Week 2 Lecture 2

Mobile Health (M-Health)

What is Mobile Health (M-Health)?

▸ One way to achieve tele-healthcare

▸ [WiKi definition] **mHealth** (also written as **m-health** or **mobile health**) is a term used for the practice of medicine and public health, supported by mobile devices. The term is most commonly used in reference to using mobile communication devices, such as mobile phones, tablet computers and PDAs, for health services and information.

▸ It is based on Wireless & Mobile technologies (such as Wireless LAN, WiMax, Cellular networks, Satellite, Sensor Networks, Ad hoc Networks, etc.)

▸

Thinking: How to monitor a patient whenever he/she goes to?

▸ When the patient is at home
▸ -- can use telephone (dial-up) – too slow
▸ -- Comcast – Cable Modem - Fast
▸ -- ADSL (Asymmetric Digital Subscriber Line) from AT & T
▸ -- Bluetooth + Internet (the above 3 also need Internet)
▸ When the patient is in a building
▸ -- Wireless LAN (also called WiFi)
▸ -- Wired LAN (high speed!)
▸ When the patient is driving /walking
▸ -- Cell phone
▸ -- WiMax
▸ -- Mobile Ah hoc Network, Vehicle Ad hoc Network, etc.

▸

What wireless & mobile networks can be used?

▸ Wireless is convenient – anywhere, anytime

▸ No cable needed

▸ However, in the backbone networks, to achieve high-speed, long-distance transmission, in many times we may still use Internet with wires (most likely optical fiber)

▸ Wireless Networks are much slower (most times) than wired ones (especially optical fiber); But WiMax can achieve >100Mbps in good conditions.

▸ Wireless also brings much higher data transmission errors or data loss due to noise / interference

▸ In the remaining contents we will discuss popular wireless

▸

Wireless networks

▸ Access computing/communication services, on the move

▸ Wireless WANs
  ▸ Cellular Networks: GSM, GPRS, CDMA
  ▸ Satellite Networks: Iridium

▸ Wireless LANs
  ▸ WiFi Networks: 802.11
  ▸ Personal Area Networks: Bluetooth

▸ Wireless MANs
  ▸ WiMaX Networks: 802.16
  ▸ Mesh Networks: Multi-hop WiFi
 ▸ Adhoc Networks: useful when infrastructure not available

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Mobile communication

▸ Wireless vs. mobile   Examples

   ✖   ✖   stationary computer
   ✖   ✔   laptop in a hotel (portable)
   ✔   ✖   wireless LAN in historic buildings
   ✔   ✔   Personal Digital Assistant (PDA)

▸ Integration of wireless into existing fixed networks:
  ▸ Local area networks: IEEE 802.11, ETSI (HIPERLAN)
  ▸ Wide area networks: Cellular 3G, IEEE 802.16
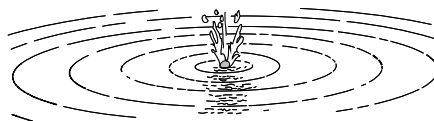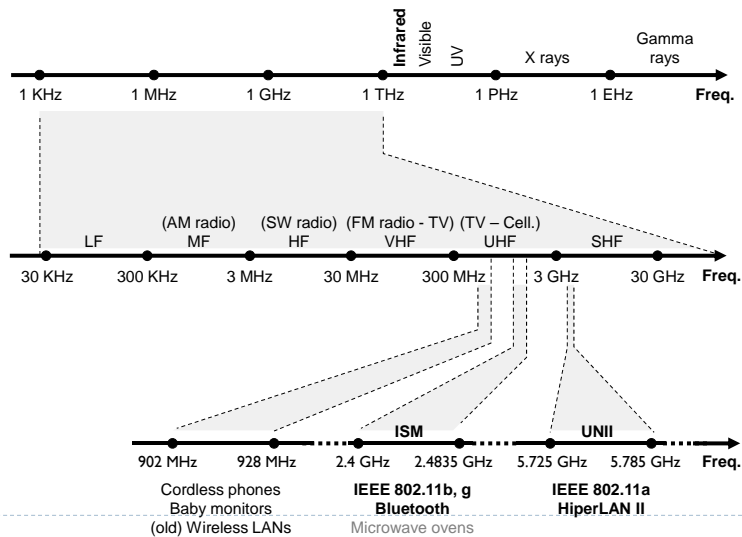 ▸ Internet: Mobile IP extension

