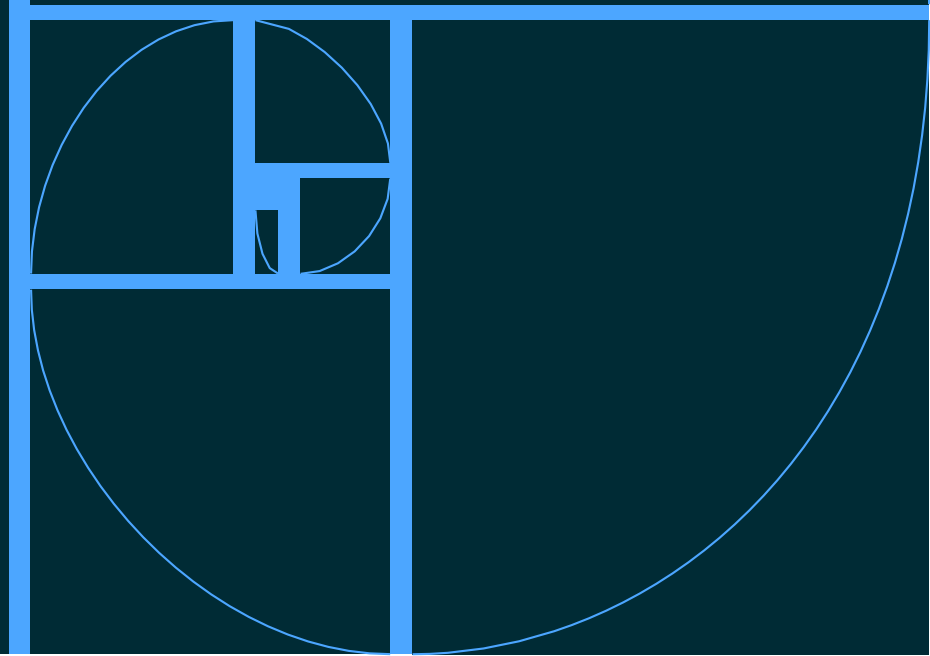
19CSE341 Mobile Ad Hoc Networks

5^{th} Jan. 2022



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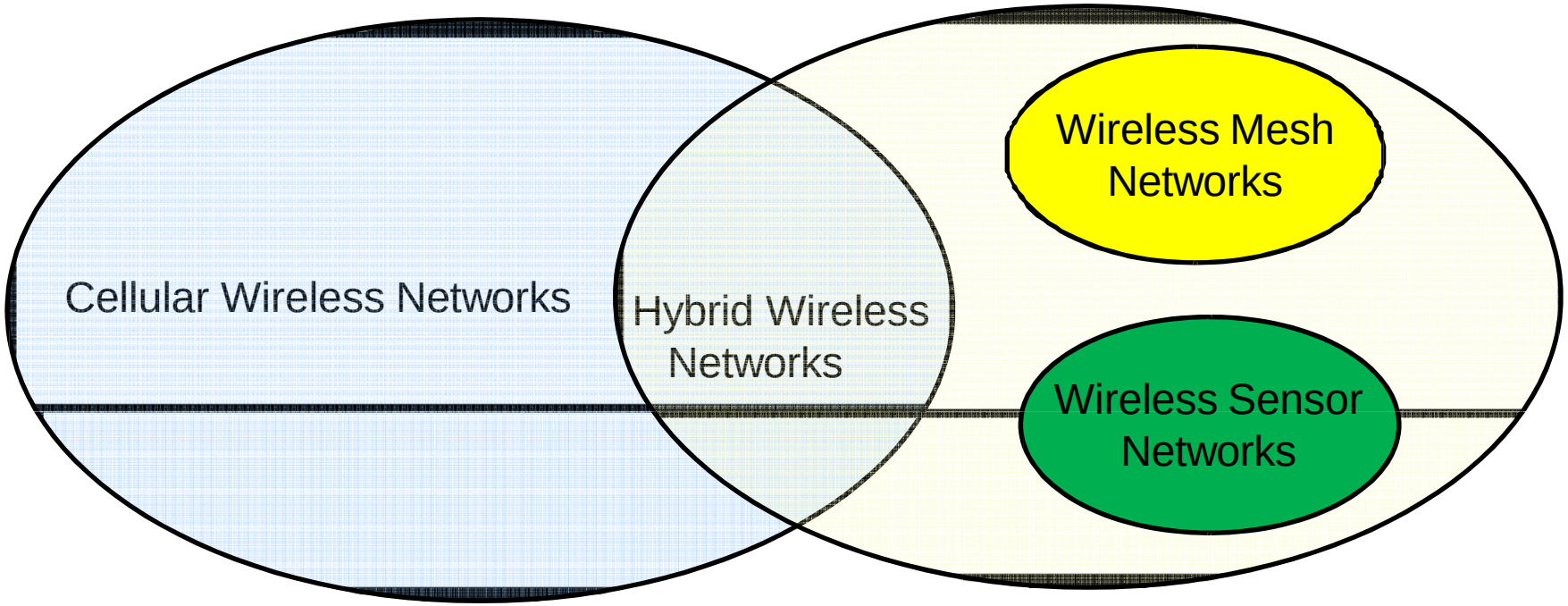
Cellular and Ad Hoc Wireless Networks

