INTRODUCTION TO AD HOC NETWORKS

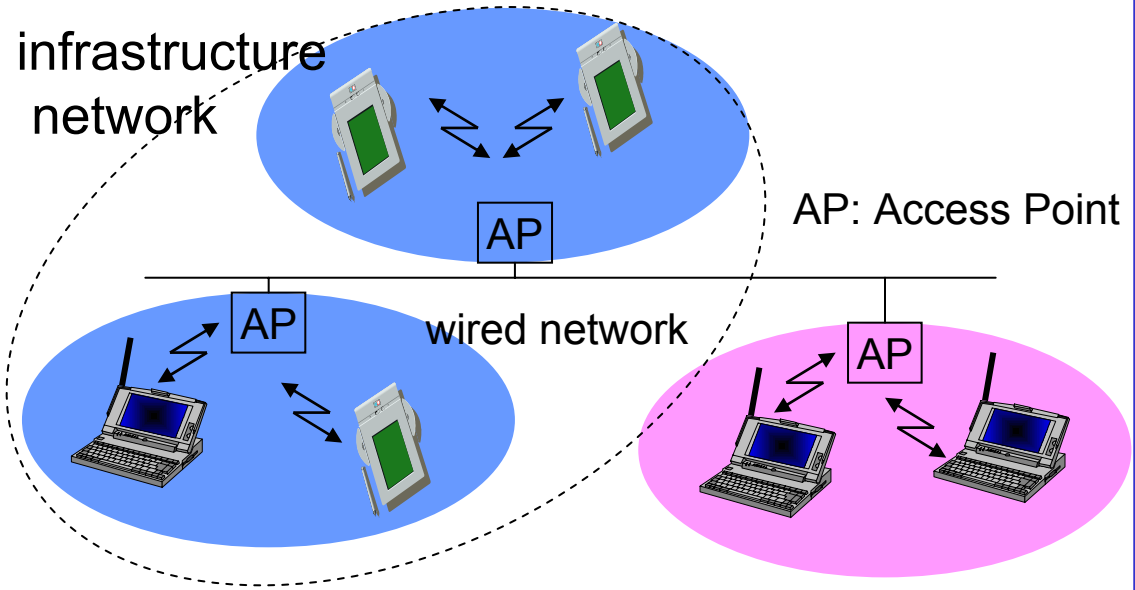
Outline

- What is an ad hoc network?
- Challenges facing ad hoc networks
- General Concepts

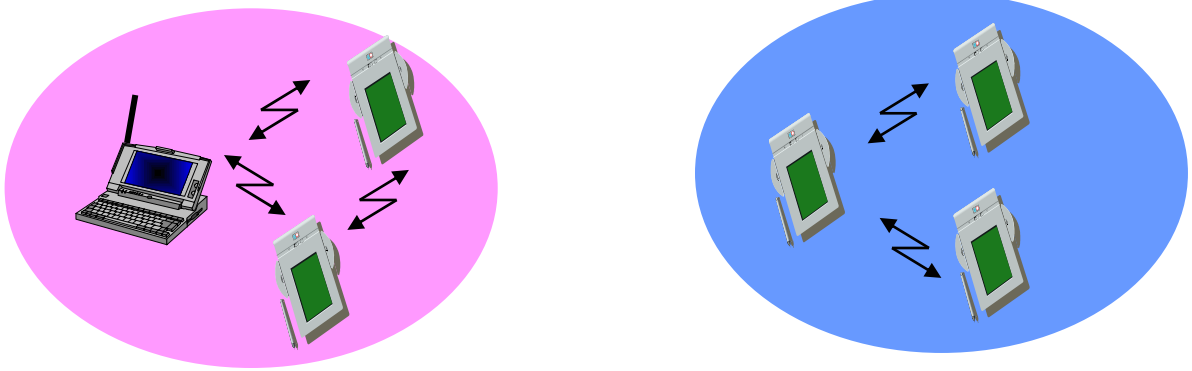
Reading

- C. K. Toh, Chapter 3, "Ad Hoc Wireless Networks", Prentice Hall, 2002
- D. P. Agrawal and Qing-An Zeng, Chapter 13, "Wireless & Mobile Systems", Thompson/Brooks Cole, 2003
- Refer one of the suggested textbooks

