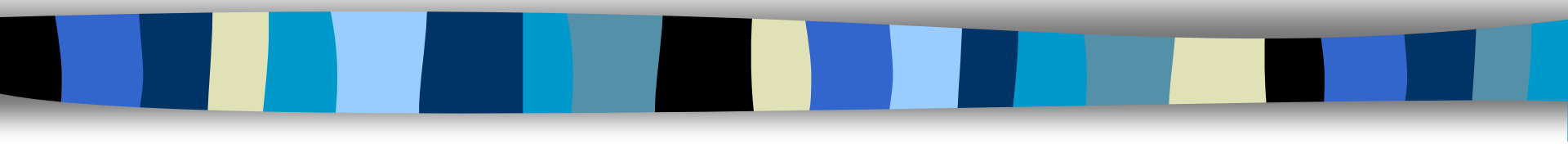
# Introduction to Mobile Ad-Hoc Networks

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# Contents

- Ad hoc networks – Differences to other networks
- MANET characteristics
- MANET applications
- Technical challenges
- Quiz on MANET applications design


# How are mobile ad hoc networks different?

Ad hoc ≈ “for a particular purpose”, improvised

- No infrastructure – *flat network*
- Radio communication – *shared medium*
- Every computer or device (*node*) is a router as well as end host
- Nodes are in general autonomous
- Mobility – *dynamic topology*
- Limited energy and computing resources

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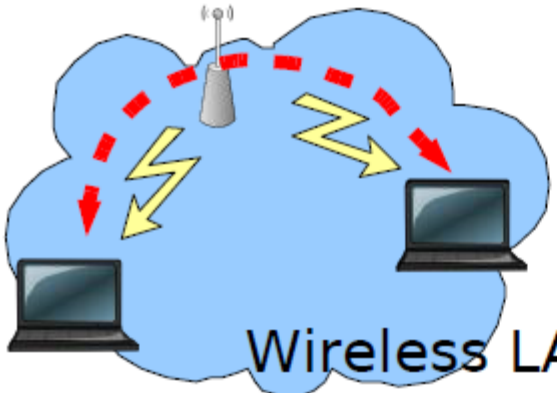
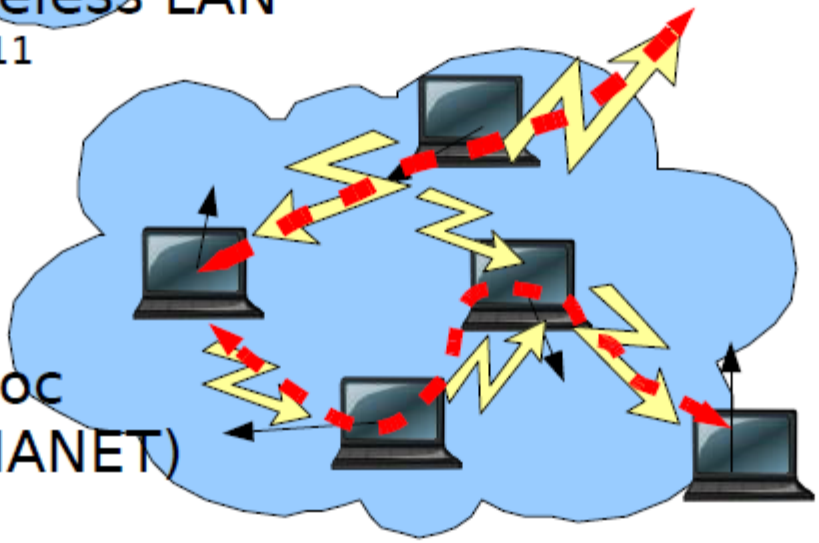
# Differences to other Wireless Networks