▸

Summary
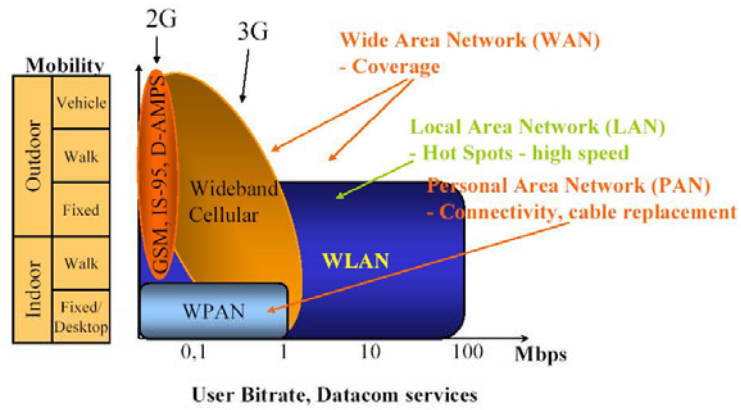
Relative coverage, mobility, and data rates of generations of cellular systems and local broadband and ad hoc networks.

Waves

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EM Spectrum Allocation

Infrared
Visible
UV
X rays
Gamma rays

1 KHz   1 MHz   1 GHz   1 THz   1 PHz   1 EHz   **Freq.**

LF   (AM radio) MF   (SW radio) HF   (FM radio - TV) VHF   (TV – Cell.) UHF   SHF

30 KHz   300 KHz   3 MHz   30 MHz   300 MHz   3 GHz   30 GHz   **Freq.**

ISM   **UNII**

902 MHz   928 MHz   2.4 GHz   2.4835 GHz   5.725 GHz   5.785 GHz   **Freq.**

Cordless phones   **IEEE 802.11b, g**   **IEEE 802.11a**
Baby monitors   **Bluetooth**   **HiperLAN II**
(old) Wireless LANs   Microwave ovens

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Wireless frequency allocation

▸ Radio frequencies range from 9KHz to 400GHZ (ITU)

▸ Microwave frequency range
  ▸ 1 GHz to 40 GHz
  ▸ Directional beams possible
  ▸ Suitable for point-to-point transmission
  ▸ Used for satellite communications
▸ Radio frequency range
  ▸ 30 MHz to 1 GHz
  ▸ Suitable for omnidirectional applications
▸ Infrared frequency range
  ▸ Roughly, 3×10^{11} to 2×10^{14} Hz
  ▸ Useful in local point-to-point multipoint applications within confined areas
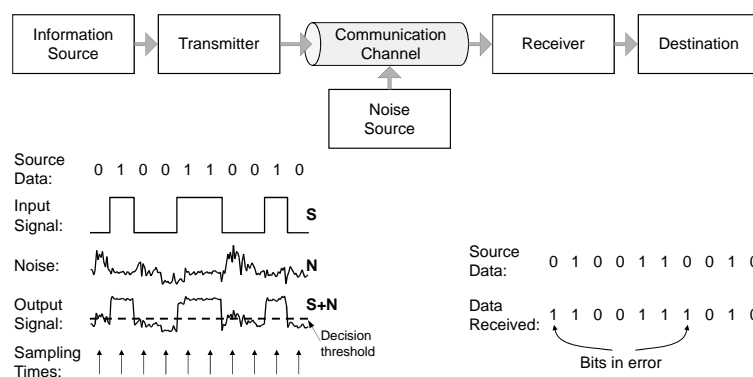
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Frequency regulations