Types of Wireless Networks: infrastructure vs. ad-hoc networks



ad-hoc network



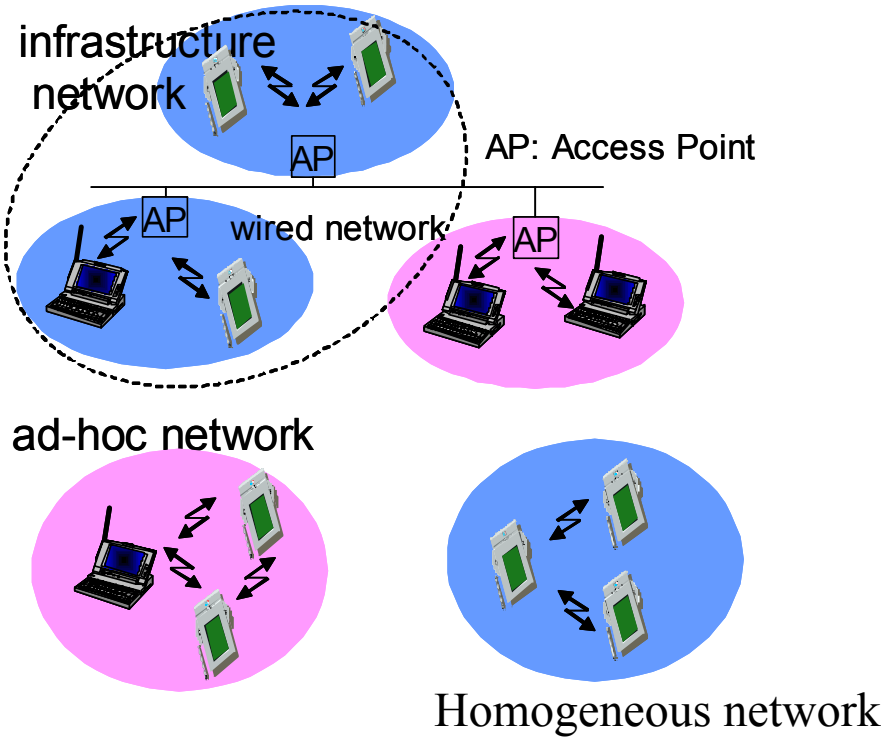
- Infrastructure Networks
  - Fixed, wired backbone
  - Mobile communicates directly with access points
  - Suitable for locations where access points can be placed
  - Cellular networks

Why Ad Hoc Networks ?

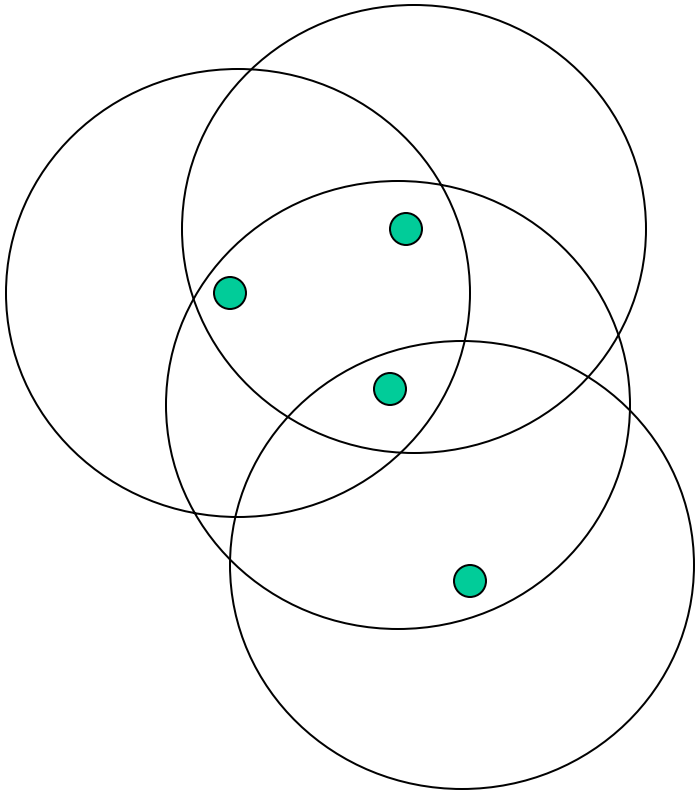
- Ease of deployment
- Speed of deployment
- Decreased dependence on infrastructure

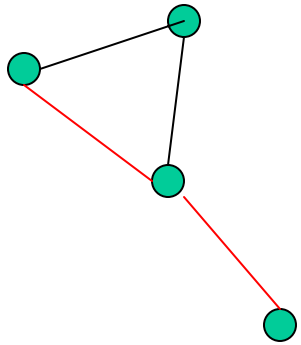
What is an Ad hoc Network?