Wireless LAN
802.11

Ad hoc network
Bluetooth/802.11
Ad hoc mode



Mobile ad hoc network (MANET)
802.11 Multi-hop

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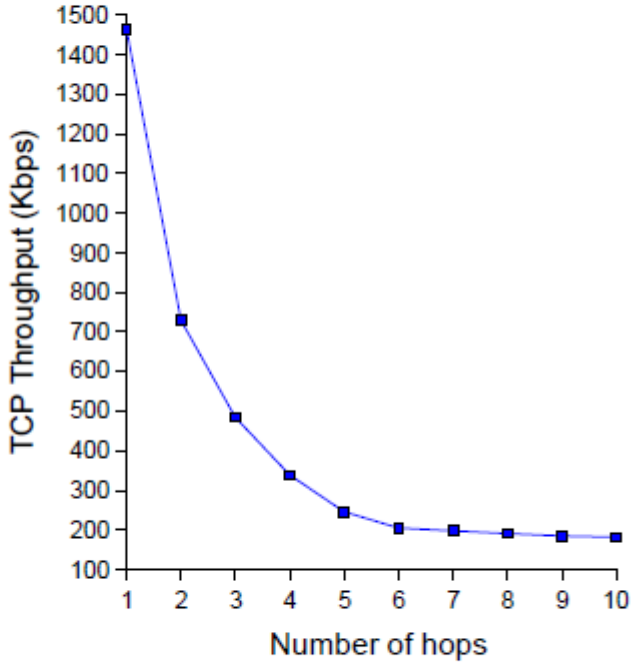
# Differences to Wired Networks – Radio (802.11x MAC)

- Varying signal-to-noise ratio
- Different rates = different transmission ranges
- CSMA
- Channel contention
- Obstructions
- Interference, e.g., “hidden terminals”


# Differences to Wired Networks - The Effect of a Shared Channel

Bandwidth decreases asymptotically with hop count

- Nodes interfere with next hops
- Over longer paths interference is constant



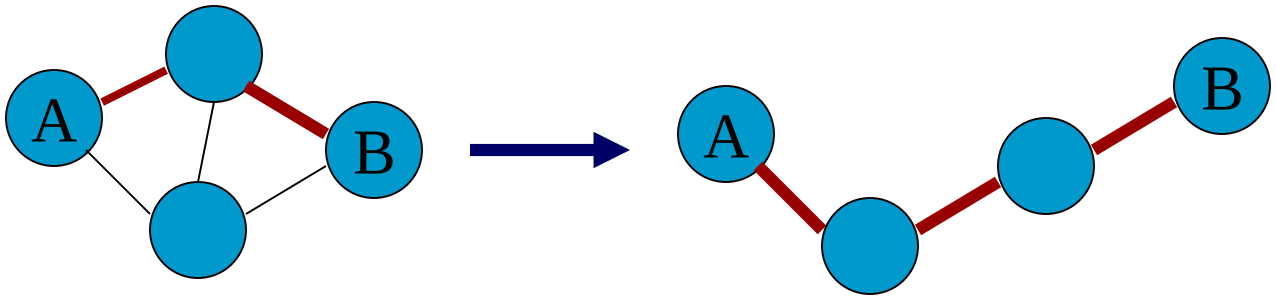

Source:Holland et al. 2002

# MANET characteristics: Why Ad Hoc Networks ?

- Setting up of fixed access points and backbone infrastructure is not always viable
  - Infrastructure may not be present in a disaster area or war zone
  - Infrastructure may not be practical for short-range radios; Bluetooth (range ~ 10m)
- Ad hoc networks:
  - Do not need backbone infrastructure support
  - Are easy to deploy
  - Useful when infrastructure is absent, destroyed or impractical

