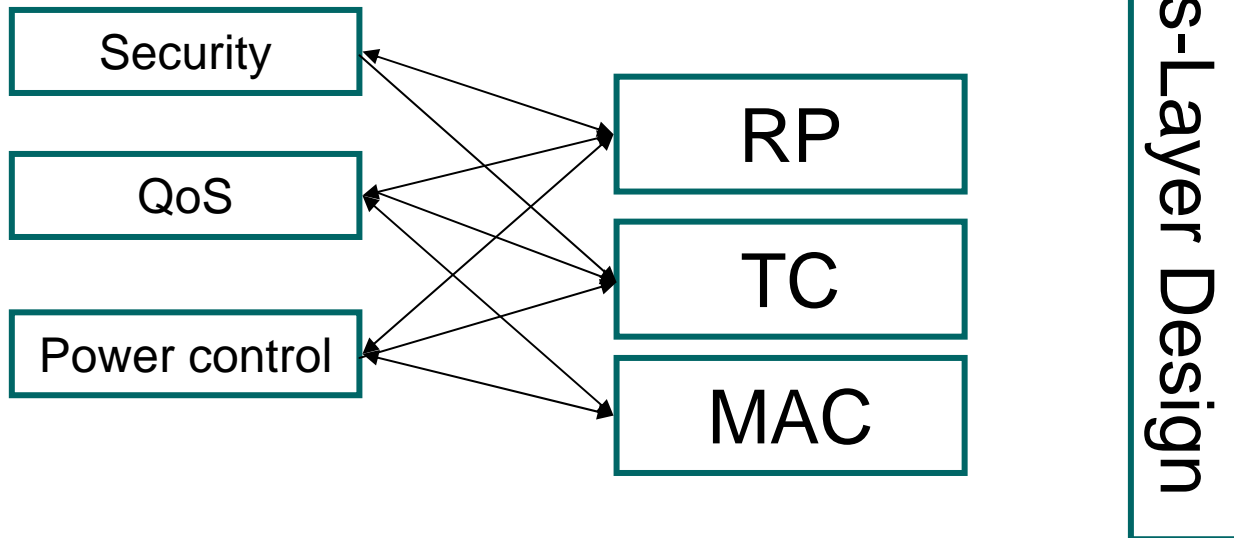


Tentative Agenda

Lecture #	Date	Time	Topic
1	Monday June 27 th	9am-12 :30pm	- Introduction to wireless networking and mobile computing and it applications - Routing and topology control
2	Tuesday June 28 th	9am-12:30pm 3pm-6pm?	- Routing and topology control - Medium Access Control (MAC)
3	Thursday June 30 th	9am-12 :30pm	- Medium Access Control
4	Friday July 1 st	9am-12:30pm 3pm-6pm?	- Cross-Layering, QoS, and Security Issues - Widens: an ad hoc network for public safety applications



General Outline



Capacity of Wireless Ad Hoc Network

An Introduction to Ad Hoc Networks and their Applications

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@June 27, 2005

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Outline

- Communication networks
 - Transmission type
 - Network topology
 - Network scale
 - Network architecture
- Wireless communication: issues
- Network architectures: OSI view
- Mobile ad hoc networks: introduction
- Network models: comparison
- Application of ad hoc networks
- Simulation tools
- Available books



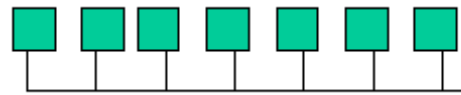
Communication Networks: Transmission type

*“A collection of nodes interconnected
by communication paths”*

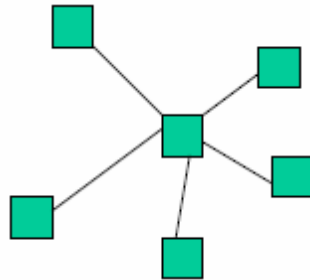
- Transmission type
 - Broadcast
 - A single communication channel shared by all nodes or
 - Point-to-point
 - A communication path must be established for each pair of source and destination nodes
 - Single hop
 - Multi-hop
 - Mobile ad hoc networks or sensor networks or a combination
 - Which route is the best ?
 - Point-to-multipoint or Multipoint-to-Multipoint
 - Multicasting or Geocasting