- A network without any base stations "infrastructure-less" or multi-hop
- A collection of two or more devices equipped with wireless communications and networking capability
- Supports anytime and anywhere computing
- Two topologies:
  - Heterogeneous (left)
    - Differences in capabilities
  - Homogeneous or fully symmetric (Right)
    - all nodes have identical capabilities and responsibilities



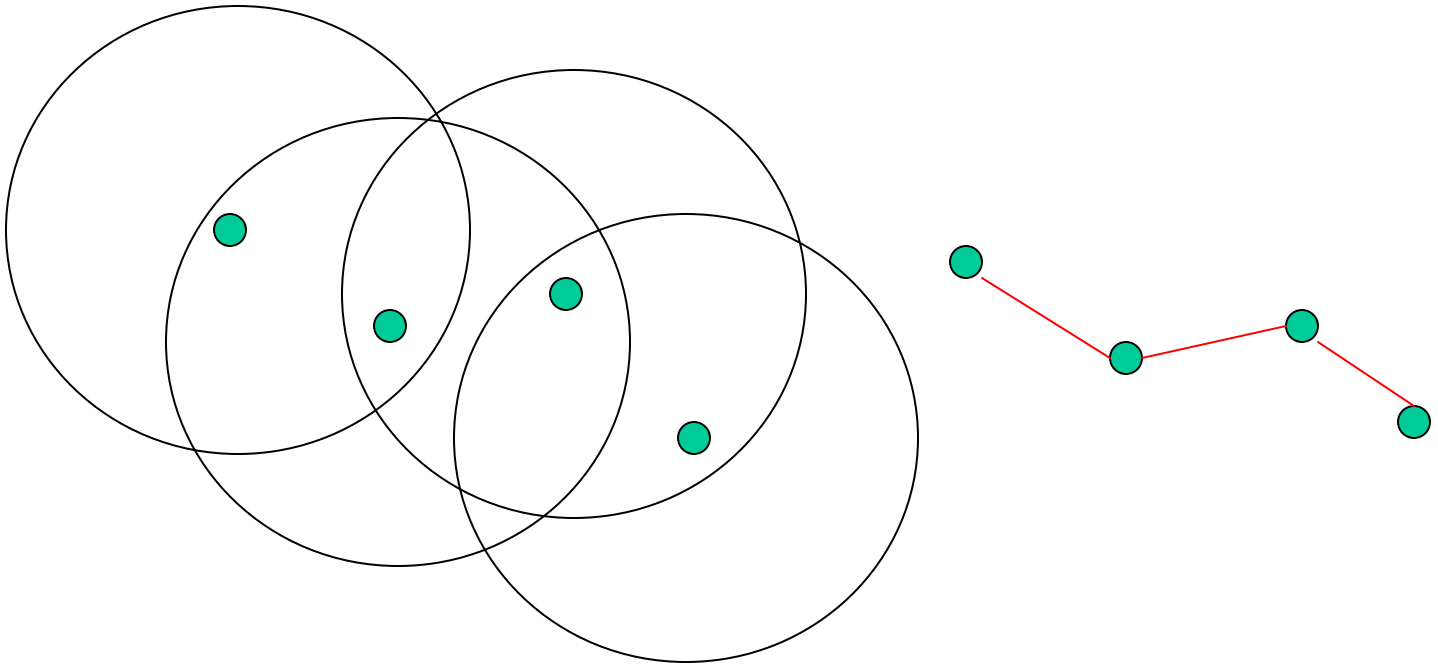
Mobile Ad Hoc Networks?





