CSE 6811: WIRELESS AD HOC NETWORKS

Prof. Ashikur Rahman

Regarding Course Material

- Mostly research oriented topics in the area will be covered
  - Grad level course
    - No lab associated with the course
    - No scope for hand-on practice

- Not about radio design or communication theory

- Most schemes include many more details, and optimizations
  - Not possible to cover all details in this course

- Be aware that some protocol specs have changed several times, and the slides may not reflect the most current specifications

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Performance evaluation

- Attendance: 10%
- Midterm: 30%
- Project: 25%
  - Presentation: 10%
  - Findings and reports: 15%
- Final Exam: 35%

Course website

- https://ashikur.buet.ac.bd/CSE6811

- Periodically Check for notices
  - Important announcements will be posted here.
    i.e., No class today ;-)

Course Outline (may not be covered in the same order)

- Introduction (Covered today)
- Broadcasting protocols
- Medium Access Control
- Uni-cast routing protocols
- Topology Control
- Selected security issues
- Congestion Control
- Open problems

Mobile Ad Hoc Networks (MANET)

Introduction and Generalities

Early computers

Quotation by "somebody" on the earth

"There is no point in having information unless it can be communicated from one point to another point or from one time to another time."
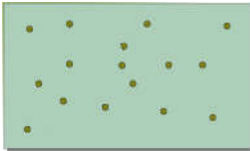
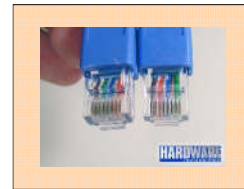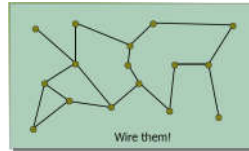(telecommunications)   (storage)

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How to turn a bunch of computing devices/nodes in a network?

9

How to turn a bunch of computing devices/nodes in a network?
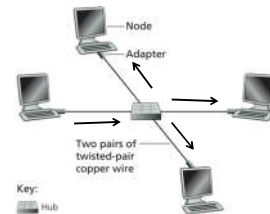
10

Wire them!

HARDWARE

Full Mesh

Doesn't scale well. Too many connections!!
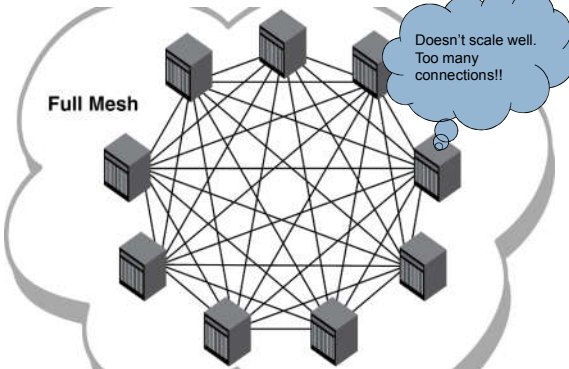
11

More organized connection: Hub

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Node
Adapter

Two pairs of twisted-pair copper wire

Key:
Hub
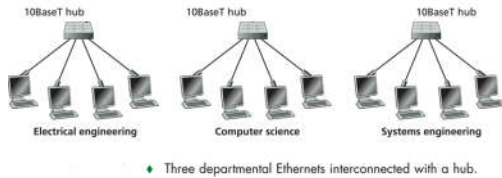
Star topology for Ethernet. Nodes are interconnected with a hub.

Connecting devices : Hub

10BaseT hub   10BaseT hub   10BaseT hub

Electrical engineering   Computer science   Systems engineering

♦ Three departmental Ethernets interconnected with a hub.

Connecting devices : Hub

Large Collision Domain!!

Backbone hub

10BaseT hub   10BaseT hub   10BaseT hub

Electrical engineering   Computer science   Systems engineering

Three departmental Ethernets interconnected with a hub.
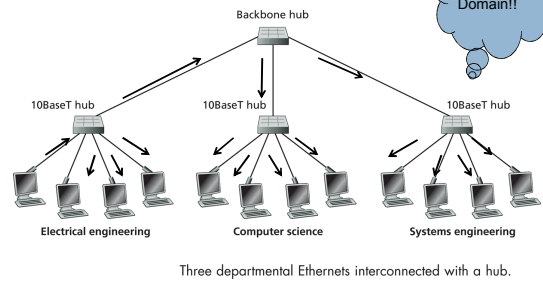
Connecting devices: Switch

