Introduction to WMNs and MANETs

CSE 6590
Fall 2010
Department of Computer Science & Engineering
York University

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Course Information

- Refer to the course web page.

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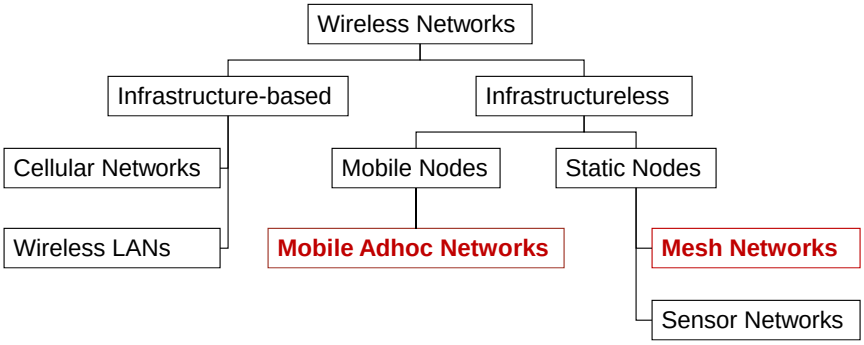
Wireless Networks: Taxonomy



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Wireless Mesh Networks

- WMNs consist of two types of nodes:
  - mesh routers: forwarding data.
  - mesh clients: acting as hosts; forwarding data.
- The architecture of WMNs can be classified into three main groups:
  - Backbone
  - Client WMNs
  - Hybrid WMNs

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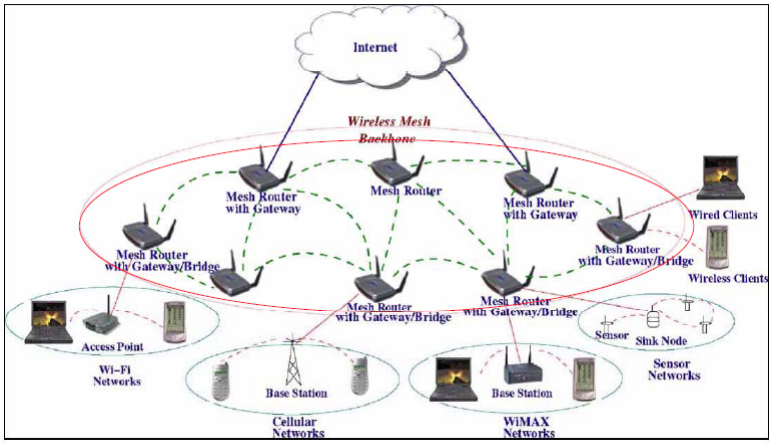
Infrastructure/Backbone



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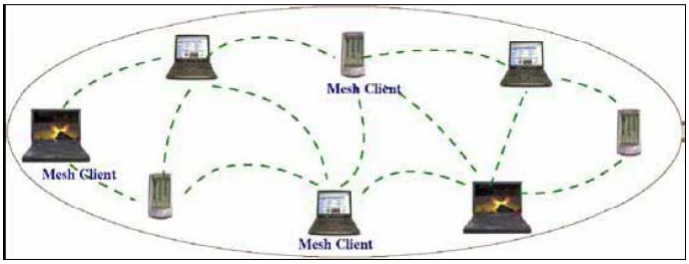
Client WMNs



- One type of radio on devices
- Supporting end-user applications

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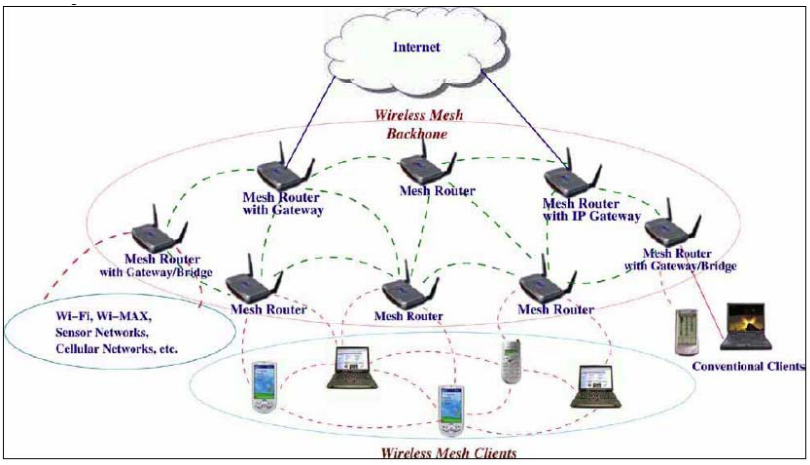
Hybrid WMNs



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Characteristics

- Multi-hop wireless networking
  - Extend the coverage range
  - Provide non-line-of-sight connections
- Ad hoc networking
- Self-forming, self-healing, self-organization
- Low upfront investment costs
- Quick deployment

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Characteristics (2)

- Enabling integration of various existing networks (WiFi, WiMax, Internet, cellular, sensor networks) through gateway/bridge functionalities in mesh routers.
- Mobility: depending on the types of mesh nodes
- Power and resource constraints:
  - mesh router: usually non restrictive
  - mobile devices: limited power supply, storage, computing resources.