- Cellular Wireless Networks: infrastructure dependent network
- Ad Hoc Networks: multi-hop radio relaying and without support of infrastructure
  - Wireless Mesh Networks
  - Wireless Sensor Networks



Infrastructure Dependent
(Single-Hop Wireless Networks)

Ad Hoc Wireless Networks
(Multi-Hop Wireless Networks)

Figure Cellular and ad hoc wireless networks.

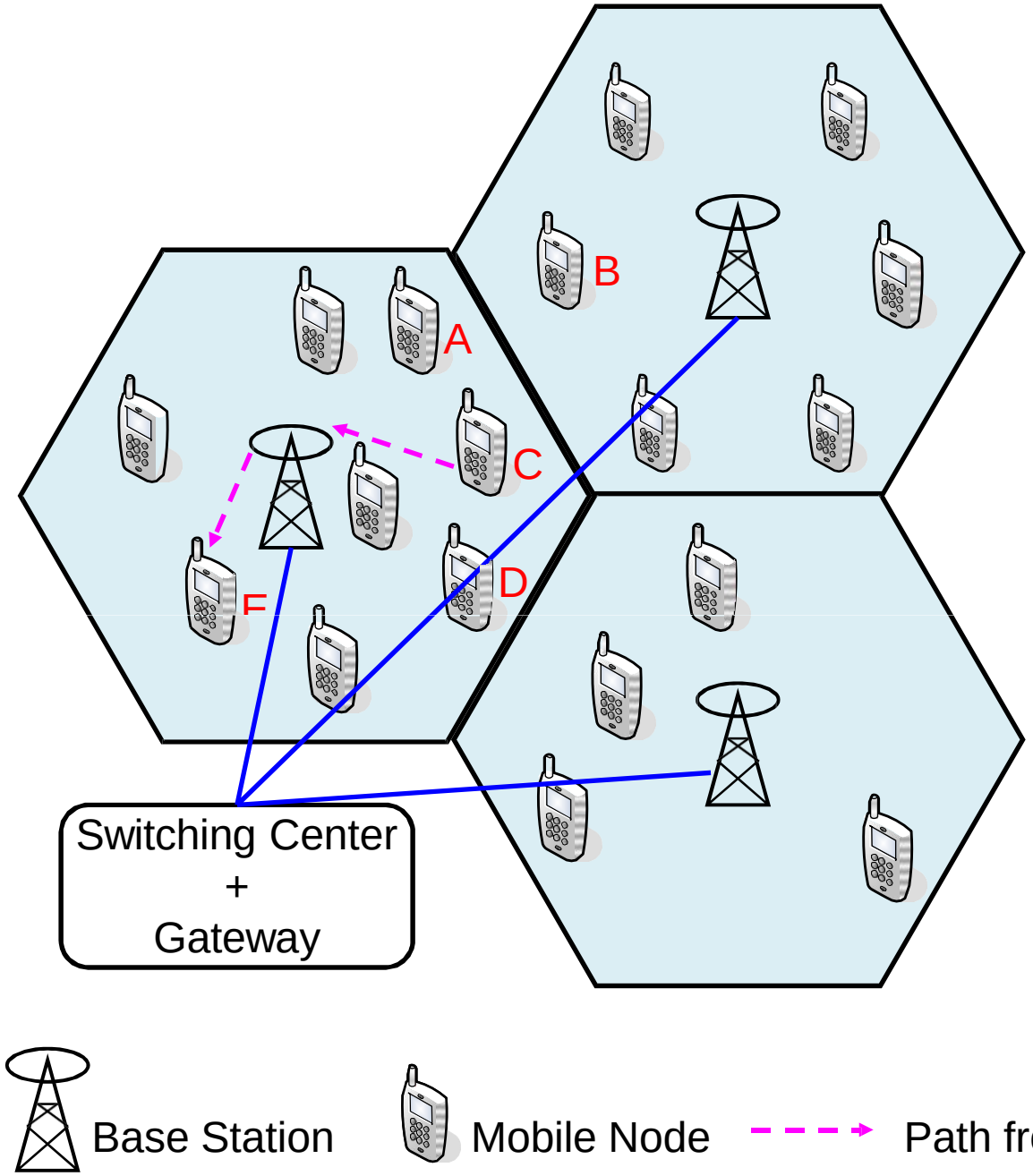
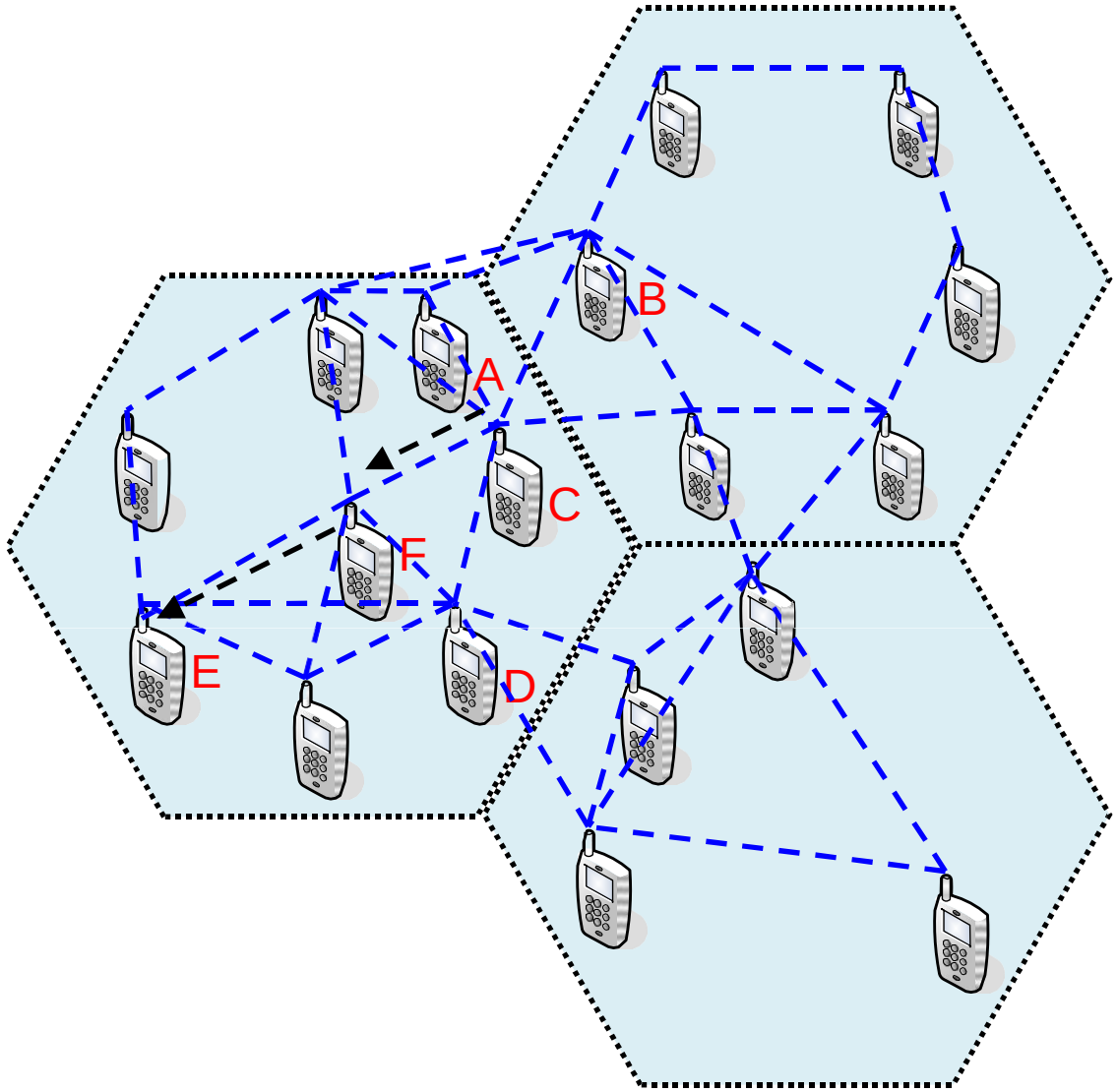


