

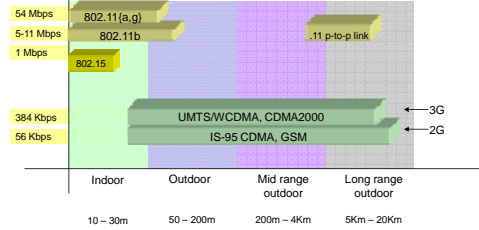
Chapter 6: Wireless and Mobile Networks

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

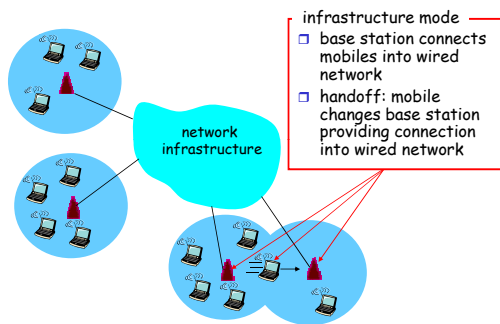
6: Wireless and Mobile Networks 6-1

Characteristics of selected wireless link standards



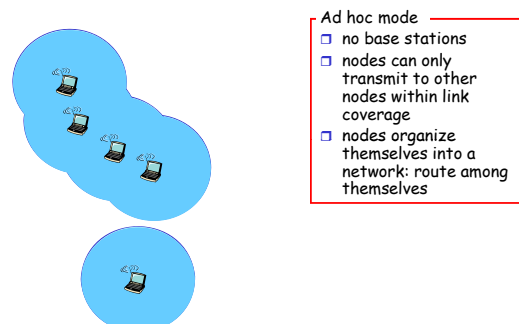
6: Wireless and Mobile Networks 6-2

Elements of a wireless network



6: Wireless and Mobile Networks 6-3

Elements of a wireless network



6: Wireless and Mobile Networks 6-4

Wireless Link Characteristics

Differences from wired link

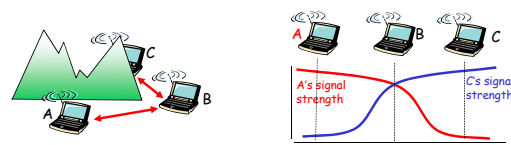
- **decreased signal strength:** radio signal attenuates as it propagates through matter (path loss)
- **interference from other sources:** standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- **multipath propagation:** radio signal reflects off objects ground, arriving at destination at slightly different times

... make communication across (even a point to point) wireless link much more "difficult"

6: Wireless and Mobile Networks 6-5

Wireless network characteristics

Multiple wireless senders and receivers create additional problems (beyond multiple access):



Hidden terminal problem

- B, A hear each other
- B, C hear each other
- A, C can not hear each other means A, C unaware of their interference at B

Signal fading:

- B, A hear each other
- B, C hear each other
- A, C can not hear each other interfering at B

6: Wireless and Mobile Networks 6-6

Code Division Multiple Access (CDMA)

- used in several wireless broadcast channels (cellular, satellite, etc) standards
- unique "code" assigned to each user; i.e., code set partitioning
- all users share same frequency, but each user has own "chipping" sequence (i.e., code) to encode data
- **encoded signal** = (original data) X (chipping sequence)
- **decoding**: inner-product of encoded signal and chipping sequence
- allows multiple users to "coexist" and transmit simultaneously with minimal interference (if codes are "orthogonal")

6: Wireless and Mobile Networks 6-7

Chapter 6 outline

6.1 Introduction

Wireless

- 6.2 Wireless links, characteristics
 - CDMA
- 6.3 IEEE 802.11 wireless LANs ("wi-fi")
- 6.4 Cellular Internet Access
 - architecture
 - standards (e.g., GSM)

Mobility

- 6.5 Principles: addressing and routing to mobile users
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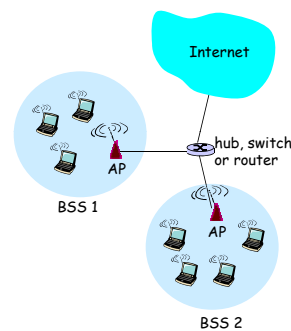
6: Wireless and Mobile Networks 6-8