Communication Networks: Network Topology

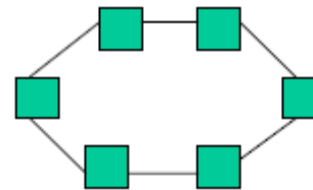
○ Bus



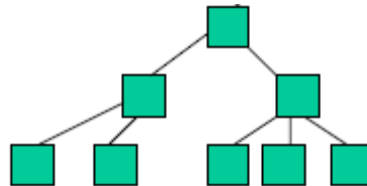
○ Star



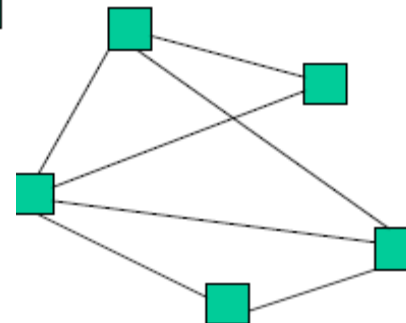
○ Ring



○ Tree

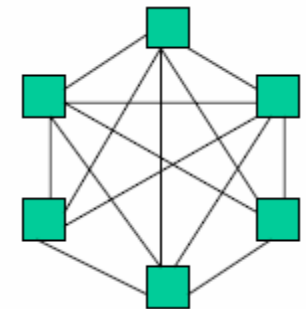


○ Irregular/Complete



Metrics:

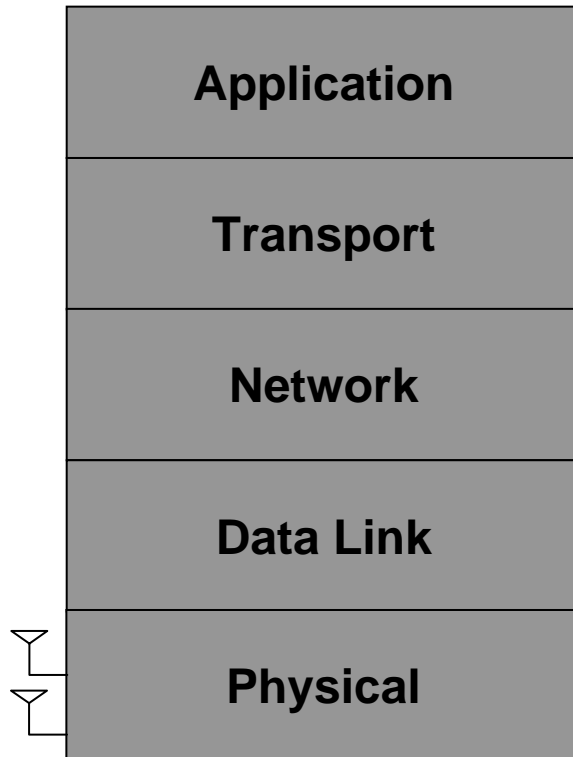
- Diameter
- Robustness
- Cost
- Mobility/traffic
- Wired/wireless



Communication Networks: Network Scale and Architecture

- Personal area network,
 - Body, e.g. Bluetooth
- Local area network
 - Building, office, e.g. WLAN
- Metropolitan area network
 - City, e.g. WiMax
- Wide area network
 - Country, e.g. GSM
- Planetary area network
 - World, e.g. internet
- Network Architecture
 - Layered
 - Cross-layered (see later)

Network Architecture: OSI (Layered)



- Source coding (mp3)
- Packet reordering and congestion control
- Routing
- Error correction, medium access control
- Channel coding, modulation, power control

Communication Links

- A link can be:
 - Simplex: unidirectional link
 - Half duplex: bidirectional but not simultaneously
 - Full duplex: bidirectional & simultaneously
- A wireless link
 - Can't be full duplex due to self-interference
 - Provides network mobility (freedom of movements)
 - Reduces cost of installation (cabling and infrastructure)
 - Facilitates network setup
 - But:
 - Medium has to be shared by users
 - Broadcast nature of wireless medium
 - Channel is noisy and time-varying (high bit error rate)
 - User and environment mobility affect radio transmissions
 - Bandwidth is limited
 - Spectrum regulations