# MANET Characteristics

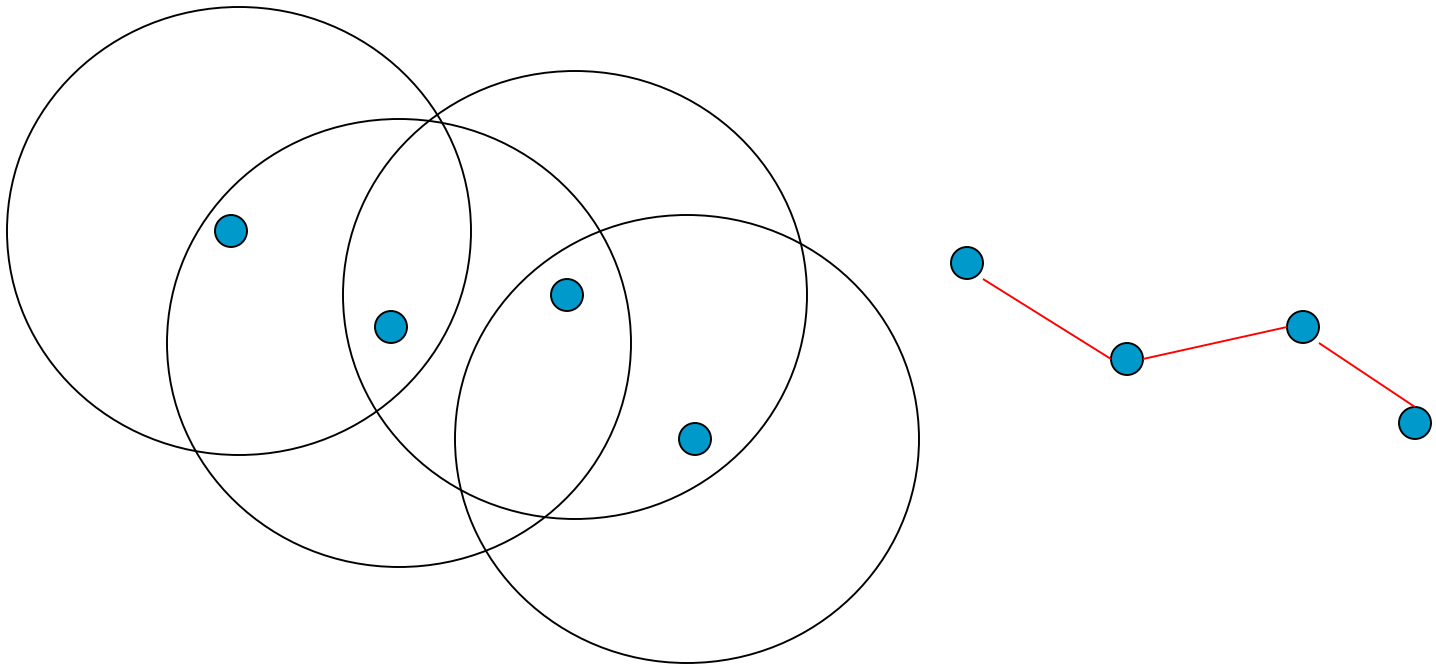
- Host movement frequent
- Topology change frequent




- No infrastructure. Multi-hop wireless links.
- Data must be routed via intermediate nodes.

# Multi-Hop Wireless

- May need to traverse multiple links to reach destination



# Mobile Ad-hoc Network

- Self-configuring network of mobile routers (and associated hosts) connected by wireless links
- This union forms a random topology
- Routers move randomly free
- Topology changes rapidly and unpredictably
- Standalone fashion or connected to the larger Internet
- Suitable for emergency situations like natural or human-induced disasters, military conflicts, emergency medical situations, etc.

# Mobile Ad-hoc Network

- While MANETs are self contained, they can also be tied to an IP-based global or local network – Hybrid MANETs

# Network Architectures

- No Infrastructure (ad hoc networks):
  - no base stations; no fixed network infrastructure