IEEE 802.11 Wireless LAN

- **802.11b**
 - 2.4-5 GHz unlicensed radio spectrum
 - up to 11 Mbps
 - direct sequence spread spectrum (DSSS) in physical layer
 - all hosts use same chipping code
 - widely deployed, using base stations
- **802.11a**
 - 5-6 GHz range
 - up to 54 Mbps
- **802.11g**
 - 2.4-5 GHz range
 - up to 54 Mbps
- All use CSMA/CA for multiple access
- All have base-station and ad-hoc network versions

6: Wireless and Mobile Networks 6-9

802.11 LAN architecture



- wireless host communicates with base station
 - base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
 - wireless hosts
 - access point (AP): base station
 - ad hoc mode: hosts only

6: Wireless and Mobile Networks 6-10

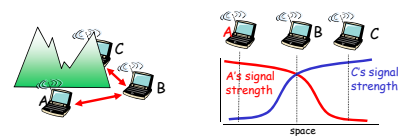
802.11: Channels, association

- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
 - AP admin chooses frequency for AP
 - interference possible: channel can be same as that chosen by neighboring AP!
- host: must **associate** with an AP
 - scans channels, listening for *beacon frames* containing AP's name (SSID) and MAC address
 - selects AP to associate with
 - may perform authentication [Chapter 8]
 - will typically run DHCP to get IP address in AP's subnet

6: Wireless and Mobile Networks 6-11

IEEE 802.11: multiple access

- avoid collisions: 2+ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
 - don't collide with ongoing transmission by other node
- 802.11: **no** collision detection!
 - difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
 - can't sense all collisions in any case: hidden terminal, fading
 - goal: **avoid collisions**: CSMA/C(ollision)A(voidance)



6: Wireless and Mobile Networks 6-12

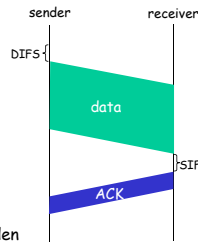
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender

- 1 if sense channel idle for (Distributed Inter-frame Space) **DIFS** then transmit entire frame (no CD)
- 2 if sense channel busy then start random backoff time timer counts down while channel idle transmit when timer expires if no ACK, increase random backoff interval, repeat 2

802.11 receiver

- if frame received OK return ACK after (Short Inter-frame Spacing) **SIFS** (ACK needed due to hidden terminal problem)



6: Wireless and Mobile Networks 6-13

Avoiding collisions (more)

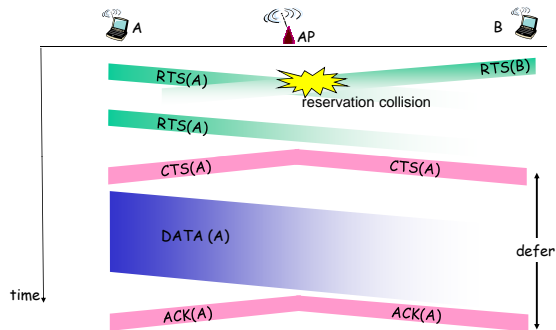
idea: allow sender to "reserve" channel rather than random access of data frames: avoid collisions of long data frames

- sender first transmits *small* request-to-send (RTS) packets to BS using CSMA
 - RTSs may still collide with each other (but they're short)
- BS broadcasts clear-to-send CTS in response to RTS
- RTS heard by all nodes
 - sender transmits data frame
 - other stations defer transmissions

Avoid data frame collisions completely using small reservation packets!