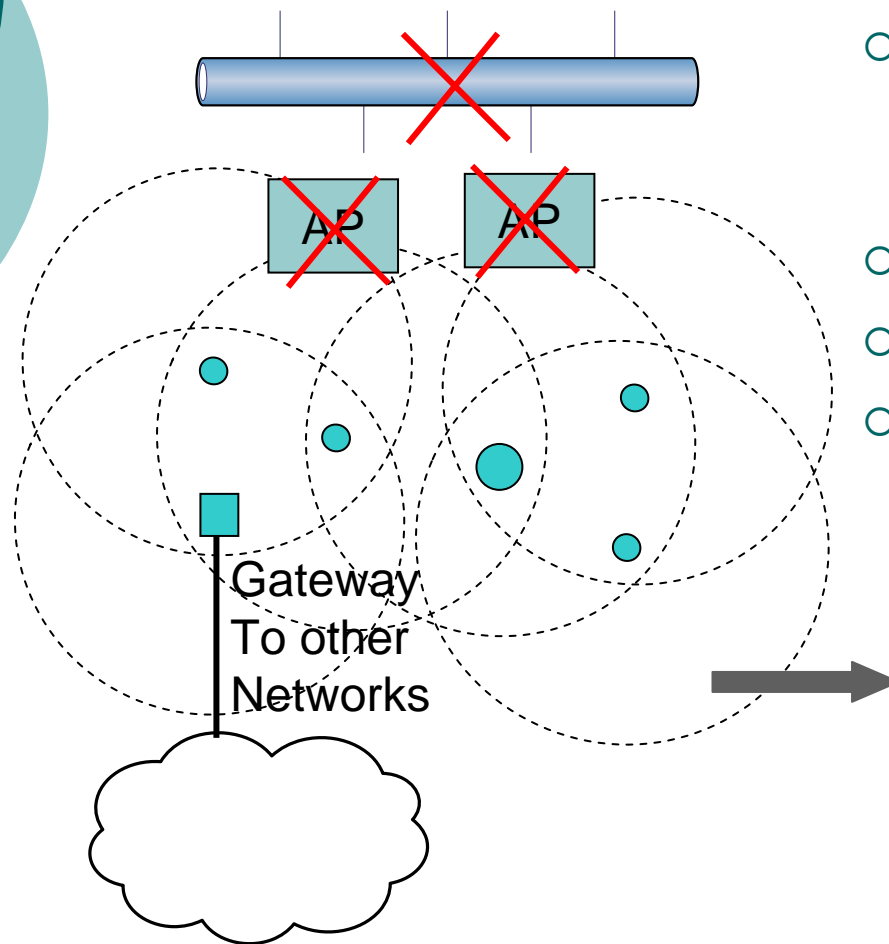
Ad Hoc Networks

- A collection of nodes forming one or potentially several dynamic autonomous networks
 - Nodes may be [mobile or fixed](#)
 - Nodes communicate
 - using wireless medium
 - without necessarily the intervention of any fixed infrastructure, i.e. AP/BS
 - potentially in [multi-hop](#) (store-and-forward) fashion due to the lack of infrastructure, limited transmission range, channel utilization considerations, and power saving
 - Nodes acts as a host, and may act as a router

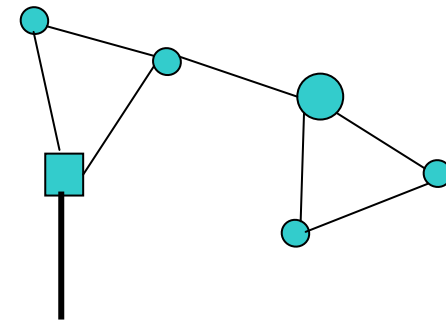
Original Motivation of MANET

- Military need for battlefield survivability [leiner87]
 - No restrictions imposed by a fixed platform
 - The military cannot rely on access to a fixed, pre-placed communication infrastructure in battlefield environment
 - Unavailable or unreliable of access due to the destruction of the local infrastructure or eavesdropping of the information
 - Lack of terrestrial communication infrastructure