Figure A cellular networks.



Mobile Node Wireless Link Path from C to E

Figure. An ad hoc wireless networks

Differences between cellular networks and ad hoc wireless networks

Cellular Networks	Ad Hoc Wireless Networks
Fixed infrastructure-based	Infrastructure-less
Single-hop wireless links	Multi-hop wireless links
Guaranteed bandwidth (designed for voice traffic)	Shared radio channel (more suitable for best-effort data traffic)
Centralized routing	Distributed routing
Circuit-switched (evolving toward packet switching)	Packet-switched (evolving toward emulation of circuit switching)
Seamless connectivity (low call drops during handoffs)	Frequency path break due to mobility
High cost and time of deployment	Quick and cost-effective deployment
Reuse of frequency spectrum through geographical channel reuse	Dynamic frequency reuse based on carrier sense mechanism

Differences between cellular networks and ad hoc wireless networks (cont.)

Easier to achieve time synchronization	Time synchronization is difficult and consumes bandwidth
Easier to employ bandwidth reservation	Bandwidth reservation requires complex medium access control protocols
Application domains include mainly civilian and commercial sector	Application domains include battlefields, emergency search and rescue operation, and collaborative computing
High cost of network maintenance (backup power source, staffing, etc.)	Self-organization and maintenance properties are built into the network
Mobile hosts are of relatively low complexity	Mobile hosts require more intelligence (should have a transceiver as well as routing/switching capacity)
Major goals of routing and call admission are to maximize the call acceptance ratio and minimize the call drop ratio	Man aim of routing is to find paths with minimum overhead and also quick reconfiguration of broken paths
Widely deployed and currently in the third generation	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
  - Establishing communication among a group of soldiers for tactical operations
  - Coordination of military object moving at high speeds such as fleets of airplanes or ships
  - Requirements: reliability, efficiency, secure communication, and multicasting routing,
- Collaborative and Distributed Computing
  - Conference, distributed files sharing
- Emergency Operations
  - Search, rescue, crowd control, and commando operations
  - Support real-time and fault-tolerant communication paths

Wireless Mesh Networks

- An alternate communication infrastructure for mobile or fixed nodes/users
- Provides many alternate paths for a data transfer session between a source and destination
- Advantages of Wireless Mesh Networks
  - High data rate, quick and low cost of deployment, enhanced services, high scalability, easy extendability, high availability, and low cost per bit