- Frequencies from 9KHz to 300 MHZ in high demand (especially VHF: 30-300MHZ)
- Two unlicensed bands
  - Industrial, Science, and Medicine (ISM): 2.4 GHz
  - Unlicensed National Information Infrastructure (UNII): 5.2 GHz
- Different agencies license and regulate
  - www.fcc.gov - US
  - www.etsi.org - Europe
  - www.wpc.dot.gov.in - India
  - www.itu.org - International co-ordination
- Regional, national, and international issues
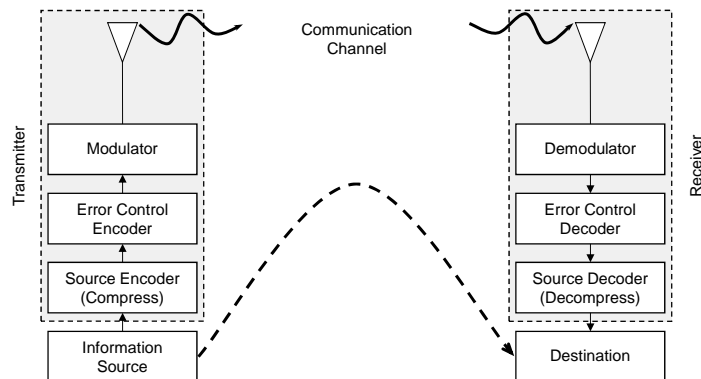- Procedures for military, emergency, air traffic control, etc

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Communication Process

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Wireless Transmission and Receiving System

Transmitter

Communication Channel

Receiver

Modulator

Error Control Encoder

Source Encoder (Compress)

Information Source

Demodulator

Error Control Decoder

Source Decoder (Decompress)

Destination

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Antennas

▸ An antenna is an electrical conductor or system of conductors to send/receive RF signals
  ▸ Transmission - radiates electromagnetic energy into space
  ▸ Reception - collects electromagnetic energy from space
▸ In two-way communication, the same antenna can be used for transmission and reception

Omnidirectional Antenna (lower frequency)

Directional Antenna (higher frequency)
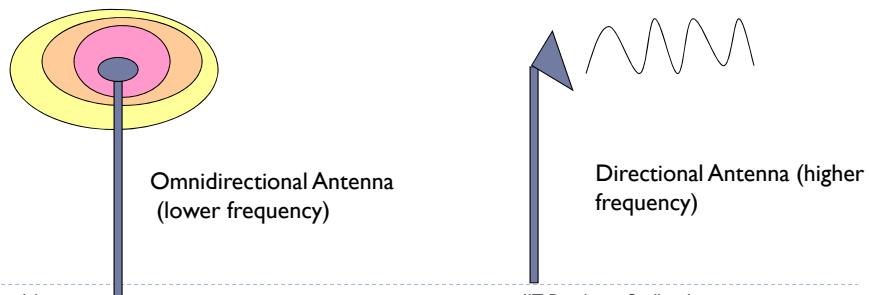
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Signal propagation

- Propagation in free space always like light (straight line)
- Receiving power proportional to $1/d^2$
  (d = distance between sender and receiver)
- Receiving power additionally influenced by
  - fading (frequency dependent)
  - shadowing
  - reflection at large obstacles
  - refraction depending on the density of a medium
  - scattering at small obstacles
  - diffraction at edges
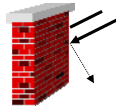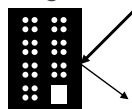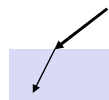
| shadowing | reflection | refraction | scattering | diffraction |

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Bandwidth

- Amount of data that can be transmitted per unit time
  - expressed in cycles per second, or Hertz (Hz) for analog devices
  - expressed in bits per second (bps) for digital devices
  - KB = 2^10 bytes; Mbps = 10^6 bps

- Link v/s End-to-End

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Latency (delay)

- Time it takes to send message from point A to point B
  - Latency = Propagation + Transmit
                              + Queue
  - Propagation = Distance /
                  SpeedOfLight
  - Transmit = Size / Bandwidth

- Queueing not relevant for direct links
- Bandwidth not relevant if Size = 1 bit
- Software overhead can dominate when Distance is small