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Applications

- Broadband Home Networking
- Community Networking
- Enterprise Networking
- Metropolitan Area Networks
- Transportation Systems
- Building Automation
- Health and Medical Systems
- Security Surveillance Systems

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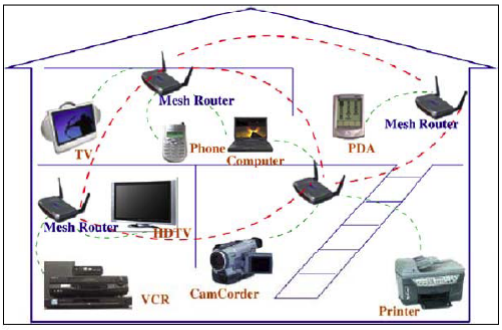
Broadband Home Networking



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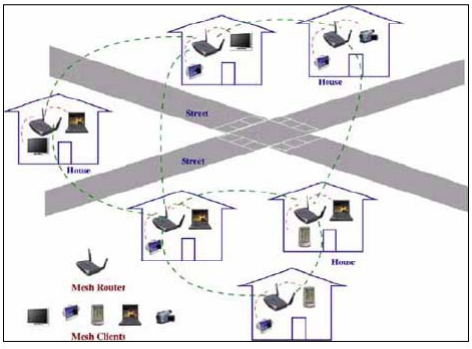
Community Networking



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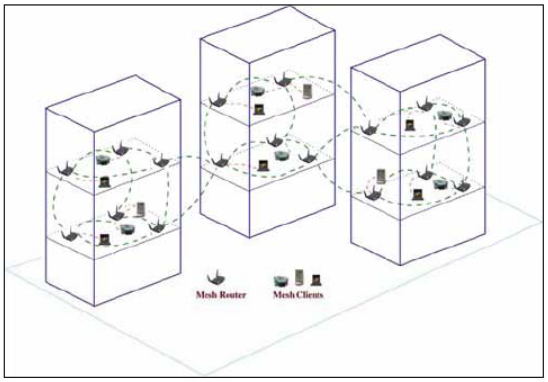
Enterprise Networking



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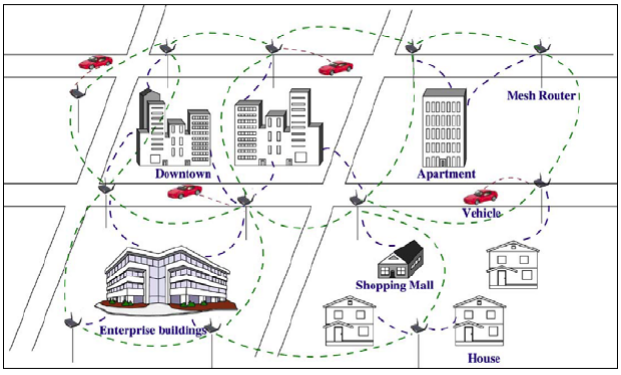
Metropolitan Area Networks



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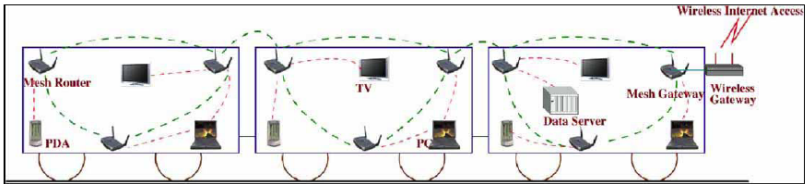
Transportation Systems



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Many Other Applications

- Building automation.
- Health and medical systems.
- Security surveillance systems.