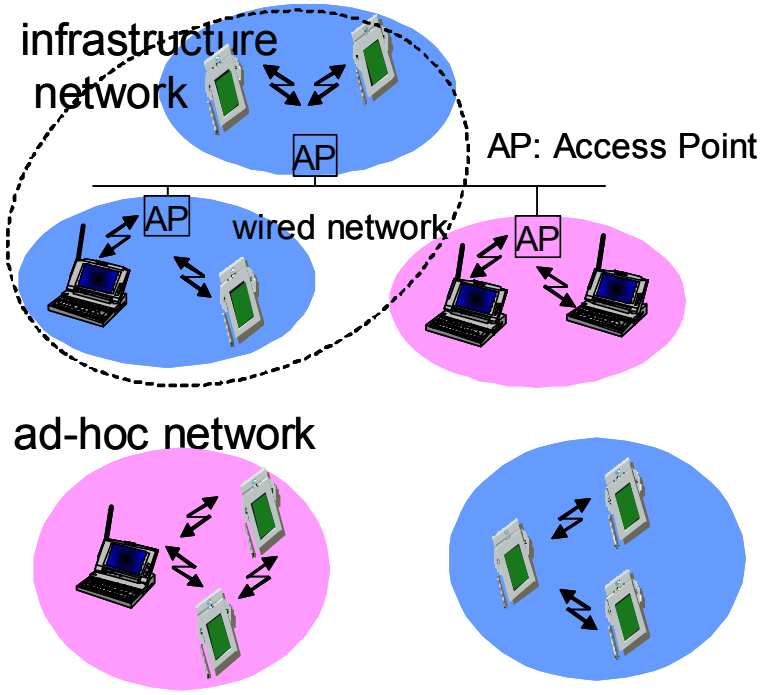
Mobile Ad Hoc Networks?

- Mobility causes route changes

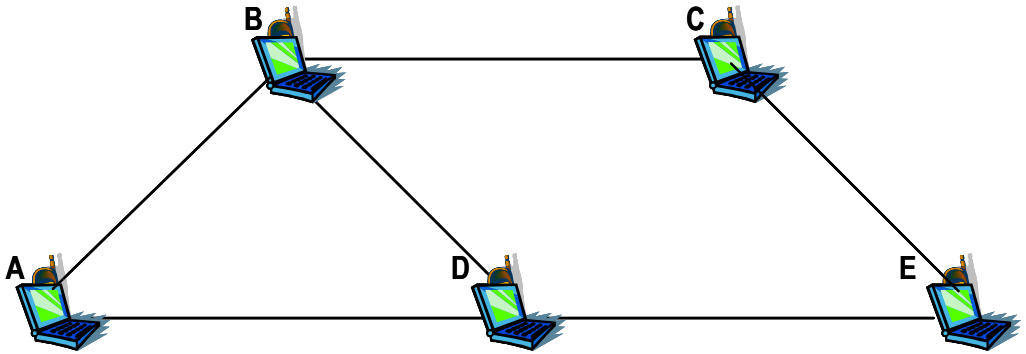


What is an Ad hoc Network?

- Self-organizing and adaptive – Allows spontaneous formation and deformation of mobile networks
- Each mobile host acts as a router
- Supports peer-to-peer communications
- Supports peer-to-remote communications
- Reduced administrative cost
- Ease of deployment