- RTT: round-trip time

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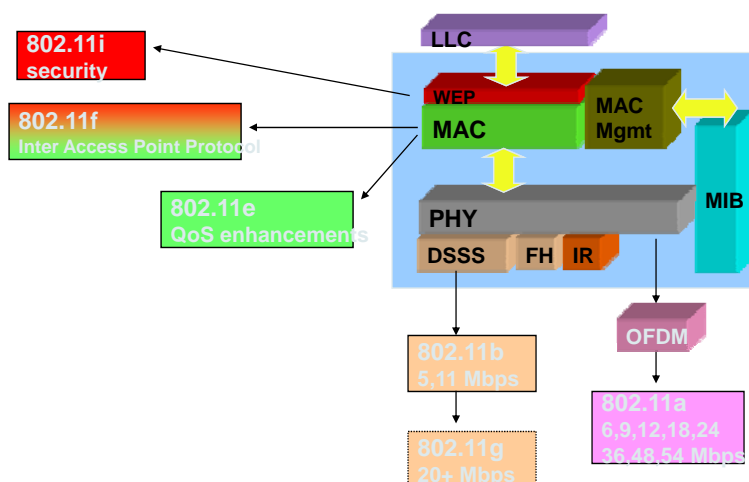
802.11 (WiFi) Overview
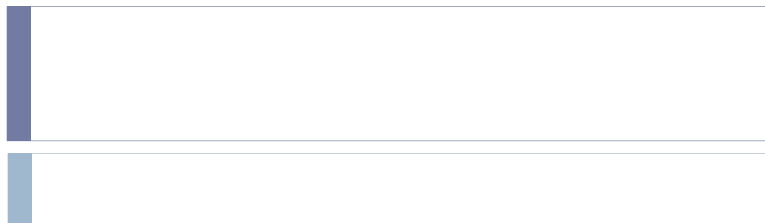
Wireless LANs

- Infrared (IrDA) or radio links (Wavelan)
- Advantages
  - very flexible within the reception area
  - Ad-hoc networks possible
  - (almost) no wiring difficulties
- Disadvantages
  - low bandwidth compared to wired networks
  - many proprietary solutions

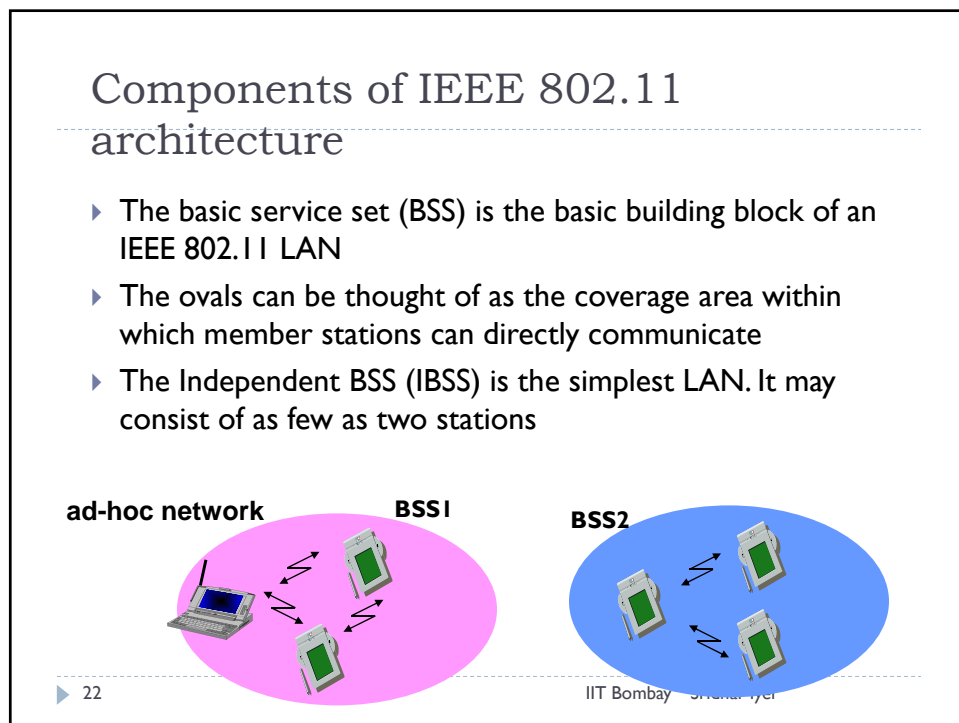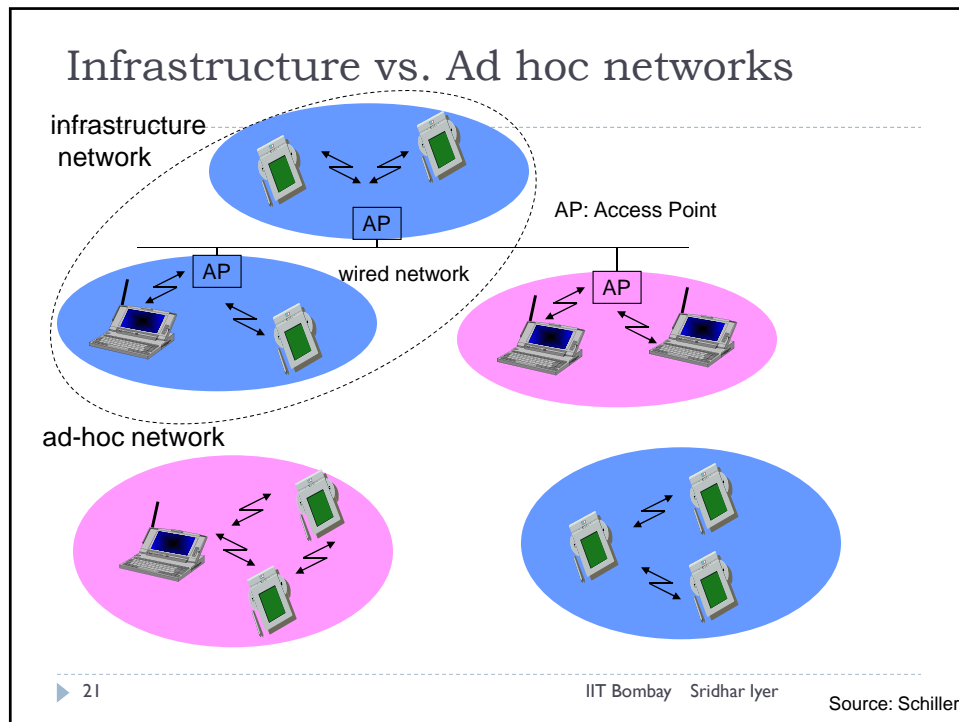- Infrastructure v/s ad-hoc networks (802.11)

