

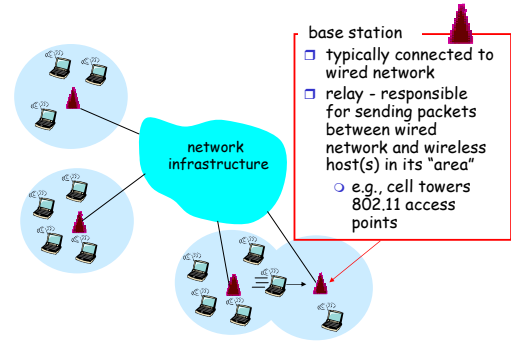
Wireless Networks

Background:

- # wireless (mobile) phone subscribers now exceeds # wired phone subscribers!
- computer nets: laptops, palmtops, PDAs, Internet-enabled phone promise anytime untethered Internet access
- two important (but different) challenges
 - communication over wireless link
 - handling mobile user who changes point of attachment to network

Wireless Networks 1

Elements of a wireless network



Wireless Networks 4

Outline

1. Introduction

2. Wireless link characteristics and PHY Layer design.

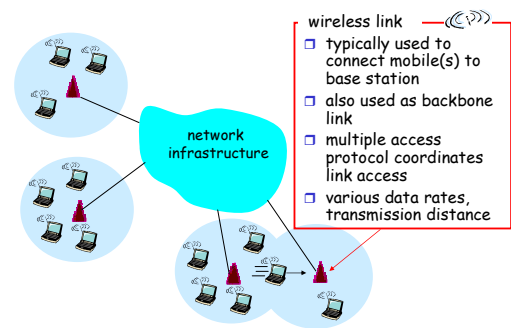
3. Multiple access and interference management:

- IEEE 802.11 wireless LANs ("wi-fi")
- cellular standards (eg. GSM, CDMA)

4. Mobility management

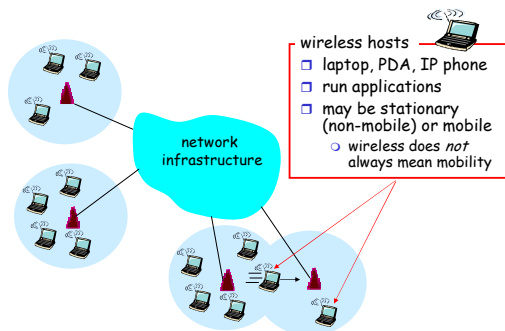
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Elements of a wireless network



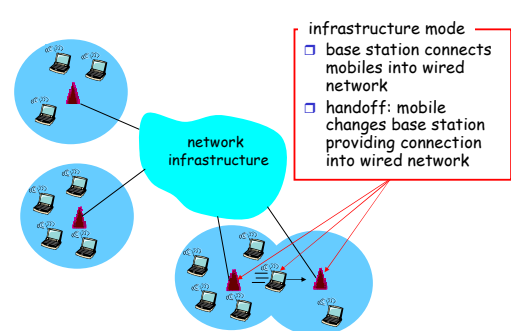
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Elements of a wireless network



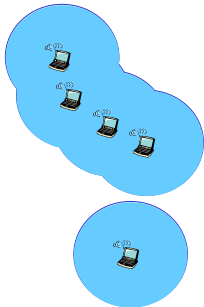
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Elements of a wireless network



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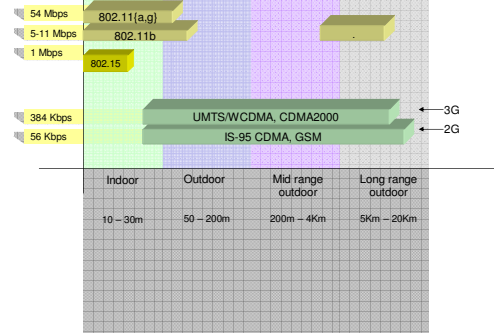
Elements of a wireless network



- Ad hoc mode
- no base stations
 - nodes can only transmit to other nodes within link coverage
 - nodes organize themselves into a network: route among themselves

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Characteristics of selected wireless standards



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History

- Cellular concept (Bell Labs, early 70's)
- AMPS (analog, early 80's)
- GSM (digital, narrowband, late 80's)
- IS-95 (digital, wideband, early 90's)
- 3G/4G systems for wireless data (UMTS, CDMA 2000)
- Explosive growth of 802.11 WiFi Lan in past 5 years.

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Cellular vs Wi-Fi

- Cellular: wide area coverage, proprietary networks, more coordination between BSs.
- Wi-Fi: local area coverage, "last link" for the Internet, little coordination between APs
- Cellular: licensed (and expensive) spectrum (around 900 MHz and 1.9 GHz)
- Wi-Fi: unlicensed (free) spectrum (2.4 GHz and 5.3 GHz)
- Cellular: high mobility
- Wi-Fi: low or no mobility

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Wireless Link: Key Parameters

- Carrier frequency f_c : 900 Mhz or 1.9 GHz for cellular. 2.4 Ghz or 5.3 Ghz for 802.11.
- Transmission bandwidth W : 200 kHz for GSM, 1.25 MHz for CDMA, 83.5 MHz for 802.11b, divided into 3 channels.
 - Determines the symbol rate.
- Data rate R bps: eg. 11 Mbps for 802.11b.
- Range.

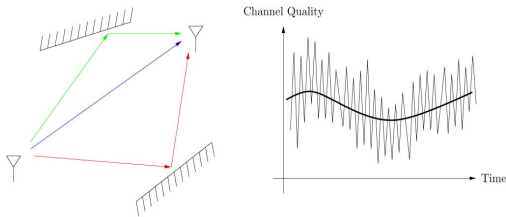
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Wireless Link Characteristics

- **decreased signal strength**: radio signal attenuates as it propagates through matter (path loss)
- **multipath fading**: constructive and destructive interference of multiple signal paths from transmitter to receiver.
- **interference**:
 - Between different users in a cell.
 - Between users across different cells
 - From external sources in unlicensed bands (eg. your microwave oven)

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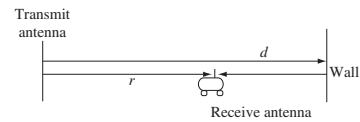
Wireless Channel



Channel varies at two spatial scales:
 large scale
 small scale (multipath fading)

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Example



- Difference in phases of direct and reflected waves:

$$\frac{2\pi}{\lambda}[(2d-r)-r] + \pi = \frac{4\pi}{\lambda}(d-r) + \pi$$

where λ is the wavelength of the signal.

- Movement of $\lambda/4$ goes from a peak to a valley. (this is 0.3m at frequency 900 MHz)

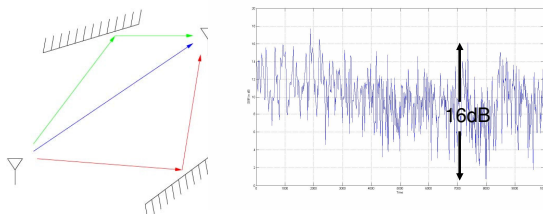
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Large-scale channel variations

- In free space, received power attenuates like $1/r^2$.
- Can also experience shadowing by objects
- Important for cell site/access point planning:
 - Coverage
 - Frequency reuse

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Small-scale multipath fading



• Multipath fading due to **constructive** and **destructive** interference of the transmitted waves at very high carrier frequency.

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