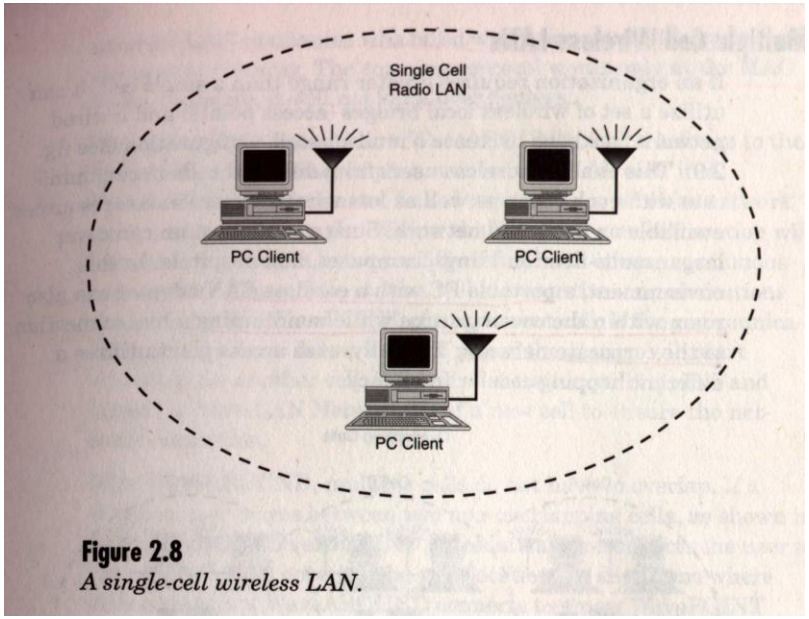
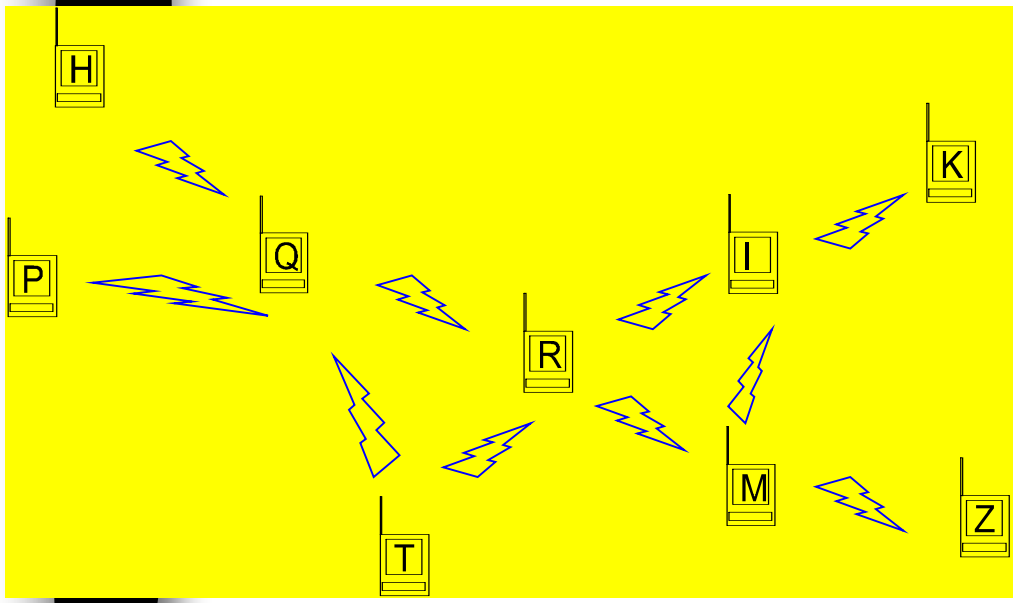