Switch

10BaseT hub   10BaseT hub   10BaseT hub

Electrical engineering   Computer science   Systems engineering

Key: Link-layer switch

Three departmental LANs interconnected with a switch.
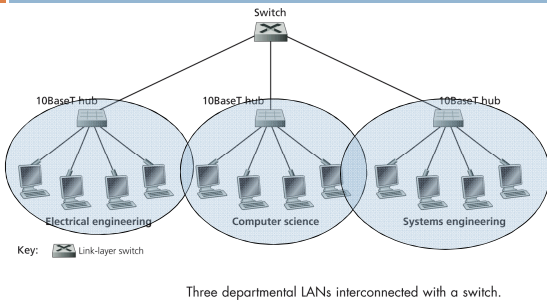
Connecting devices: Router

Web server

To external internet

100 Mbps

100 Mbps

Mail server

100 Mbps

10BaseT hub   10BaseT hub   10BaseT hub

Electrical Engineering   Computer Science   Systems Engineering

An institutional network using a combination of hubs, Ethernet switches, and a router

...and they liv

Happily EVER

Really??

My Primitive Boutique
©2011 All Rights Reserved

Let's get rid of wires

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It started with Wireless Cellular Networks (Roughly in 1947)

20

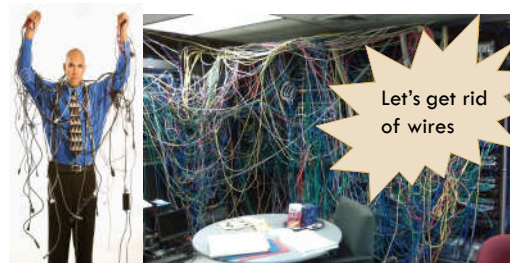

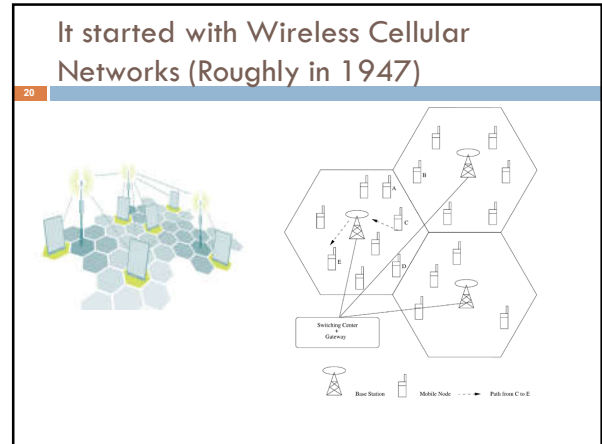Base Station   Mobile Node   - - - - Path from C to E

21

And then Realized indoor device-to-device communication is more important than outdoor communication……

WHY?

- An average person spends more time indoors than outdoors

Realized indoor intra-device comm. is more important than outdoor comm……

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- An average person spends more time indoors than outdoors
- According to EPA: Average American spends…..

Indoor: 93% of their life

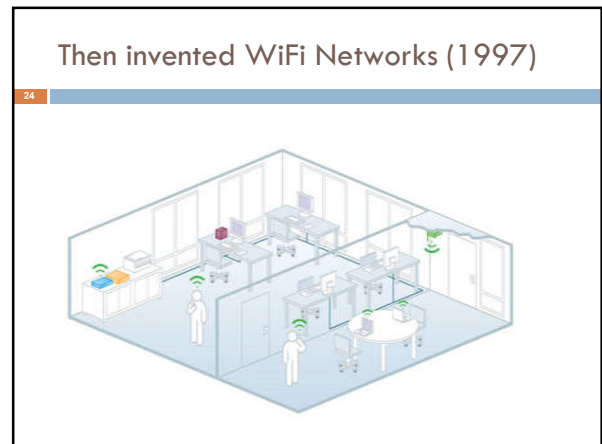87% of their life: Truly Indoor

6% of their life: In automobiles

Why Indoor communication…..

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ONLY HALF OF A DAY PER WEEK IN OUTDOORS

That boils down to……….

Only 7% of their entire life truly outdoors

Then invented WiFi Networks (1997)

24

4

But…..

Both Cellular networks and Wi-Fi networks share a common problem
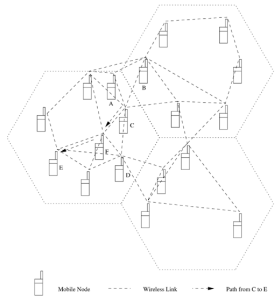
They Depend on INFRASTRUCTURE

What if we remove infrastructure?

