

Ad Hoc Wireless Network

Introduction

- Ad Hoc Network is a multi-hop relaying network
- ALOHAnet developed in 1970
- Ethernet developed in 1980
- In 1994, Bluetooth proposed by Ericsson to develop a short-range, low-power, low-complexity, and inexpensive radio interface
- WLAN 802.11 spec. is proposed in 1997

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

Issues in Ad Hoc Wireless Networks

- Medium access scheme
- Routing, Multicasting, Transport Layer 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

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

Major Security Threats

- Denial of service: either consume the network BW or overloading the system
- Resource consumption
 - Energy depletion: by directing unnecessary traffic through nodes
 - Buffer overflow: filling unwanted data, routing table attack (filling nonexistent destinations)
- Host impersonation: A compromised node can act as another node and respond control packets to create wrong route entries and terminate the traffic
- Information disclosure: support **useful** traffic pattern
- Interference: create wide-spectrum noise

Addressing and Service Discovery

- An address that is globally unique is required for a node to participate communication
 - Auto-configuration of address is required to allocate non-duplicate address to the nodes
 - In networks frequent partitioning and merging of network components require duplicate address detection mechanisms
- Nodes in the network should be able to locate services that other nodes provide

Energy Management

- Transmission power management:
 - RF hardware design ensure minimum power consumption
 - Uses variable power MAC protocol
 - Load balance in network layer
 - Reducing the number of retransmissions at the transport layer
 - Application software developed for mobile computers

Energy Management (cont.)

- Battery energy management: extending the battery life by taking chemical properties, discharge patterns, and by the selection of a battery from a set of batteries that is available for redundancy
- Processor power management: CPU can be put into different power saving modes during low processing load conditions
- Devices power management: can be done by OS by selectively powering down interface devices that are not used or by putting devices into different power-saving modes

Scalability

- The latency of path-finding involved with an on-demand routing protocol in a large ad hoc wireless network may be unacceptably high
- A hierarchical topology-based system and addressing may be more suitable for large ad hoc wireless networks

Deployment Considerations

- The deployment of a commercial ad hoc wireless network has the following benefits
 - Low cost of deployment
 - Incremental deployment
 - Short deployment time
 - Re-configurability

Major Issues for Deployment

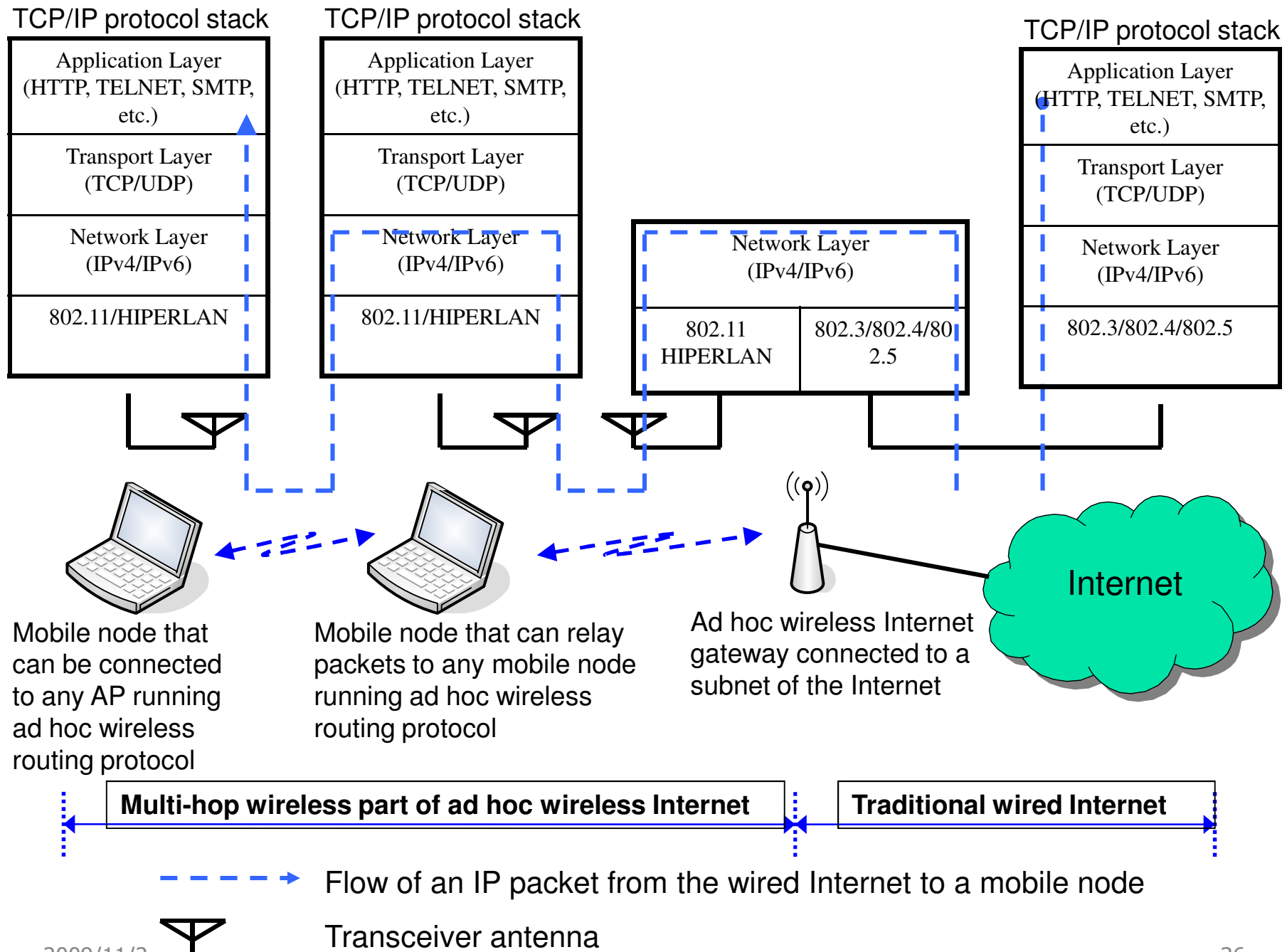
- Scenario of deployment
 - Military deployment
 - Data-centric (e.g. WSN)
 - User-centric (soldiers or vehicles carrying with wireless communication devices)
 - Emergency operations deployment
 - Commercial wide-area deployment
 - Home network deployment
- Required longevity of network: regenerative power source can be deployed when the connectivity is required for a longer duration of time
- Area of coverage

