QoS support
  - Voice over IP (VoIP) and multimedia applications require the QoS support.
- Service, address, and location discovery
  - **Service discovery** refers to the activity of discovering or identifying the party which provides a particular service or resource.
  - **Address discovery** refers to the services such as address resolution protocol (ARP) or domain name service (DNS).
  - **Location discovery** refers to different activities such as detecting the location of a particular mobile node.