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802.11 variants

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Infrastructure vs. Ad hoc networks

infrastructure
network

AP

AP: Access Point

AP

wired network

ad-hoc network

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Source: Schiller

Components of IEEE 802.11 architecture

▸ The basic service set (BSS) is the basic building block of an IEEE 802.11 LAN

▸ The ovals can be thought of as the coverage area within which member stations can directly communicate

▸ The Independent BSS (IBSS) is the simplest LAN. It may consist of as few as two stations

ad-hoc network   BSS1

BSS2

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802.11 - infrastructure network (PCF)

802.11 LAN

802.x LAN

STA₁

BSS₁

Access Point

Portal

Distribution System

Access Point

ESS

BSS₂

STA₂   *802.11 LAN*   STA₃

▸Station (STA)
  ▸ terminal with access mechanisms to the wireless medium and radio contact to the access point

▸Basic Service Set (BSS)
  ▸ group of stations using the same radio frequency

▸Access Point
  ▸ station integrated into the wireless LAN and the distribution system

▸Portal
  ▸ bridge to other (wired) networks

▸Distribution System
  ▸ interconnection network to form one logical network (EES: Extended Service Set) based on several BSS

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Source: Schiller

W-LAN Transmission Rates

1Mbps DBPSK

2Mbps DQPSK

5.5Mbps

11Mbps

550 m

400 m

270 m   **160 m**

DQPSK/CCK

DBPSK/CCK

☐ Access Point

○ Mobile Node

▦ Obstacle

11 Mbps ⇔   8 % of coverage area
1 Mbps ⇔ 47 % of coverage area
⇒ **Low probability of having good link!!**

Lucent ORiNICO 802.11b
outdoors, no obstruction—ideal conditions!

802.16 (WiMaX) Overview

Motivation for 802.16

▶ Broadband:
  ▶ A transmission facility having a bandwidth sufficient to carry multiple voice, video or data, simultaneously.
  ▶ High-capacity fiber to every user is expensive.

▶ Broadband Wireless Access:
  ▶ provides "First-mile" network access to buildings.
 ▶ Cost effective and easy deployment.