Ad Hoc Networks

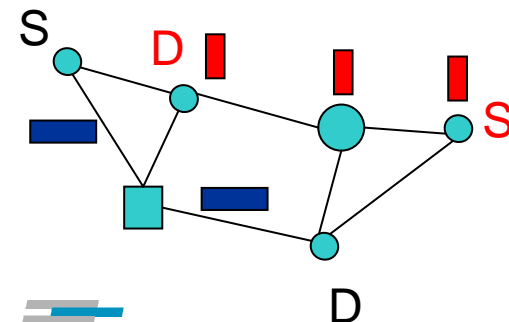
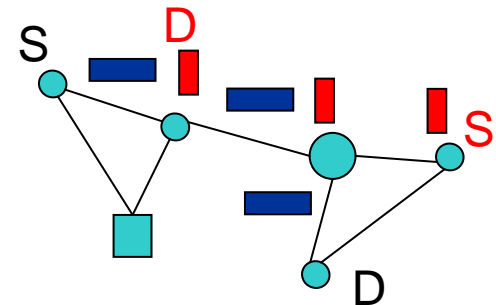
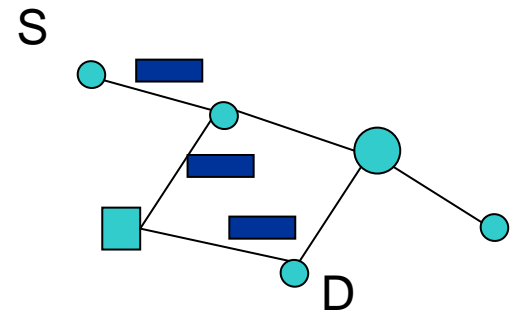


- Packet Radio Networks
 - Term invented by military research @ 70
- Mobile Mesh Networks
- Multihop Networks
- Mobile Ad Hoc Networks



Main characteristics of Mobile Ad Hoc Networks

- Packets may need to traverse multiple nodes to reach the destination
- Mobility may render link connections / disconnections thereby route changes
- Traffic may render congestions and thereby route changes



Key Factors in MANET

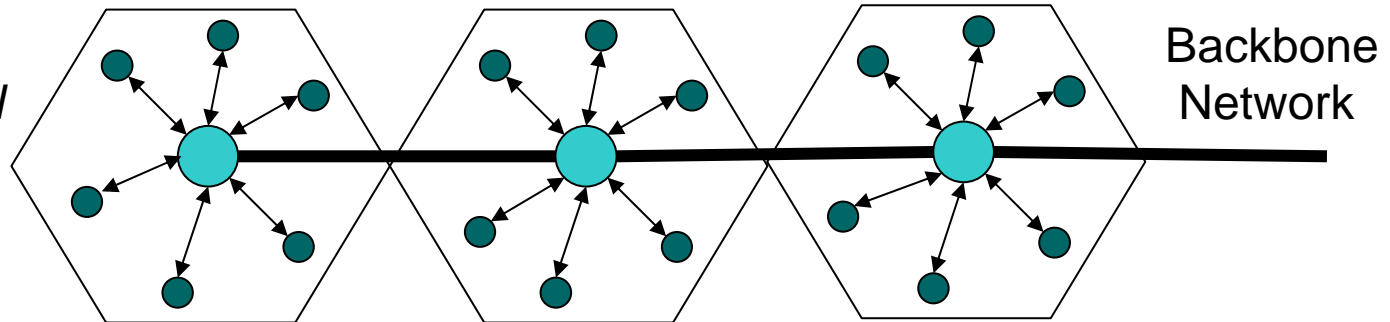
- No wires or cabling
 - Cost effective
- Mobile infrastructure
 - Flexibility
 - Reconfigurability
 - Cooperative network
- Autonomous
 - Stand-alone self organized system
- Multihop routing
 - Create diversity
- Wireless medium
 - Limited capacity
 - error-prone communication
- Lack of fixed infrastructure
 - Distributed operation
 - Complexity
- Dynamic topology
 - Time-varying resources
 - Location dependent resources
- Limited nodes resources
 - Limit processing capability
 - Limited transmission range

Ad Hoc Network Model

- Ad hoc networks can be model as a graph $G=(V, E)$, unit or min-power graph (radii)
 - V set of vertexes, $|V|$ =number of nodes = degree
 - E set of edges, $|E|$ =number of edges
- Evolving graph models dynamic networks by formalizing a time domain in a graph[ferreiro]
 - $\mathbf{G}=(G, S_G, S_T)$
 - $S_G = G_1, G_2, \dots, G_T$, an ordered sequence sub-graphs of G such that $G = \bigcup_{i=1}^T G_i$
 - $S_T = t_0, t_1, t_2, \dots, t_T$, an ordered sequence time instants, where each G_i is the sub-graph during $[t_{i-1}, t_i[$