Can we communicate without any infrastructure?
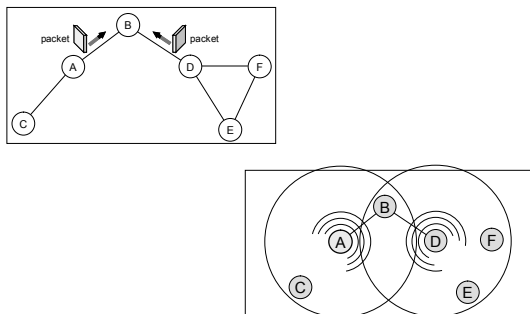
An Ad hoc wireless networks

Benefit

- □ "Art of networking without any network!"
- □ Ease of deployment
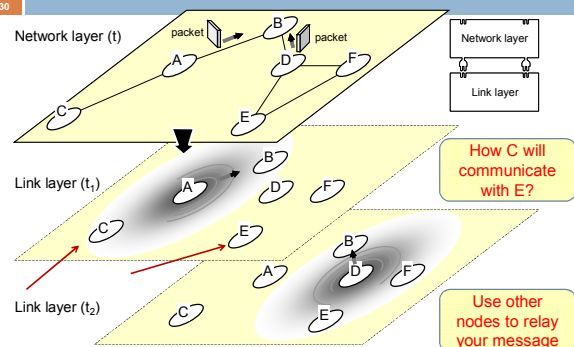- □ Speed of deployment
- □ Decreased dependence on infrastructure

Communicate to whoever is within your transmission range

Behind the scene

Use of relay: an old concept of communication!

Use of relay: an old concept of communication!

- Persian Emperor Darius I (500 BC)
- Extended his empire to a long geographic region.

Darius the Great !

Use of relay: an old concept of communication!

- Persian Royal Road ran some 2,857 km
- Used to take about 3 months (on foot of an army man!) to send a courier from one end to the other end

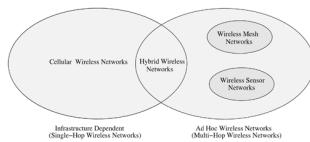## Horses creating ad hoc communication!

- Fresh horses and riders ready at each relay on the road
- Courier could be sent only in nine days.
- This system was used until development of effective optical telegraph systems in late 18th century.

Source: http://www.historyofinformation.com/detail.php?id=131

Wireless Networks (SUMMARY)

Infrastructure based wireless networks

Infrastructure based wireless networks

| Name	Effective Range	Pros	Cons
GSM	35km	Long range	Very low accuracy
Wi-Fi	50m-100m	Readily available; Medium range	Low accuracy
Bluetooth	10m	Readily Available; Medium accuracy	Short range
RFID & IR	1m	Moderate to high accuracy	Short range, Line-Of-Sight (LOS)
NFC	<4cm	High accuracy	Very short range

Mobile Ad Hoc Networks

- Formed by wireless hosts which may be mobile
- Without using a pre-existing infrastructure
- Each node acts as packet sender/recipient and router/forwarder
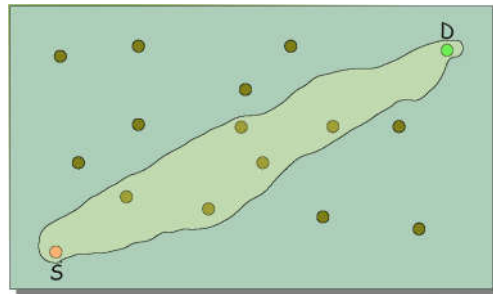- Routes between nodes may potentially contain multiple hops

Broadcast nature of wireless medium in single hop
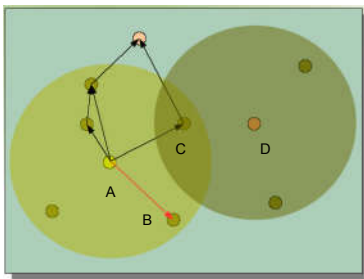
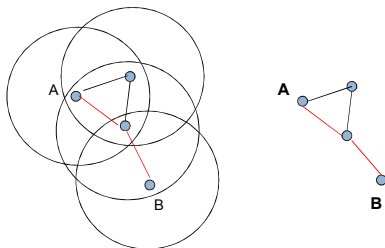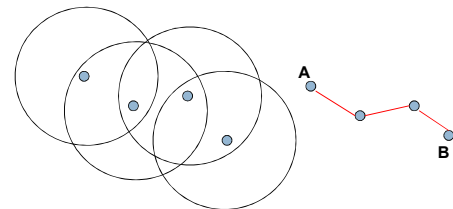## Still transmission can be guided through a narrow region!