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IEEE 802.16

‣ WirelessMAN air interface
  ‣ for fixed point to multi-point BWA

‣ Broad bandwidth: 10-66 GHz
  ‣ Channel as wide as 28 MHz and
  ‣ Data rate upto 134 Mbps

‣ MAC designed for efficient use of spectrum
  ‣ Bandwidth on demand
  ‣ QoS Support

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802.16 Architecture

WirelessMAN: Wireless Metropolitan Area Network
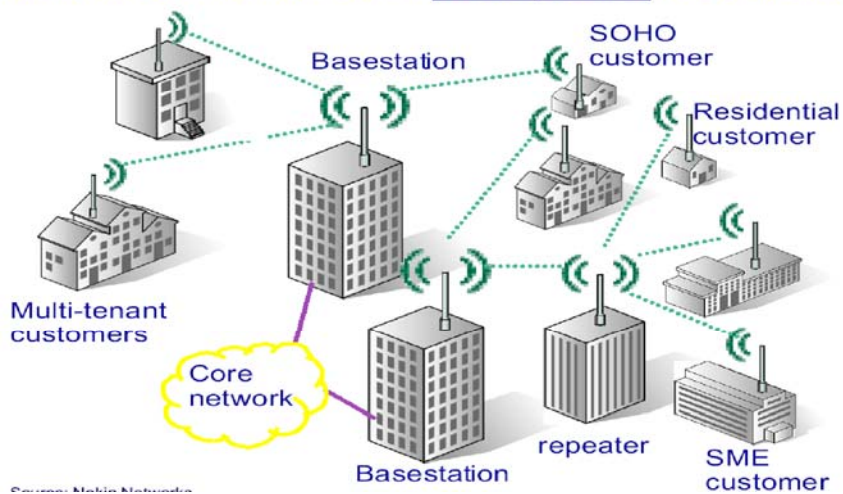
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802.16: Summary

▸ **Higher throughput at longer ranges (**up to 50 km**)**
  ▸ Better bits/second/Hz at longer ranges

▸ **Scalable system capacity**
  ▸ Easy addition of channels maximizes cell capacity
  ▸ Flexible channel bandwidths accommodate allocations for *both licensed and license-exempt* spectrums

▸ **Coverage**
  ▸ Standards-based mesh and smart antenna support
  ▸ Adaptive modulation enables tradeoff of bandwidth for range

▸ **Quality of Service**
  ▸ Grant / request MAC supports voice and video
  ▸ Differentiated service levels: E1/T1 for business, best effort for residential

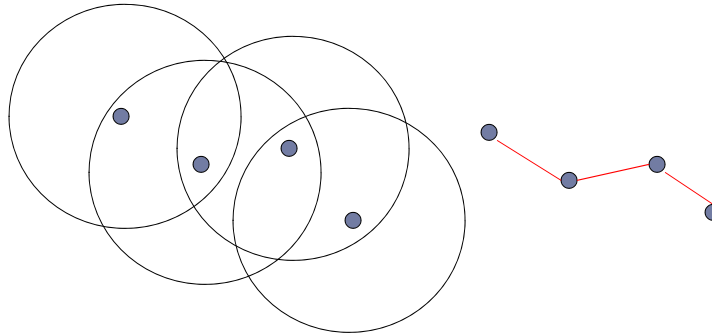▸ 29   IIT Bombay   Sridhar Iyer

Mesh and Adhoc Networks

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Multi-Hop Wireless
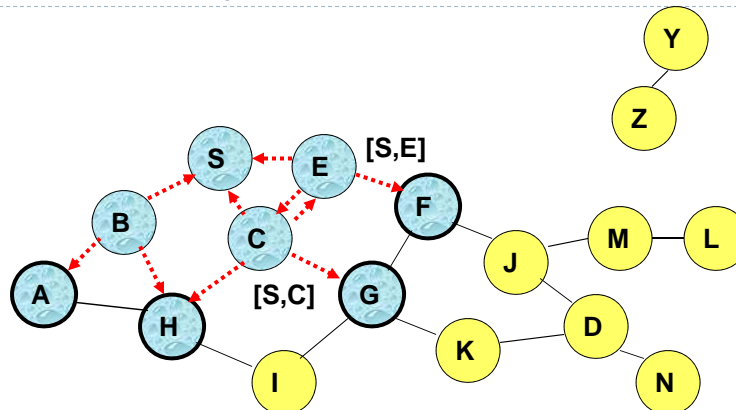
▸ May need to traverse multiple links to reach destination

▸ Mobility causes route changes

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Route discovery

[S,E]

[S,C]