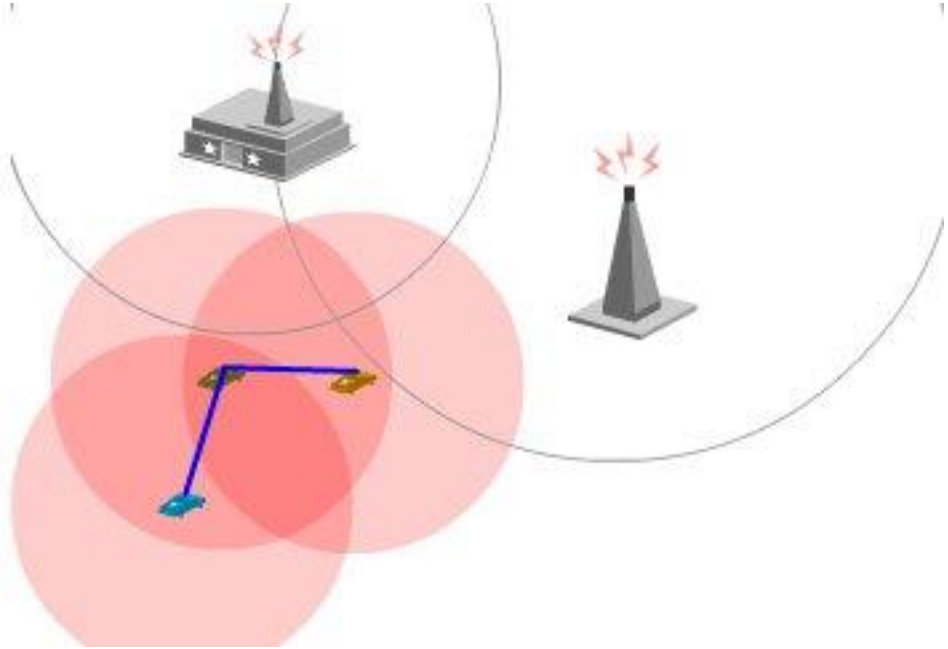

**Figure 2.8**
*A single-cell wireless LAN.*

# MANET

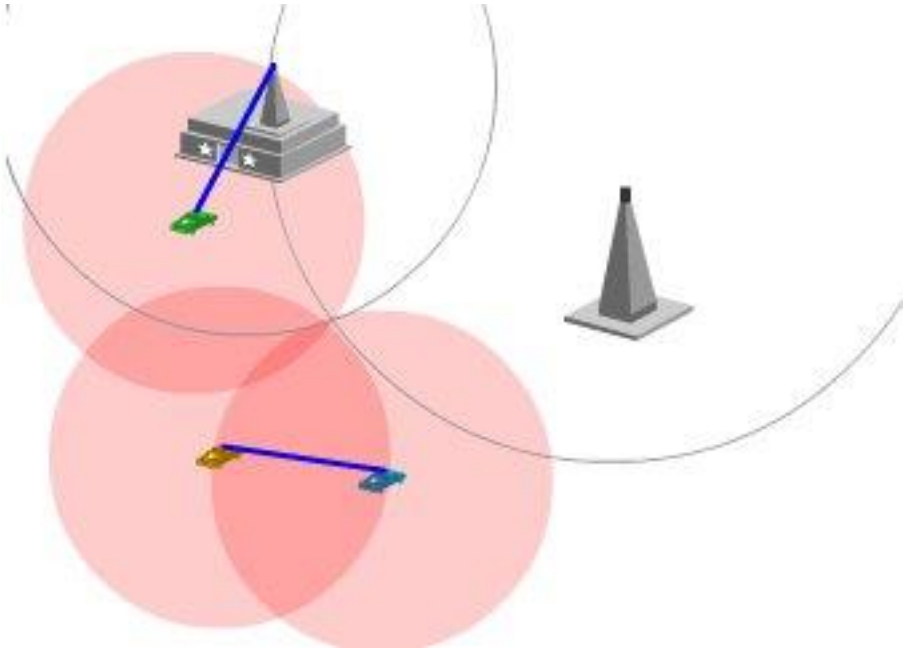
- MANET = Mobile Ad Hoc Networks
  - multi-hop communication
  - needs support of dynamic routing protocols