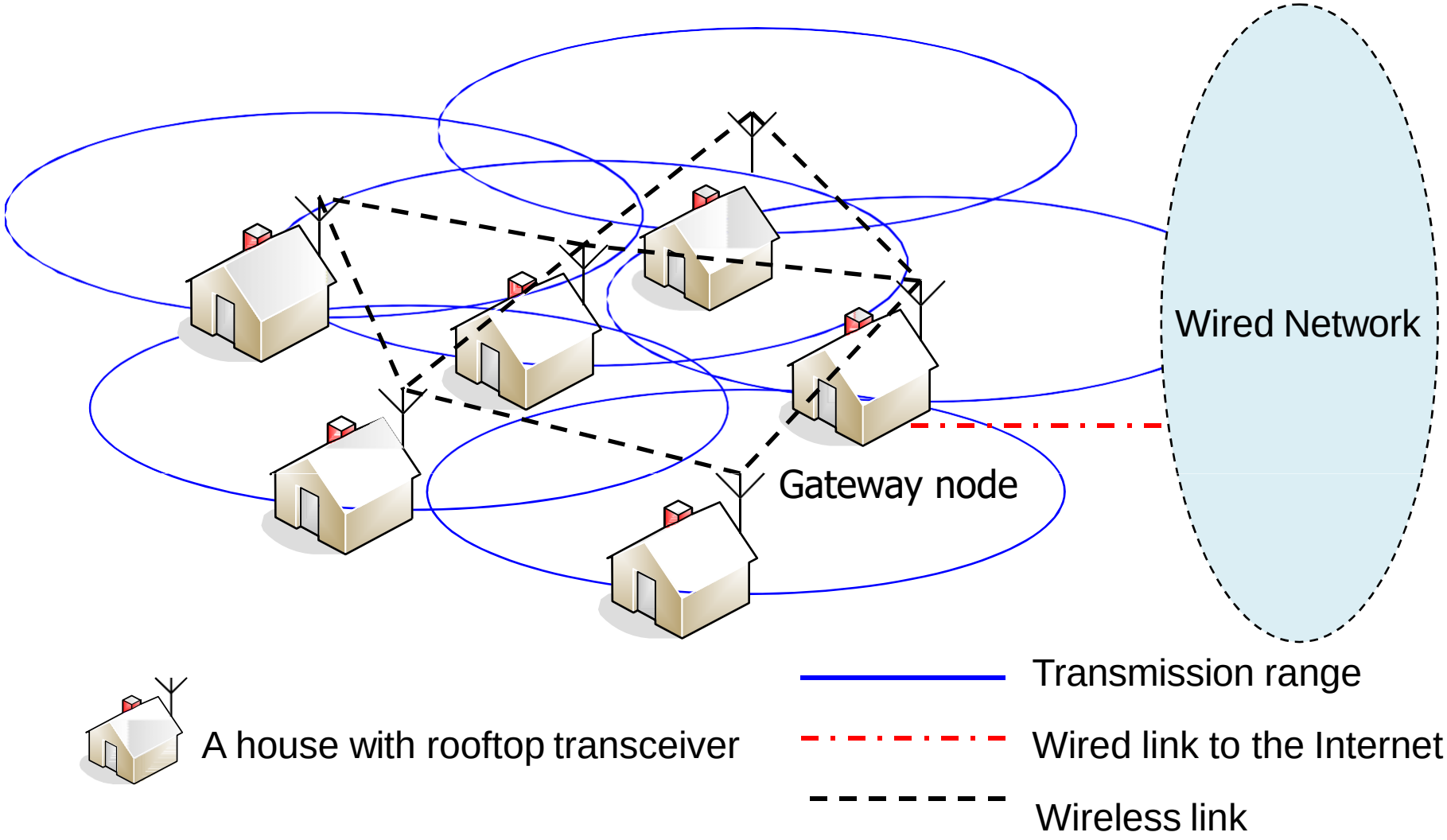


Figure 5.4. Wireless mesh networks operating in a residential zone

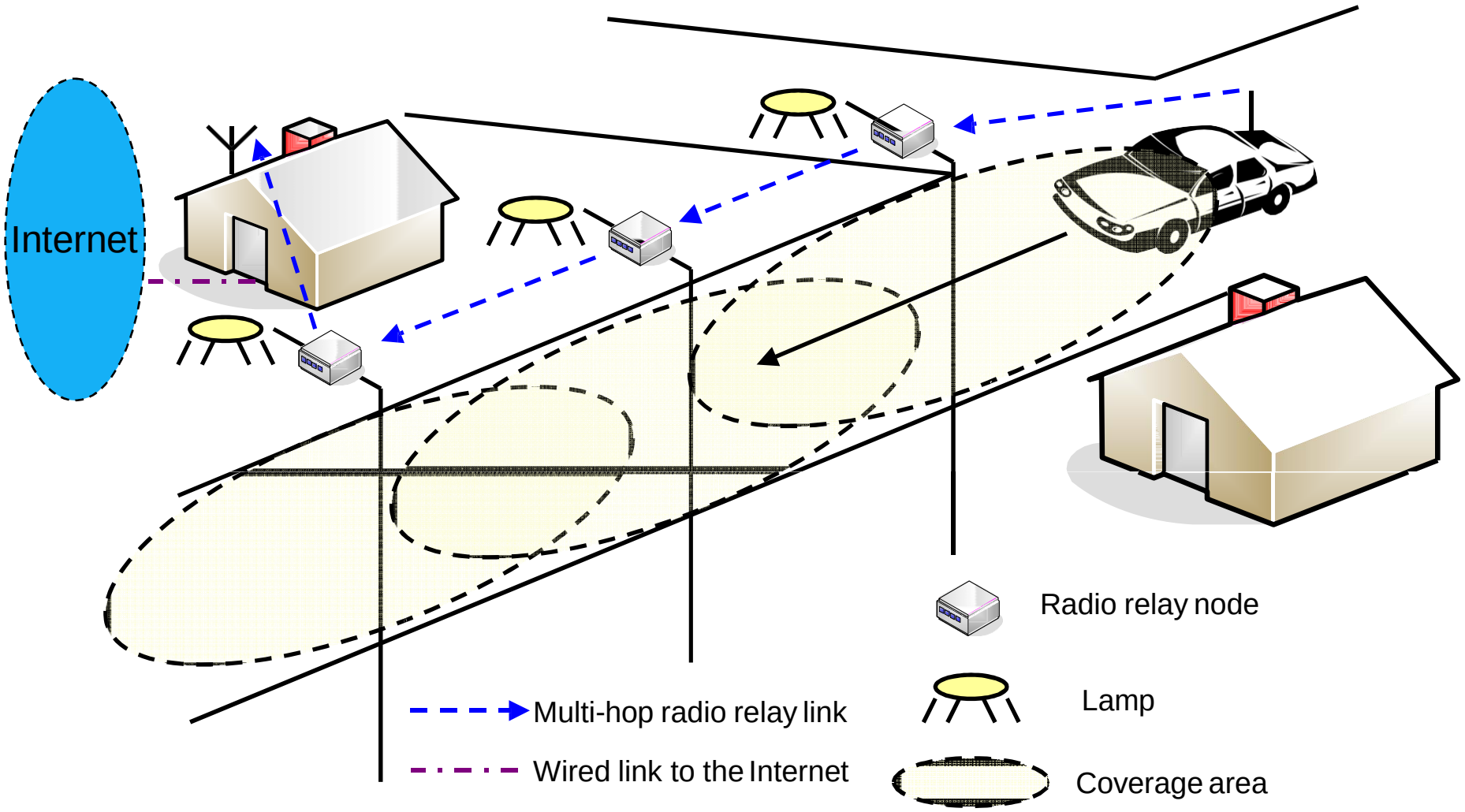


Figure 5.5 Wireless mesh network covering a highway

Wireless Sensor Networks

- A collection of a large number of sensor nodes that are deployed in a particular region
- Applications:
  - military, health care, home security, and environmental monitoring
- Differences with the ad hoc wireless networks:
  - Mobility of nodes, size of network, density of deployment, power constraints, data/information fusion, traffic distribution