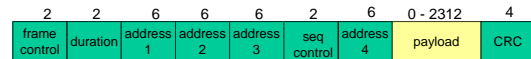
6: Wireless and Mobile Networks 6-14

Collision Avoidance: RTS-CTS exchange



6: Wireless and Mobile Networks 6-15

802.11 frame: addressing



Address 1: MAC address of wireless host or AP to receive this frame

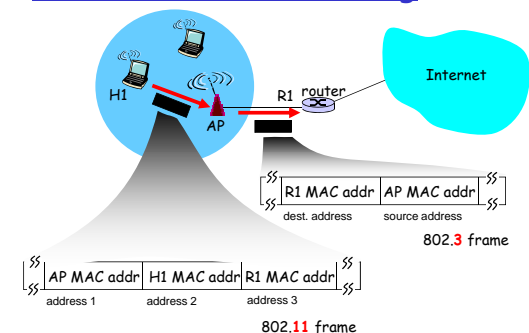
Address 2: MAC address of wireless host or AP transmitting this frame

Address 3: MAC address of router interface to which AP is attached

Address 3: used only in ad hoc mode

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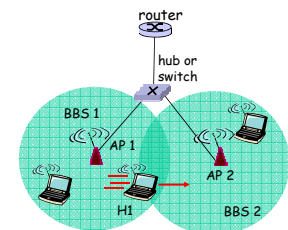
802.11 frame: addressing



6: Wireless and Mobile Networks 6-17

802.11: mobility within same subnet

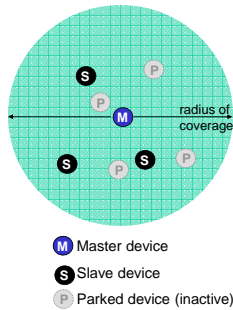
- H1 remains in same IP subnet: IP address can remain same
- switch: which AP is associated with H1?
 - self-learning (Ch. 5): switch will see frame from H1 and "remember" which switch port can be used to reach H1



6: Wireless and Mobile Networks 6-18

802.15: personal area network

- less than 10 m diameter
- replacement for cables (mouse, keyboard, headphones)
- ad hoc: no infrastructure
- master/slaves:
 - slaves request permission to send (to master)
 - master grants requests
- 802.15: evolved from Bluetooth specification
 - 2.4-2.5 GHz radio band
 - up to 721 kbps



6: Wireless and Mobile Networks 6-19

Chapter 6 outline

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Wireless

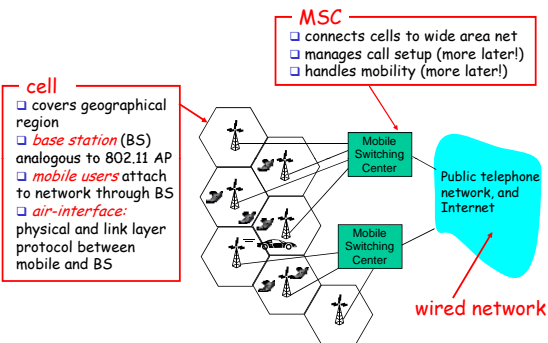
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6: Wireless and Mobile Networks 6-20

Components of cellular network architecture

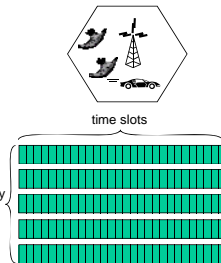


6: Wireless and Mobile Networks 6-21

Cellular networks: the first hop

Two techniques for sharing mobile-to-BS radio spectrum

- combined FDMA/TDMA: divide spectrum in frequency channels, divide each channel into time slots
- CDMA: code division multiple access

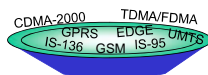


6: Wireless and Mobile Networks 6-22

Cellular standards: brief survey

2G systems: voice channels

- IS-136 TDMA: combined FDMA/TDMA (north america)
- GSM (global system for mobile communications): combined FDMA/TDMA
 - most widely deployed
- IS-95 CDMA: code division multiple access