Mobile Ad Hoc Networks

- Implicitly defined topology

Mobile Ad Hoc Networks (MANET)

- Mobility causes topology and route changes

Challenges

- Limited wireless transmission range (needs multi hop)
- Broadcast nature of the wireless medium
  - Redundancy + Hidden terminal problem
- Packet losses due to transmission errors (Air interface)
  - BER of the order of 10^{-5} to 10^{-3} as opposed to 10^{-12} to 10^{-9}
- Mobility-induced route changes (frequent route changes)
- Mobility-induced packet losses (false congestion)
- Battery constraints (hot spots)
- Potentially frequent network partitions
  - Transport layer should be more resilient
- Ease of snooping on wireless trans. (security hazard)

Many Applications

- Personal area networking
  - cell phone, laptop, ear phone, wrist watch
- Military environments
  - soldiers, tanks, planes
- Civilian environments
  - Temporary communication infrastructure
  - Quick communication with minimal configuration among a group of people
  - Research groups, meeting rooms, sports stadiums
  - Examples
    - A group of researchers who want to share their research findings during a conference
    - A lecturer distributing notes to a class on the fly

Many Applications

- Emergency operations
  - Rescue, crowd control, and commando operations
  - Major favors
    - Self-configuration with minimal overhead
    - Independency of fixed or central infrastructure
    - Freedom and flexibility of mobility
    - Unavailability of conventional communication infrastructure

Many Applications

- Wireless Sensor Networks
  - Special category of ad hoc wireless networks, special issues:
    - Mobility of nodes —commonly it is believed that sensor networks being stationary or low mobile
    - Size of the network —usually much larger that in a classical ad hoc wireless network
    - Density of deployment —varies with the application domain, can be very high
    - Power constraints —much more stringent than that in ad hoc wireless networks, in certain cases the recharging of the energy source is impossible
      - Replenishable power source —in certain applications, the power source can be replaced, e.g. for wearable sensors
      - Non-replenishable power source —in some specific applications, the power source cannot be replenished, e.g. deployment of sensors in remote, hazardous terrain
      - Regenerative power source -capability of regenerating power from the physical parameter under measurement
    - Data / information fusion —limited bandwidth and power constraints demand aggregation

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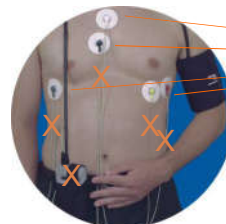The role of wireless sensor networks in health monitoring

ECG/BCG for Heart monitoring.

The role of wireless in medical monitoring

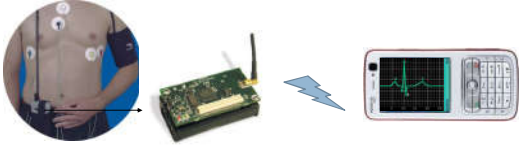The predominant trend in the industry is to reduce this role to that of providing trivial (typically one-way) links:

… i.e., eliminating the wires connecting sensors (electrodes) to a (dedicated) monitoring device.
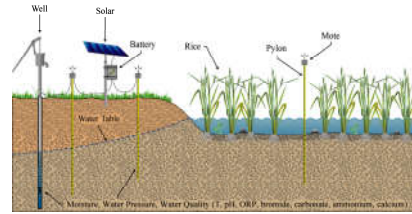
Overall System

Environment Monitoring

50

☐ Level of Arsenic detection Project: UCLA+BUET

Some snapshots
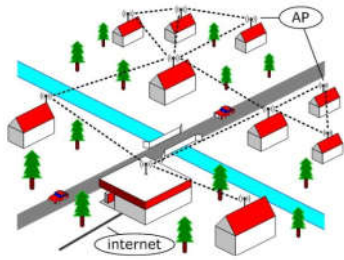
51

Some of snapshots

52

Some of snapshots
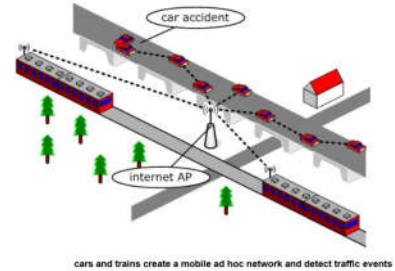
53

Some of snapshots

54

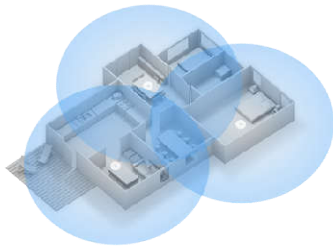## Wireless mesh networks

VANET (Vehicular Ad hoc Networks)

cars and trains create a mobile ad hoc network and detect traffic events

Wireless mesh networks (Google's solution for home networking)

Question or Comment

Brief introduction to each of the problems

- □ Introduction
- □ Unicast routing protocols
- □ Medium Access Control
- □ Broadcasting protocols
- □ Topology Control
- □ Selected fairness and security issues
- □ Stimulating cooperation
- □ Open problems