Hybrid Wireless Networks

- HWN such as Multi-hop cellular networks and integrated cellular ad hoc relay networks
  - The base station maintains the information about the topology of the network for efficient routing
  - The capacity of a cellular network can be increased if the network incorporates the properties of multi-hop relaying along with the support of existing fixed infrastructure
- Advantages:
  - Higher capacity than cellular networks due to better channel reuse
  - Increased flexibility and reliability in routing
  - Better coverage and connectivity in holes

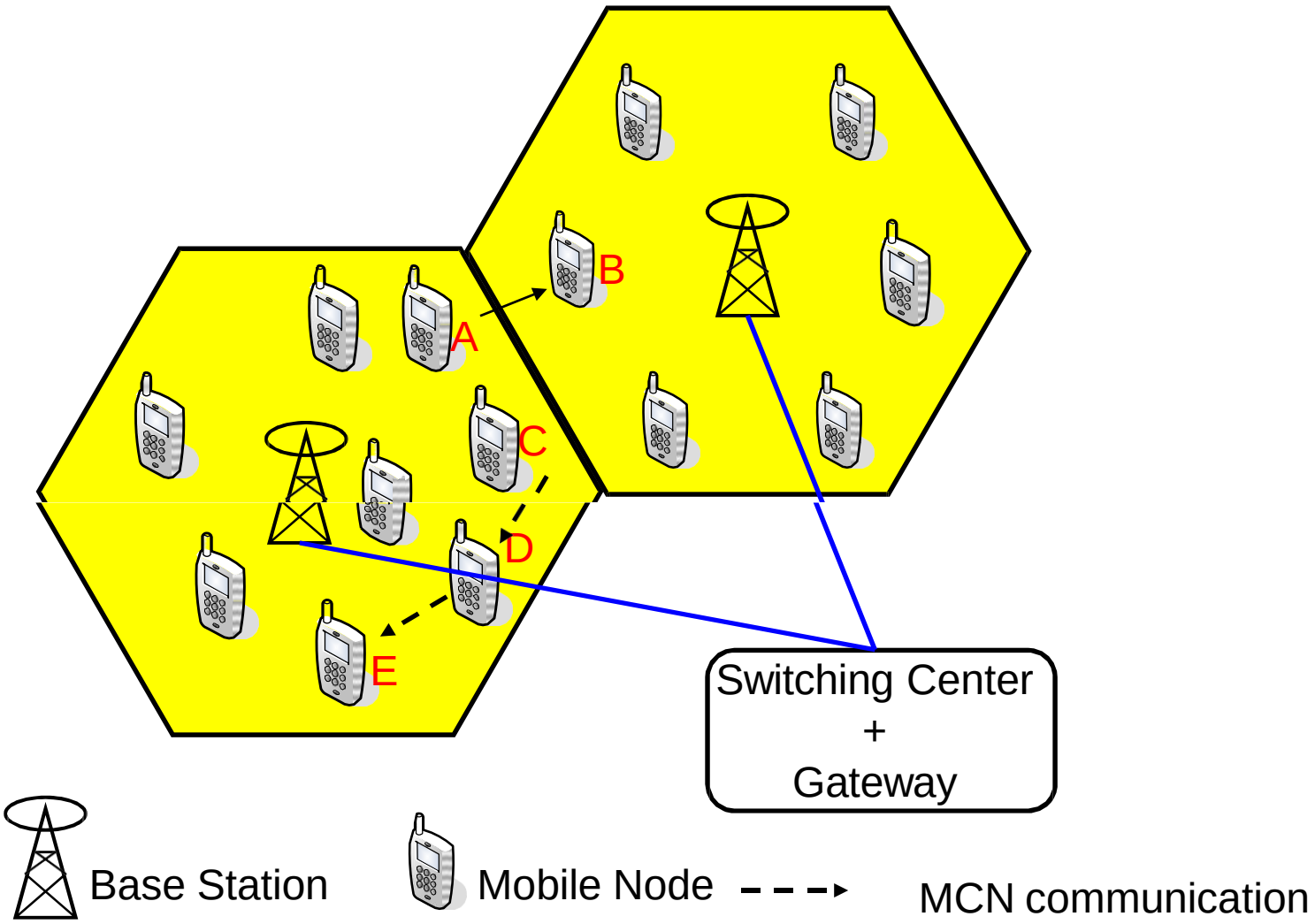


Figure 5.6. MCN architecture.