• **Node H receives packet RREQ from two neighbors:
potential for collision**
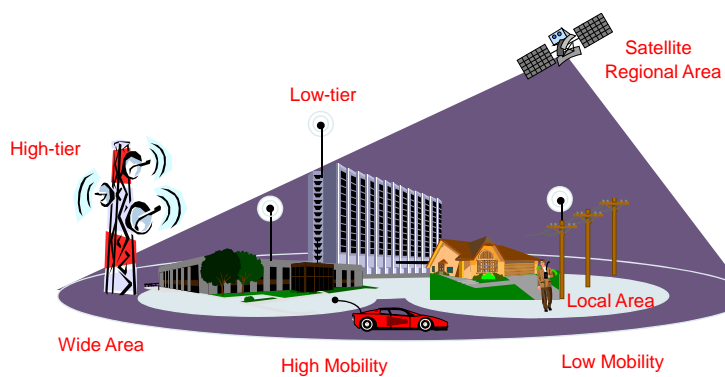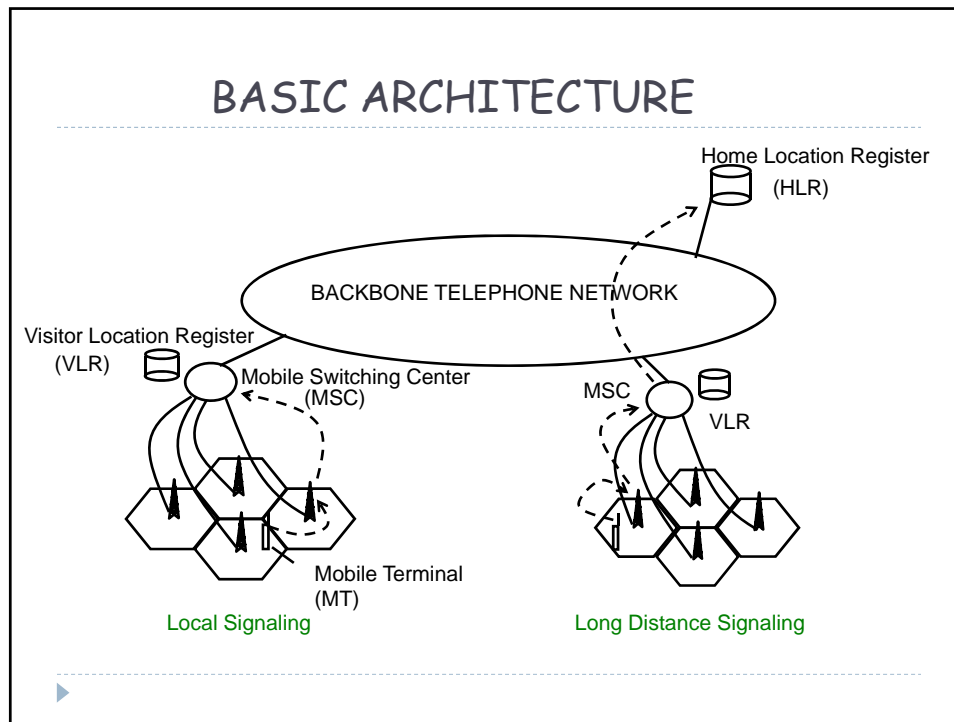
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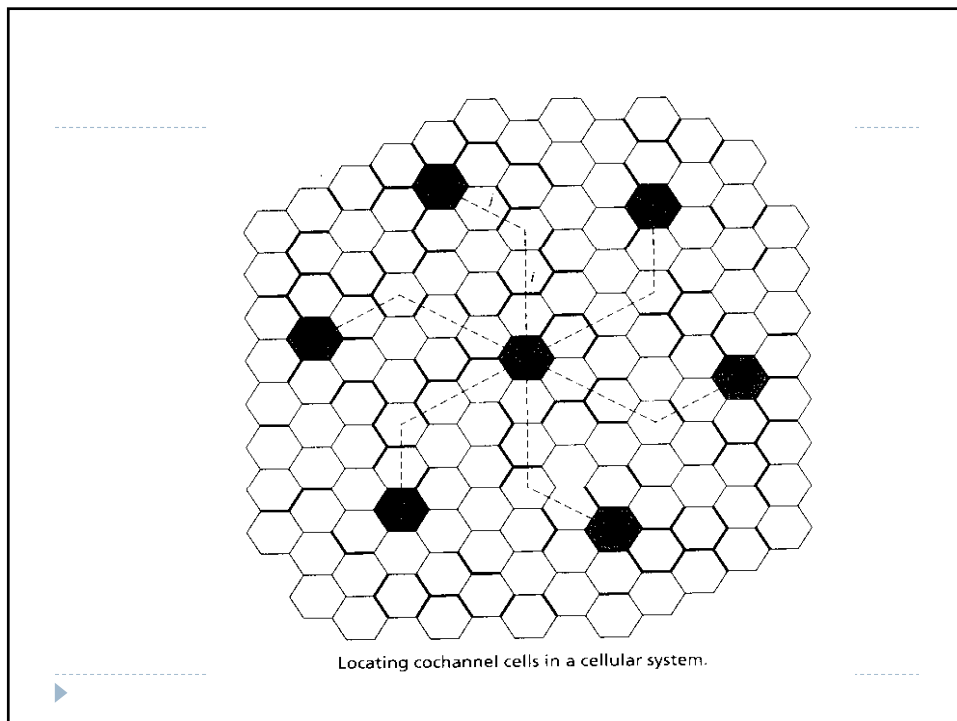## Cellular Networks (cell phone)