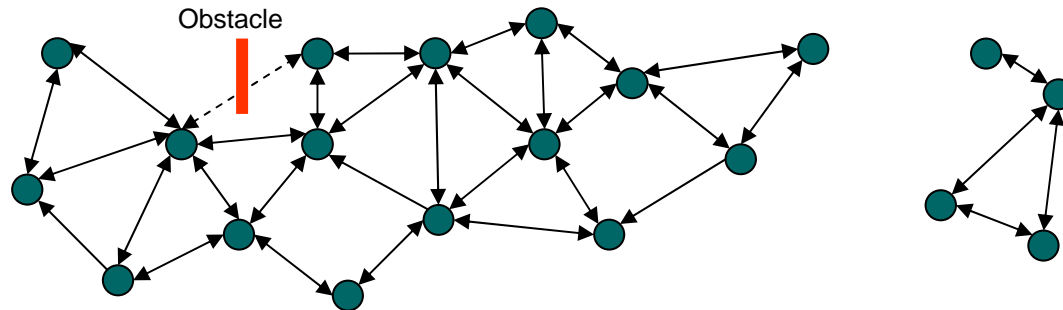
Network Models: Comparison

Single-hop network model
e.g. Cellular Network

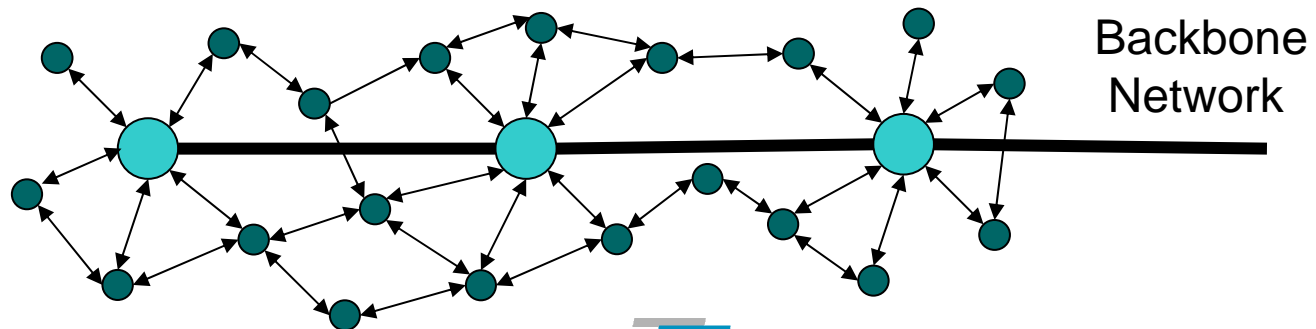


Backbone Network

Multi-hop network model
e.g. ad hoc networks



Hybrid ad hoc network model
e.g. sensor network



Backbone Network

Network Model: Comparison

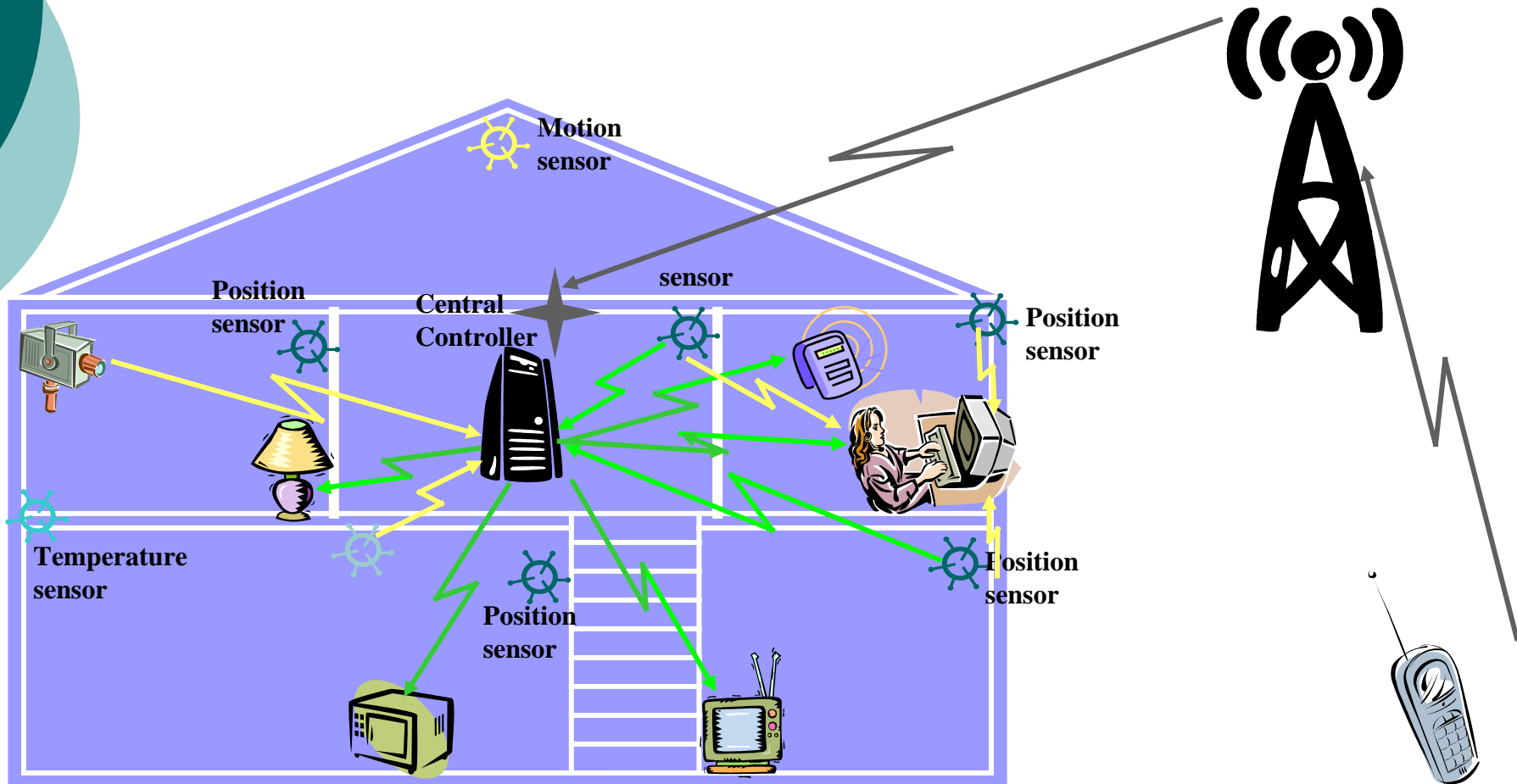
- Cellular Model
 - Uplink/downlink
 - Intra-cell/inter-cell, handoff
 - High capacity backbone
 - Centralized
 - Backbone
 - Fixed infrastructure
- Ad Hoc Model
 - Direct link
 - Multi-Hop routing
 - Limited network resources
 - Distributed
 - Fully mobile infrastructure
- These models, but mainly the ad hoc one, can either be homogeneous or heterogeneous
 - Whether all nodes have the same capabilities and responsibilities
 - **Capability:** transmission range, battery life, processing capacity
 - **Responsibility:** leader, cluster-head, gateway, coordinator