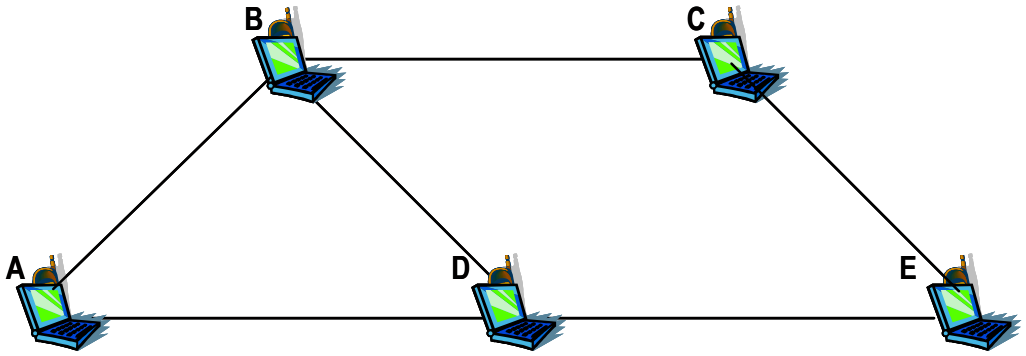
Ad Hoc Networks – Operating Principle



Example of an Ad Hoc Network

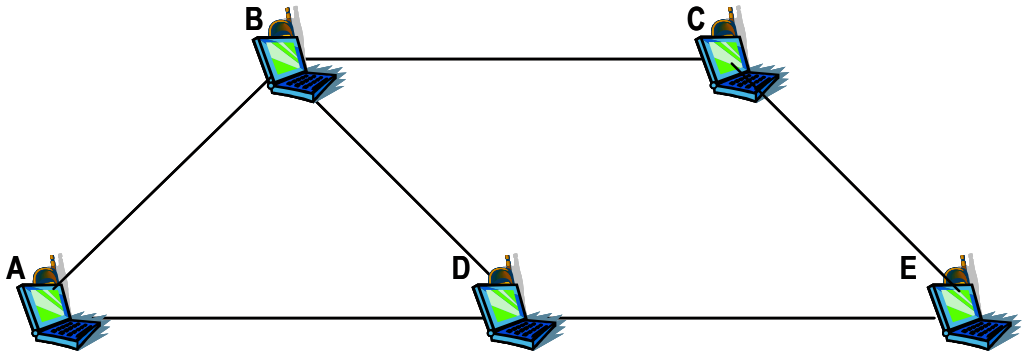
- Fig. depicts a peer-to-peer multihop ad hoc network
- Mobile node A communicates directly with B (single hop) when a channel is available
- If Channel is not available, then multi-hop communication is necessary e.g. A->D->B
- For multi-hop communication to work, the intermediate nodes should route the packet i.e. they should act as a router
- Example: For communication between A-C, B, or D & E, should act as routers

Bringing up an Ad hoc Network



1. Ad hoc network begins with at least two nodes broadcasting their presence (beaconing) with their respective address information
2. They may also include their location info if GPS equipped
3. Beaconing messages are control messages. If node A is able to establish a direct communication with node B verified by appropriate control messages between them, they both update their routing tables

Bringing up an Ad hoc Network

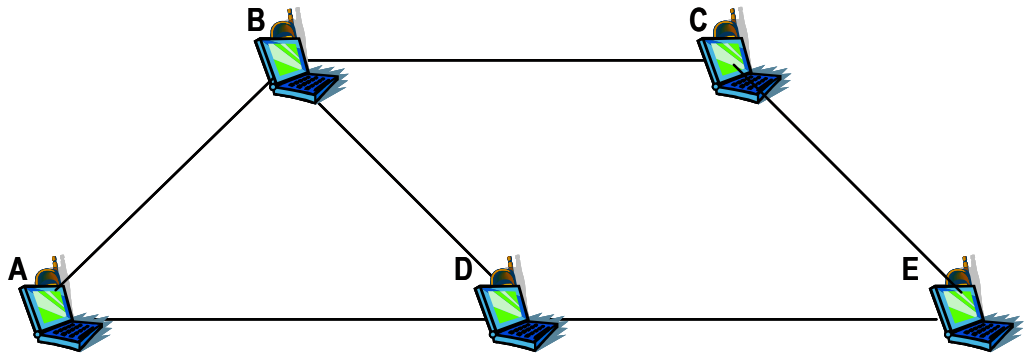


4. Third node C joins the network with its beacon signal. Two scenarios are possible:

   (i) A & B both try to determine if single hop communication is feasible

   (ii) Only one of the nodes e.g. B tries to determine if single hop communication is feasible and establishes a connection

Bringing up an Ad hoc Network



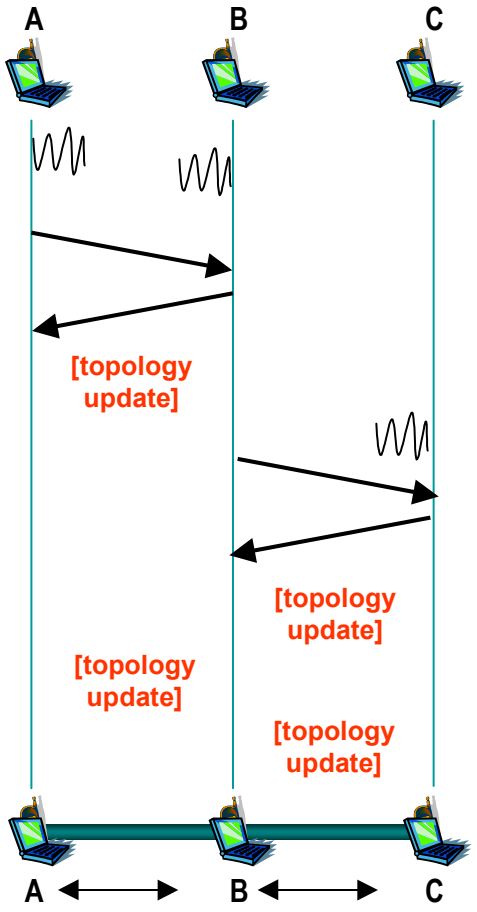
5. The distinct topology updates consisting of both address and the route updates are made in three nodes immediately.