Don't drown in a bowl of alphabet soup: use this for reference only

6: Wireless and Mobile Networks 6-23

Cellular standards: brief survey

2.5 G systems: voice and data channels

- for those who can't wait for 3G service: 2G extensions
- general packet radio service (GPRS)
 - evolved from GSM
 - data sent on multiple channels (if available)
- enhanced data rates for global evolution (EDGE)
 - also evolved from GSM, using enhanced modulation
 - Data rates up to 384K
- CDMA-2000 (phase 1)
 - data rates up to 144K
 - evolved from IS-95

6: Wireless and Mobile Networks 6-24

Cellular standards: brief survey

3G systems: voice/data

- Universal Mobile Telecommunications Service (UMTS)
 - GSM next step, but using CDMA
- CDMA-2000

..... more (and more interesting) cellular topics due to mobility (stay tuned for details)

6: Wireless and Mobile Networks 6-25

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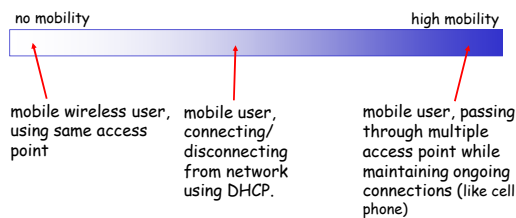
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6: Wireless and Mobile Networks 6-26

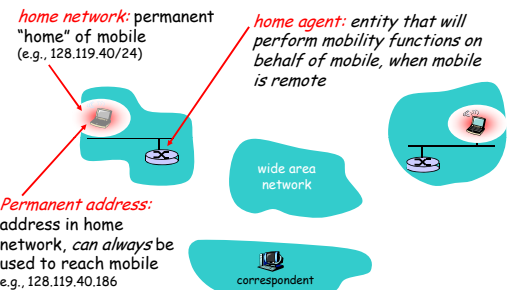
What is mobility?

- spectrum of mobility, from the *network* perspective:



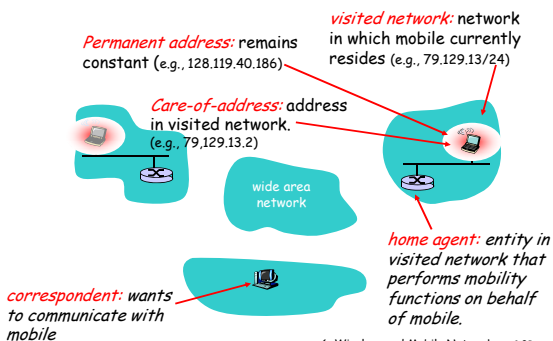
6: Wireless and Mobile Networks 6-27

Mobility: Vocabulary



6: Wireless and Mobile Networks 6-28

Mobility: more vocabulary



6: Wireless and Mobile Networks 6-29

How do you contact a mobile friend:

Consider friend frequently changing addresses, how do you find her?

- search all phone books?
- call her parents?
- expect her to let you know where he/she is?

I wonder where Alice moved to?



6: Wireless and Mobile Networks 6-30

Mobility: approaches

- **Let routing handle it:** routers advertise permanent address of mobile-nodes-in-residence via usual routing table exchange.
 - routing tables indicate where each mobile located
 - no changes to end-systems
- **Let end-systems handle it:**
 - **indirect routing:** communication from correspondent to mobile goes through home agent, then forwarded to remote
 - **direct routing:** correspondent gets foreign address of mobile, sends directly to mobile

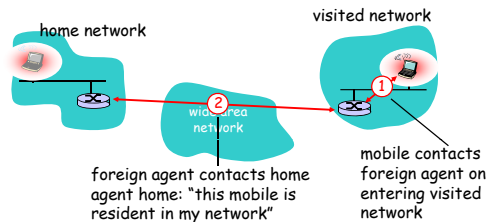
6: Wireless and Mobile Networks 6-31

Mobility: approaches

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6: Wireless and Mobile Networks 6-32