Applications of Ad Hoc Networks

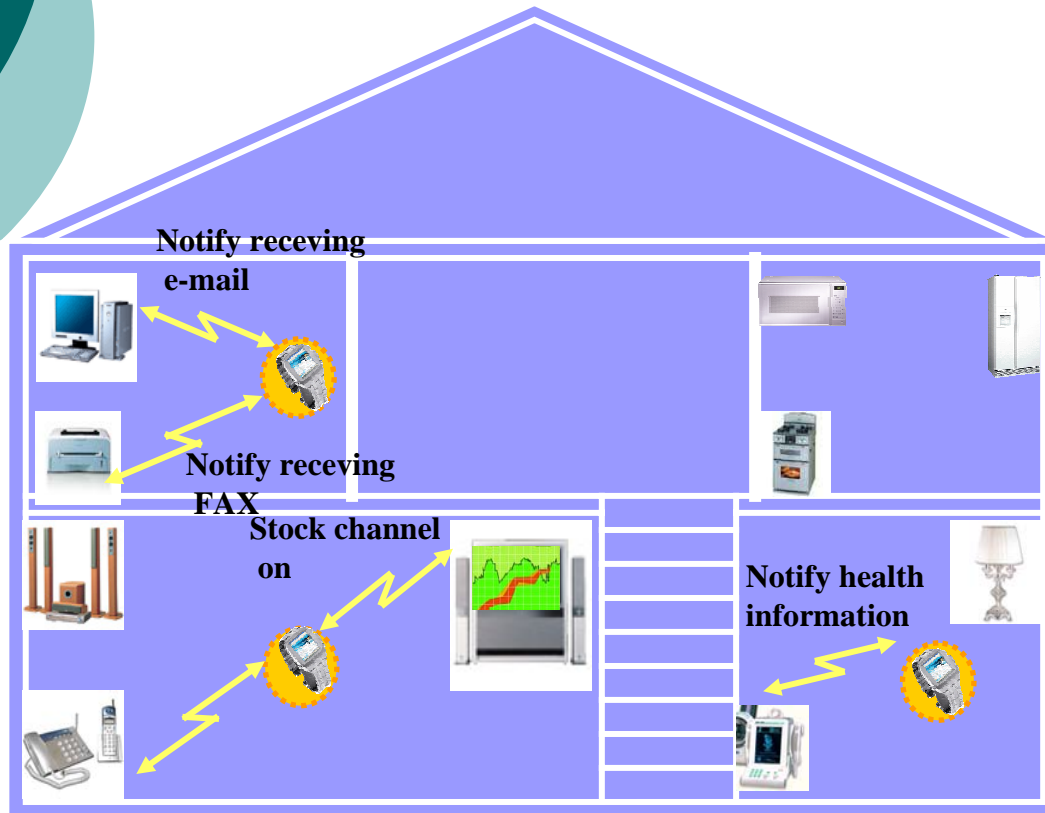
[chlamtek,hoebeke]

- Tactical networks
 - Military communication and operations
- Public safety networks
 - Rescue operation, disaster recovery (firefighters, police, doctors)
- Commercial and civilian services
 - Vehicular services such as road, weather, and accident information, inter-vehicle communication
 - Spontaneous network for group collaboration
 - Sport stadiums, trade-fairs, and shopping mall
- Home, office, and university networking
 - Smart Home, Conference, meeting room, virtual classroom
- Entertainments
 - Multiuser game, wireless P2P networking, Robotic pets
- Sensor Networks
 - Intelligent environments
 - Body area networks
 - Data tracking of environment conditions (weather, earthquake, bridge)

Smart Home



RF-ID



- Personal tags (in a watch ...) for activating services
- Open door, personalized services ...

Simulation Tools

- NS-2
 - <http://www.isi.edu/nsnam/ns/>
 - TCL-TK for scenario setup
 - C++ for protocol design
- GloMoSim
 - <http://pcl.cs.ucla.edu/projects/glomosim/>
 - C and parsec (parallel simulation capability)
- Qualnet
 - <http://www.scalable-networks.com/>
 - Commercial version of GloMoSim

Books

- [Santi 2005] Topology Control in Wireless Ad Hoc and Sensor Networks
- [Ganesh 2005] Emerging Location Aware Broadband Wireless Ad Hoc Networks
- [Safwat 2005] Wireless Ad-Hoc and Sensor Networks
- [Cheng 2004] Ad Hoc Wireless Networking Network Theory and Applications
- [Murthy 2004] Ad Hoc Wireless Networks : Architectures and Protocols
- [Basagni 2004] Mobile Ad hoc Networking
- [Prasant 2004] Ad Hoc Network Technologies and Protocols
- [Aggelou 2003] Mobile Ad-Hoc Networks
- [Toh 2002] Ad Hoc Mobile Wireless Networks Protocols and Systems
- [Ilvas 2002] The Handbook of Ad hoc Wireless Networks
- [Stojmenovic 2002] Handbook of Wireless Networks and Mobile Computing
- [Perkins 2001] Ad Hoc Networking