5. In first scenario, all routes are direct i.e. A->B, B->C, and A->C (Lets assume bi-directional links)

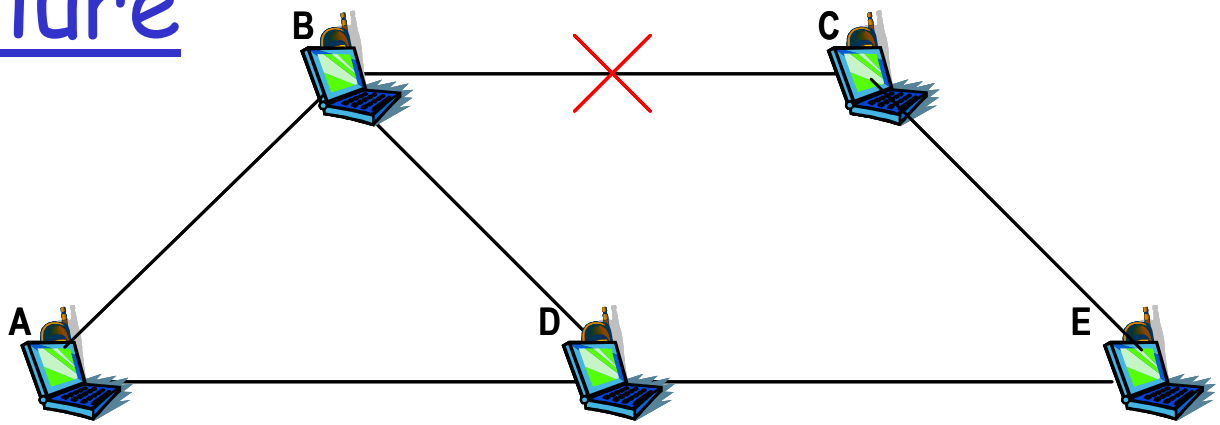
Bringing up an Ad hoc Network

- In the second scenario, the routes are updated

1. First between B & C,
2. then between B & A,
3. Then between B & C again confirming that A and C both can reach each other via B



Topology Update Due to a Link Failure



- Mobility of nodes may cause link breakage requiring route updates
- Assume link between B & C breaks because of some reason
- Nodes A & C are still reachable via D and E
- So old route between A &C was A->B->C is to be replaced by A->D->E->C
- All five nodes are required to incorporate this change in their routing table
  - This change will happen first in nodes B & C
  - Then A & E
  - Then D

Outline

- What is an ad hoc network?
- Challenges facing ad hoc networks
- General Concepts

Challenges in Ad hoc Mobile Networks (1)

- Host is no longer an end system - can also be an acting intermediate system
- Changing the network topology over time
- Potentially frequent network partitions
- Every node can be mobile
- Limited power capacity
- Limited wireless bandwidth
- Presence of varying channel quality

Challenges in Ad hoc Mobile Networks (2)

- No centralized entity – distributed
- How to support routing?
- How to support channel access?
- How to deal with mobility?
- How to conserve power?
- How to use bandwidth efficiently?

Problems Facing Routing in Ad hoc Networks

- Routers are now moving
- Link changes are happening quite often
  - Packet losses due to transmission errors
- Event updates are sent often – a lot of control traffic
- Routing table may not be able to, converge
- Routing loop may exist
- Current wired routing uses shortest path metric

Problems facing channel access in Ad hoc Networks

- Distributed channel access, i.e. no fixed base station concept
- Very hard to avoid packet collisions
- Very hard to support QoS
- Early work on packet radio is based on CSMA

Problems of Mobility in Ad hoc

- Mobility affects signal transmission -> Affects communication
- Mobility affects channel access
- Mobility affects routing
  - Mobility-induced route changes
  - Mobility-induced packet losses
- Mobility affects multicasting
- Mobility affects applications

Mobility in Ad hoc Networks

- Mobility patterns may be different
  - people sitting at an airport lounge
  - New York taxi cabs
  - kids playing
  - military movements
  - personal area network

- Mobility characteristics
  - speed
  - predictability
    - direction of movement
    - pattern of movement
  - uniformity (or lack thereof) of mobility characteristics among different nodes

Problems of Power in Ad hoc

- Ad hoc devices come in many different forms
- Most of them battery powered
- Battery technology is not progressing as fast as memory or CPU technologies
- Wireless transmission, reception, retransmission, beaconing, consume power!
- Quest for power-efficient protocols
- Quest for better power management techniques