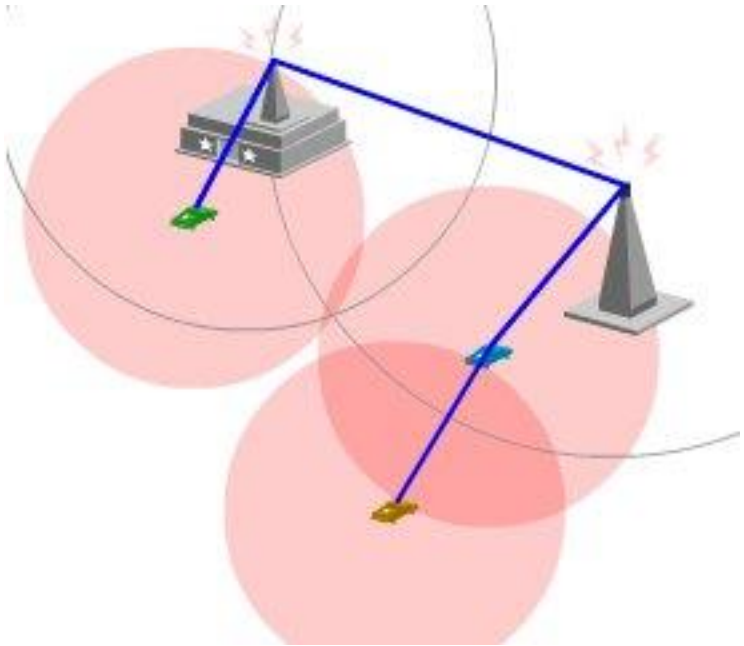

# Hybrid Mobile Ad-hoc Network



# Hybrid Mobile Ad-hoc Network



# Hybrid Mobile Ad-hoc Network



# IEFT MANET Working Group

- goal:
  - to standardize an interdomain unicast routing protocol which provides one or more modes of operation, each mode specialized for efficient operation in a given mobile networking "context", where a context is a predefined set of network characteristics.
- a dozen candidate routing protocols have been proposed
- http://datatracker.ietf.org/wg/manet/charter/

# MANET Applications

- ad hoc conferencing
- home networking
- emergency services
- personal area network (PAN)
- ubiquitous computing
  - "computers are all around us, constantly performing mundane tasks to make our lives a litter easier"
  - "Ubiquitous intelligent internetworking devices that detect their environment, interact with each other, and respond to changing environmental condition will create a future that is as challenging to imagine as a science fiction scenario."

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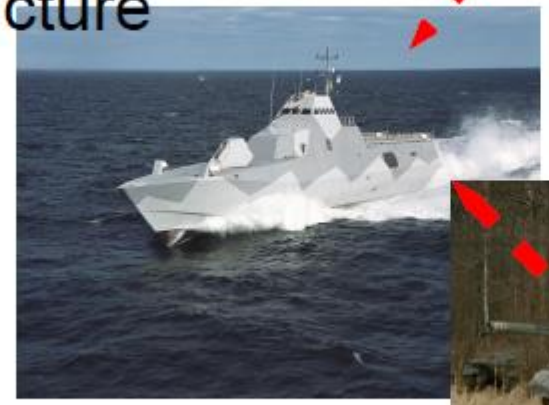
# MANET Applications - Military

- Unknown terrain
- Limit the range of communication
  - Directional antennas
- Destroyed infrastructure

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# MANET Applications – Disaster Relief

- Disaster relief
  - Earthquakes, tsunamis, hurricanes
  - Wiped out infrastructure
  - Search & rescue