Issues in Ad Hoc Wireless Networks

- Medium access scheme
- Routing, Multicasting, TPC protocol
- Pricing scheme, QoS, Self-organization
- Security, Energy management
- Addressing and service discovery
- Deployment considerations

Medium Access Scheme

- Distributed operation
  - fully distributed involving minimum control overhead
- Synchronization
  - Mandatory for TDMA-based systems
- Hidden terminals
  - Can significantly reduce the throughput of a MAC protocol
- Exposed terminals
  - To improve the efficiency of the MAC protocol, the exposed nodes should be allowed to transmit in a controlled fashion without causing collision to the on-going data transfer
- Access delay

The Major Issues of MAC Scheme

- Throughput and access delay
  - To minimize the occurrence of collision, maximize channel utilization, and minimize controloverhead
- Fairness
  - Equal share or weighted share of the bandwidth to all competing nodes
- Real-time traffic support
- Resource reservation
  - Such as BW, buffer space, and processing power
- Capability for power control
- Adaptive rate control
- Use of directional antennas

The Major Challenge of Routing Protocol

- Mobility result in frequent path break, packet collision, and difficulty in resource reservation
- Bandwidth constraint: BW is shared by every node
- Error-prone and share channel: high bit error rate
- Location-dependent contention: distributing the network load uniformly across the network
- Other resource constraint: computing power, battery power, and buffer storage

The Major Requirement of Routing Protocol

- Minimum route acquisition delay
- Quick route reconfiguration: to handle path breaks
- Loop-free routing
- Distributed routing approach
- Minimum control overhead
- Scalability
- Provisioning of QoS:
  - supporting differentiated classes of services
- Support for time-sensitive traffic
- Security and privacy

The Major Issues in Multicast Routing Protocols

- Robustness
  - recover and reconfigure quickly from link breaks
- Efficiency
  - minimum number of transmissions to deliver a data packet to all the group members
- Minimal Control overhead
- QoS support
- Efficient group management
- Scalability
- Security

Transport Layer Protocols

- Objectives: setting up and maintaining
  - End-to-end connections, reliable end-to-end data delivery, flow control, and congestion control
- Major performance degradation:
  - Frequent path breaks, presence of old routing information, high channel error rate, and frequent network partitions

Quality of Service Provisioning

- QoS often requires negotiation between the host and the network, resource reservation schemes, priority scheduling and call admission control
- QoS in Ad hoc wireless networks can be on a per flow, per link, or per node
- Qos Parameters: different applications have different requirements
  - Multimedia: bandwidth and delay are the key parameters
  - Military: BW, delay, security and reliability
  - Emergency search –and-rescue: availability is the key parameters, multiple link disjoint paths
  - WSN: battery life, minimum energy consumption

Quality of Service Provisioning

- QoS-aware routing:
  - To have the routing use QoS parameters for finding a path
  - The parameters are network through put, packet delivery ratio, reliability, delay, delay jitter, packet lost rate, bit error rate, and path loss
- QoS framework:
  - A frame work for QoS is a complete system that attempts to provide the promised service
  - The QoS modules such as routing protocol, signaling protocol, and resource management should react promptly according to changes in the network state

Self-Organization

- An important property that an ad hoc wireless network should exhibit is organizing and maintaining the network by itself
- Major activities: neighbor discovery, topology organization, and topology reorganization
- Ad hoc wireless networks should be able to perform self-organization quickly and efficiently

Security

- The attack against ad hoc wireless networks are classified into two types: passive and active attacks
- Passive attack: malicious nodes to observe the nature of activities and to obtain information in the network without disrupting the operation
- Active attack: disrupt the operation of the network
  - Internal attack: nodes belong to the same network
  - External attack: nodes outside the network