Major Issues for Deployment

- Service availability: redundant nodes can be deployed to against nodes failure
- Operational **integration** with other infrastructure: can be considered for improve the performance or gathering additional information, or for providing better QoS
- Choice of protocols: the choices of protocols at different layers of the protocol stack is to be done taking into consideration the deployment scenario

Ad Hoc Wireless in Internet

- Similar to wireless internet, the ad hoc wireless internet extends the service of the Internet to the end user over an ad hoc wireless network
- Gateways: entry points to the wired Internet
- Address mobility: similar to the Mobile IP
- Routing: major problem in ad hoc wireless Internet
- Transport layer protocol
- Load balancing, pricing/billing, security, QoS
- Service, address, and location discovery



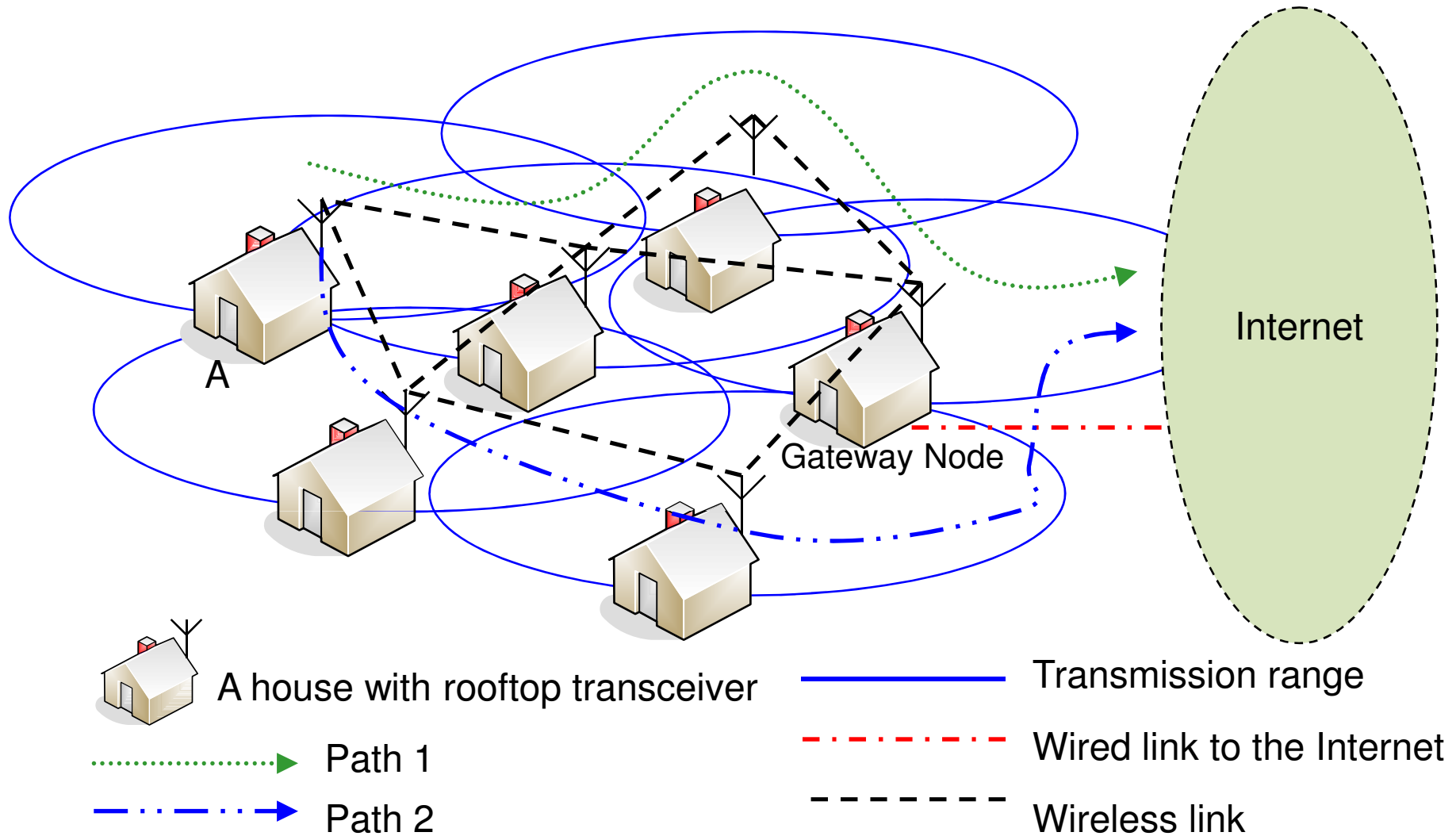


Figure 5.8. An illustration of the ad hoc wireless Internet implemented by a wireless mesh network

Home Work

- 4, 8, 11, 13