Heterogeneous Cellular Networks

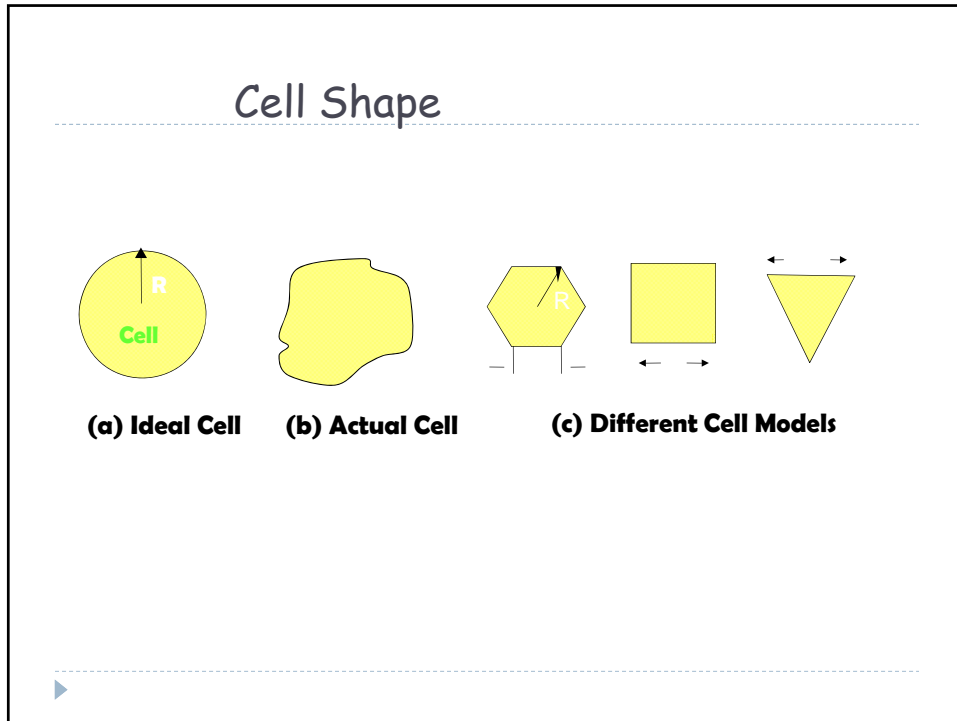▸ **Seamless mobility across diverse overlay networks**
  ▸ "vertical" hand-offs
  ▸ software "agents" for heterogeneity management
  ▸ IP as the common denominator?
▸

BASIC ARCHITECTURE

Cellular Concept

▸ The most important factor is the size and the shape of a CELL.

▸ A cell is the radio coverage area by a transmitting station or a BS.

▸ Ideally, the area covered a by a cell could be represented by a circular cell with a radius R from the center of a BS.

▸ Many factors may cause reflections and refractions of the signals, e.g., elevation of the terrain, presence of a hill or a valley or a tall building and presence in the surrounding area.

▸ The actual shape of the cell is determined by the received signal strength.

▸ Thus, the coverage area may be a little distorted.

▸ We need an appropriate model of a cell for the analysis and evaluation.

▸ Many posible models: HEXAGON, SQUARE, EQUILATERAL TRIANGLE.

Cell Shape

(a) Ideal Cell   (b) Actual Cell   (c) Different Cell Models

Locating cochannel cells in a cellular system.

Community Mesh Network