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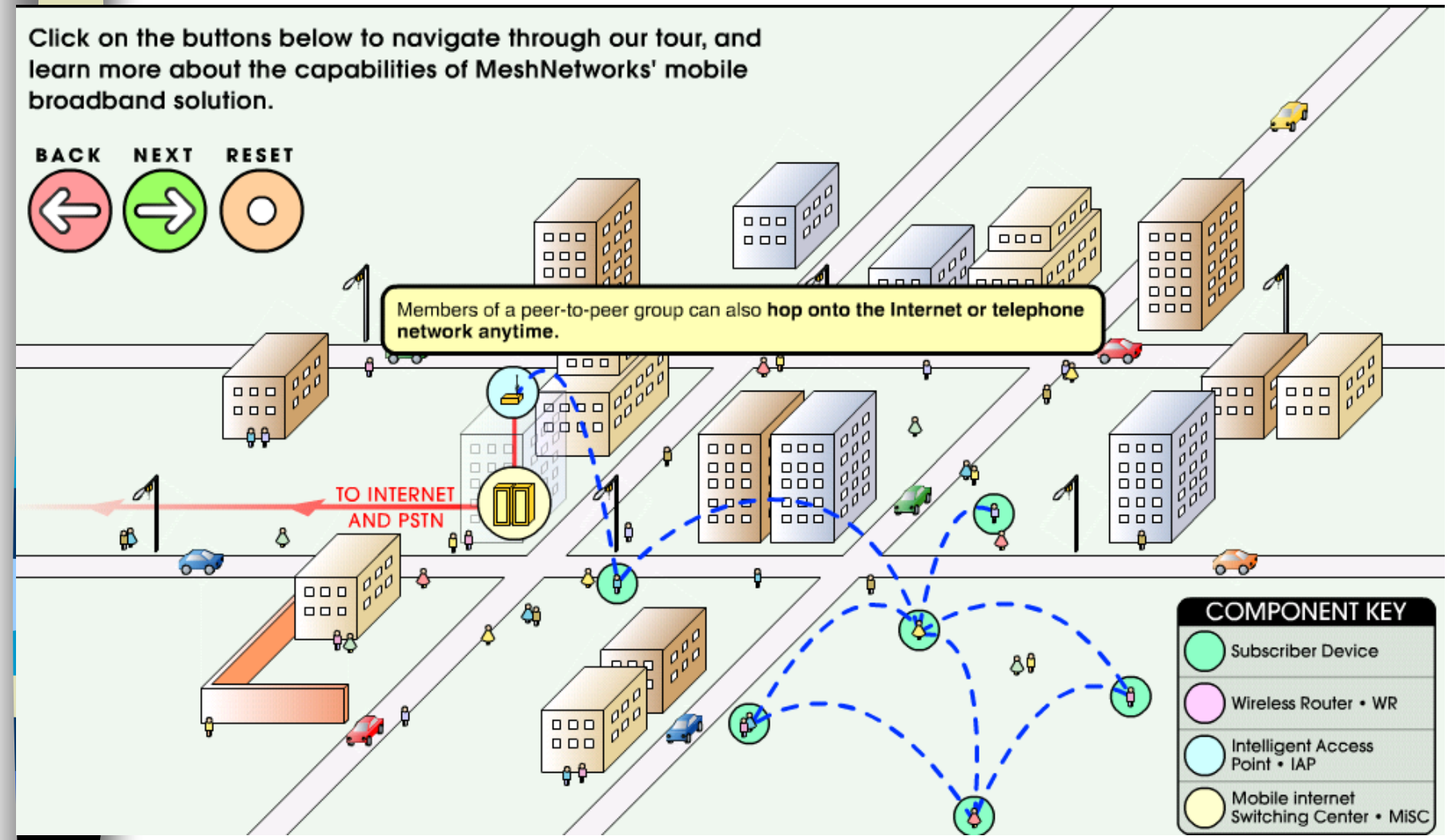
# MANET Applications – Economic & Commercial