Mobility: registration

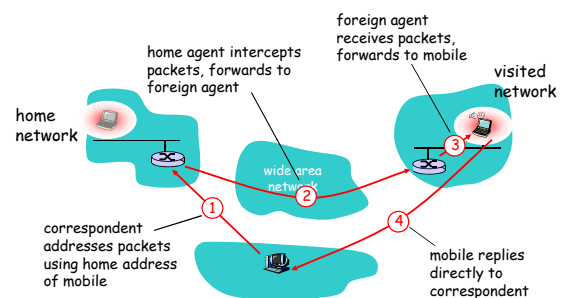


End result:

- Foreign agent knows about mobile
- Home agent knows location of mobile

6: Wireless and Mobile Networks 6-33

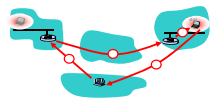
Mobility via Indirect Routing



6: Wireless and Mobile Networks 6-34

Indirect Routing: comments

- Mobile uses two addresses:
 - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
 - care-of-address: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- **triangle routing:** correspondent-home-network-mobile
 - inefficient when correspondent, mobile are in same network



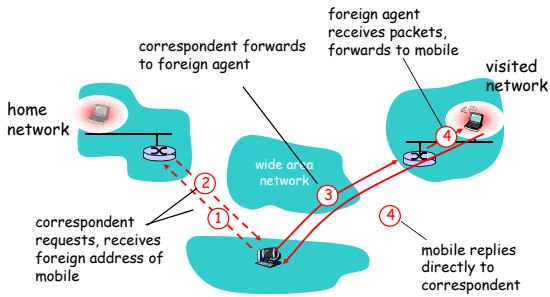
6: Wireless and Mobile Networks 6-35

Indirect Routing: moving between networks

- suppose mobile user moves to another network
 - registers with new foreign agent
 - new foreign agent registers with home agent
 - home agent update care-of-address for mobile
 - packets continue to be forwarded to mobile (but with new care-of-address)
- mobility, changing foreign networks transparent: *on going connections can be maintained!*

6: Wireless and Mobile Networks 6-36

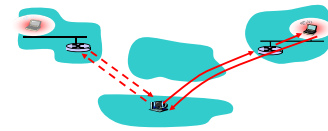
Mobility via Direct Routing



6: Wireless and Mobile Networks 6-37

Mobility via Direct Routing: comments

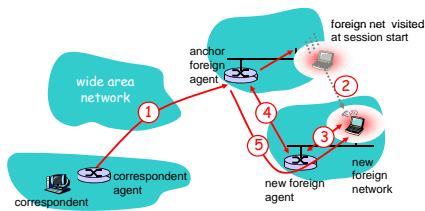
- overcome triangle routing problem
- **non-transparent to correspondent:** correspondent must get care-of-address from home agent
 - what if mobile changes visited network?



6: Wireless and Mobile Networks 6-38

Accommodating mobility with direct routing

- anchor foreign agent: FA in first visited network
- data always routed first to anchor FA
- when mobile moves: new FA arranges to have data forwarded from old FA (chaining)



6: Wireless and Mobile Networks 6-39

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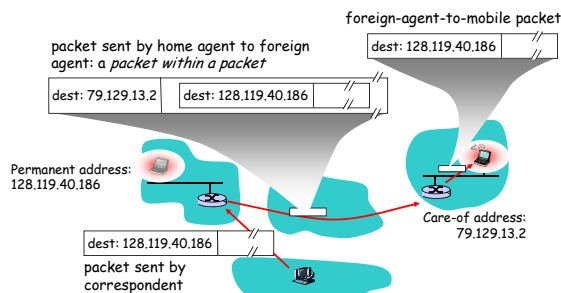
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6: Wireless and Mobile Networks 6-40

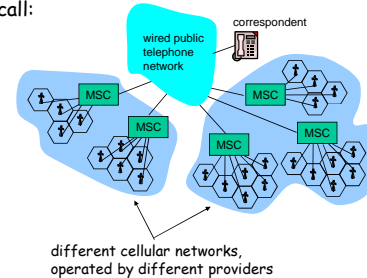
Mobile IP: indirect routing



6: Wireless and Mobile Networks 6-41

Components of cellular network architecture

recall:



6: Wireless and Mobile Networks 6-42