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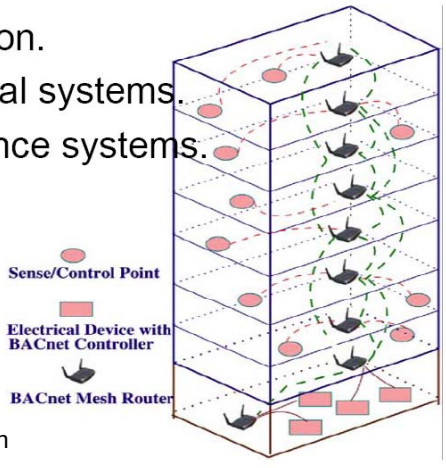

BACnet: Building Automation and Control NETworking

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WMNs: Challenges

- Wireless channels: error-prone media
- Low bandwidth channels
- Scalability
- Quality of service (QoS) guarantee
- Security
- Comparability, interoperability
- Mobility

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Scalability

- When the size of network increases, the network performance degrades significantly.
- Current IEEE 802.11 MAC protocol and its derivatives cannot achieve a reasonable throughput as the number of hops increases to 4 or higher.
  - For 802.11b, the TCP throughput is lower than 1 Mbps.

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Single Channel: Capacity

• Theoretical upper limit of the per node throughput capacity :

$$O(1/\sqrt{n})$$

• Experimental results from CSMA/CA MAC on a string topology: throughput $\approx 1 / n$

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Scalability (2)

- Routing protocols may not be able to find a reliable routing path.
- Transport protocols may loose connections.
- MAC protocols may experience significant throughput reduction.

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Scalability (3)

- CSMA/CA has very low frequency spatial-reuse efficiency.
- Centralized medium access schemes such as TDMA, CDMA are difficult to implement
  - Ad hoc nature of WMNs
  - Complexities of TDMA, CDMA
  - Time synchronization of TDMA

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Security

- Routers, devices: physically vulnerable
- Jamming attacks
- No centralized trusted authority to distribute public keys in a WMN due to distributed system architectures.

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Critical Design Factors

- Scalability
- Security
- Compatibility and interoperability
  - WiFi, WiMax, ZigBee, cellular, Internet
- Broadband and QoS
  - end-to-end delay, delay jitter, PDR, throughput, fairness
- Mesh connectivity
  - Self-organization, topology control
  - Topology-aware MAC and routing

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Critical Design Factors (2)

- Ease of use
  - As automatic as possible (power management, self-organization, topology control, fault tolerance, fast subscription/authentication)
  - For quick and inexpensive deployment
- Radio techniques
  - Directional and smart antennas
  - MIMO systems
  - **Multi-radio/multi-channel systems**
  - Software radio

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Mobile Ad hoc Networks (MANETs)

- No infrastructure (no base stations or access points)
- Mobile nodes
  - Form a network in an ad-hoc manner
  - Act both as hosts and routers
  - Communicate using single or multi-hop wireless links
- Topology, locations, connectivity, transmission quality are variable.

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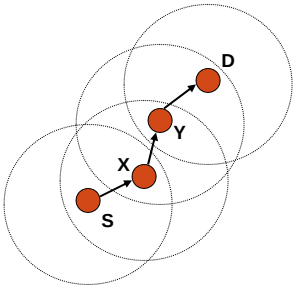
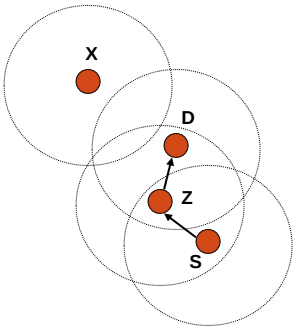
MANETs: Operations





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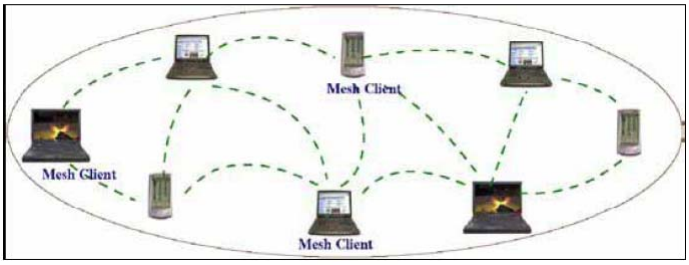
MANETs vs. WMNs



- One type of radio on devices
- Supporting end-user applications

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MANETs vs. WMNs (2)

- MANETs: end-user devices also perform routing and configuration functionalities for all other nodes.
- WMNs: mesh routers perform these tasks.
- Mesh routers vs. mobile devices:
  - power and resource constraints
  - mobility
- MANETs: usually only one radio.
- WMNs: can have multiple channels, multiple radios.

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MANETs: Applications

- Civil
  - Disaster recovery
  - Taxi cabs
  - Communications over water using floats
  - Vehicular ad-hoc network
- Military
  - Battlefield communications
  - Monitoring and planning

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MANETs: Challenges

- Wireless channels: error-prone media
- Low bandwidth channels
- Security
- Unpredictable mobility
- Devices: low power, limited resources
- Maintaining connectivity, states

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References

- Wireless Mesh Networks (Akyildiz), chapter 1
- Ad Hoc Wireless Networks (Murthy)

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