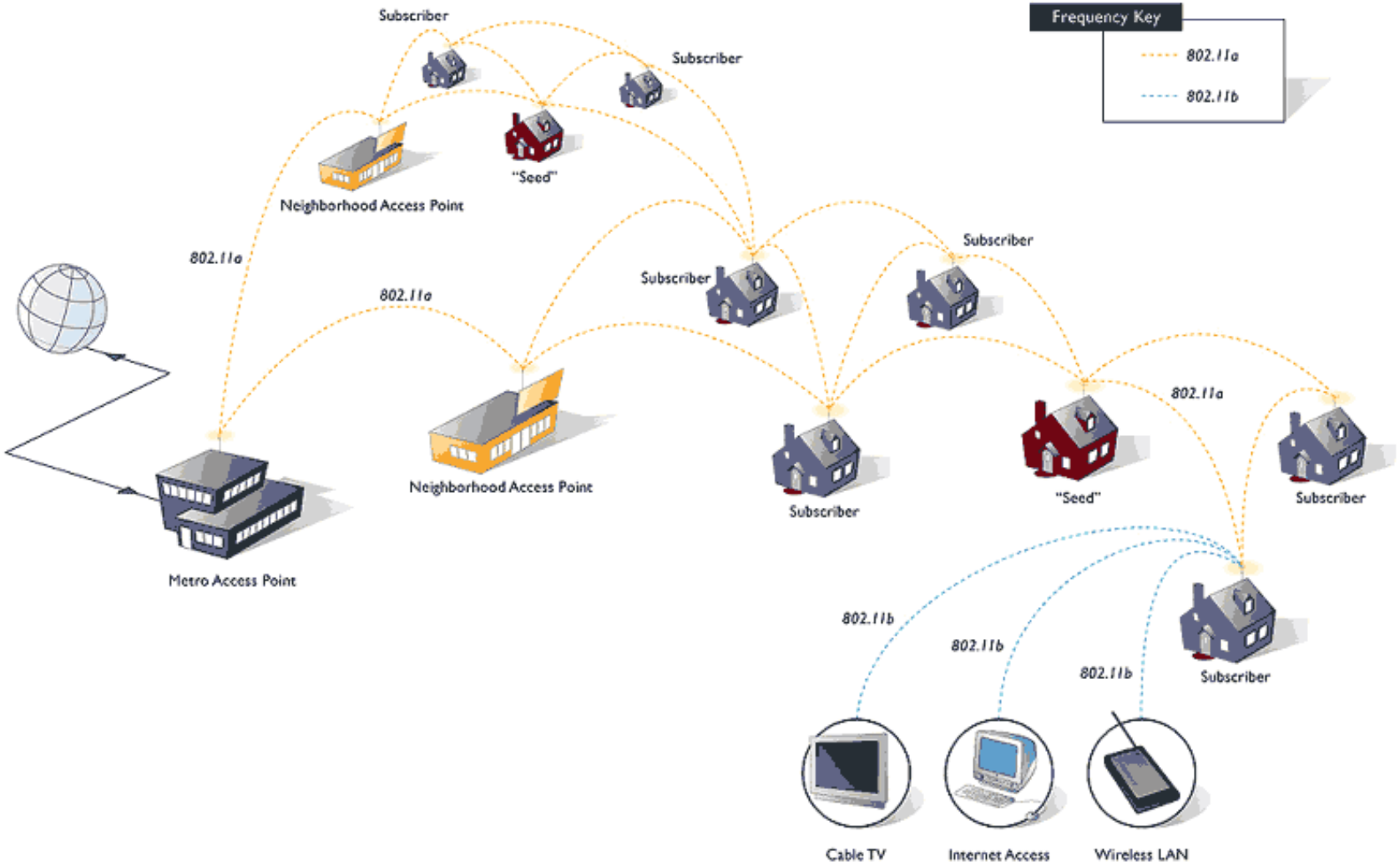
- Community Mesh networks
- Access extensions
- Personal Area Networks (PANs)
- Ad hoc Gaming (on subway, cafés, etc)


# Networking Scenario : To Internet



# SkyPilot NeighborNet

- SkyPilot Network, USA



- Sensor Dust:
  - a large collection of tiny sensor devices
    - once situated, the sensors remain stationary
    - largely homogeneous
    - power is likely to be a scarce resource, which determines the lifetime of the network
  - can offer detailed information about terrain or environmental dangerous conditions.
- Intelligent Transportation System:
  - may be integrated with cars, positioning devices, etc.

# And some video clips

- Car2car communication
- Robotic MANETs

# Technical Factors, Challenges

- scalability
- power budget vs. latency
- protocol deployment and incompatibility standards
- wireless data rate
  - e.g., TCP over multi-hop wireless links
- security issues

# Many Physical Variations

- **Symmetric Deployments**
  - all nodes have identical capabilities and responsibilities
- **Asymmetric Deployments**
  - **Capabilities**
    - transmission ranges and radios may differ
    - battery life at different nodes may differ
    - processing capacity may be different at different nodes
    - speed of movement
  - **Responsibilities**
    - only some nodes may route packets
    - some nodes may act as leaders of nearby nodes (e.g., cluster head)

# Many Application Variations

- Traffic characteristics may differ in different ad hoc networks
  - bit rate
  - timeliness constraints
  - reliability requirements
  - unicast / multicast / geocast
  - host-based addressing / content-based addressing / capability-based addressing
- May co-exist (and co-operate) with an infrastructure-based network

# Many Mobility Variations

- 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

# Challenges

- Limited wireless transmission range
- Broadcast nature of the wireless medium
  - Hidden terminal problem (see next slide)
- Packet losses due to transmission errors
- Mobility-induced route changes
- Mobility-induced packet losses
- Battery constraints
- Potentially frequent network partitions
- Ease of snooping on wireless transmissions (security hazard)

# Quiz 1: In-class Presentation

- Within 30 minutes, design your own MANET applications
  - Application scenarios
  - Technical challenges
  - Benefits/Costs
  - Prepare slides and present your MANET applications within 15 minutes
    - Any one?