

CS 305: Computer Networks

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Week 15 Wireless and Mobile Networks

Ming Tang

Department of Computer Science and Engineering
Southern University of Science and Technology (SUSTech)

Why we need MAC address?

- LAN is designed for arbitrary network layer protocol; not only IP and the Internet
- If use IP, IP needs to be stored at RAM and configured every time when moving
- [Independent building blocks: each layer has its own address]

Chapter 7 outline

7.1 Introduction

Wireless

7.2 Wireless links, characteristics

- CDMA

7.3 IEEE 802.11 wireless LANs (“Wi-Fi”)

7.4 Cellular Internet Access

- architecture
- standards (e.g., 3G, LTE)

Mobility

7.5 Principles: addressing and routing to mobile users

7.6 Mobile IP

7.7 Handling mobility in cellular networks

7.8 Mobility and higher-layer protocols

IEEE 802.11 Wireless LAN

802.11b

- 2.4-5 GHz unlicensed spectrum
- up to 11 Mbps
- direct sequence spread spectrum (DSSS) in physical layer
 - all hosts use same chipping code

802.11a

- 5-6 GHz range
- up to 54 Mbps

802.11g

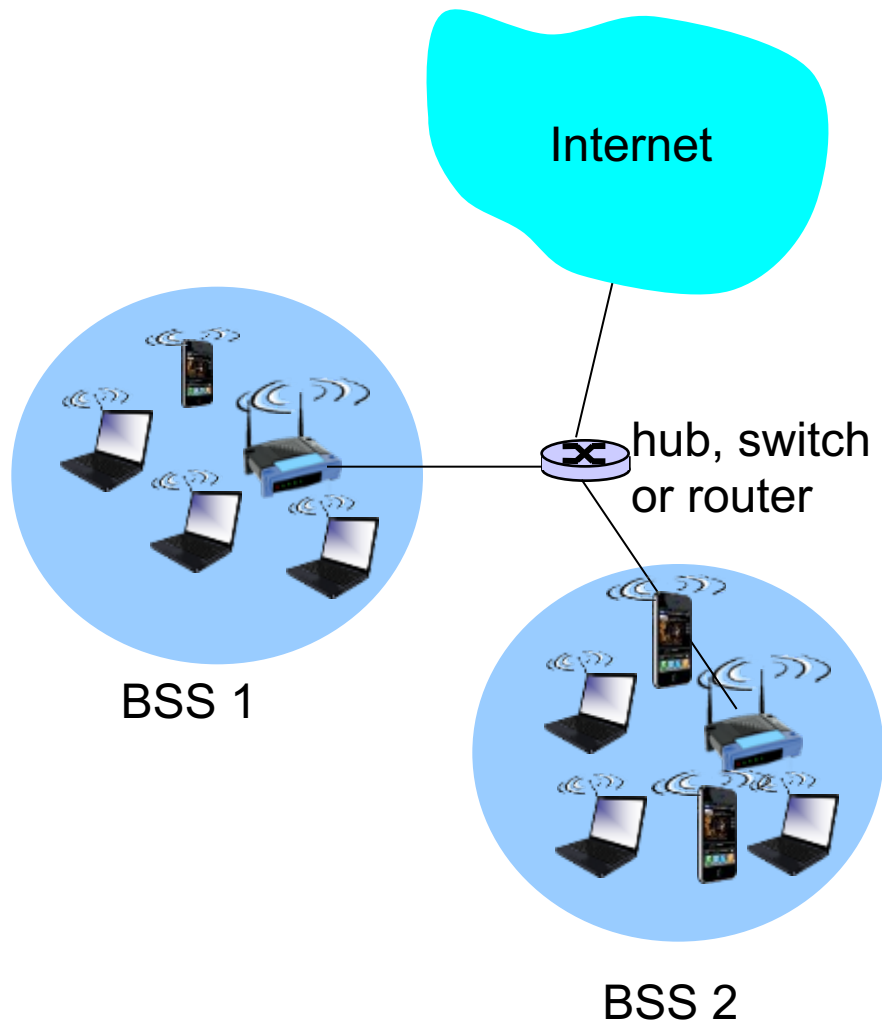
- 2.4-5 GHz range
- up to 54 Mbps

802.11n: multiple antennae

- 2.4-5 GHz range
- up to 200 Mbps

-
- all use CSMA/CA for multiple access
 - all have base-station and ad-hoc network versions

802.11 LAN architecture

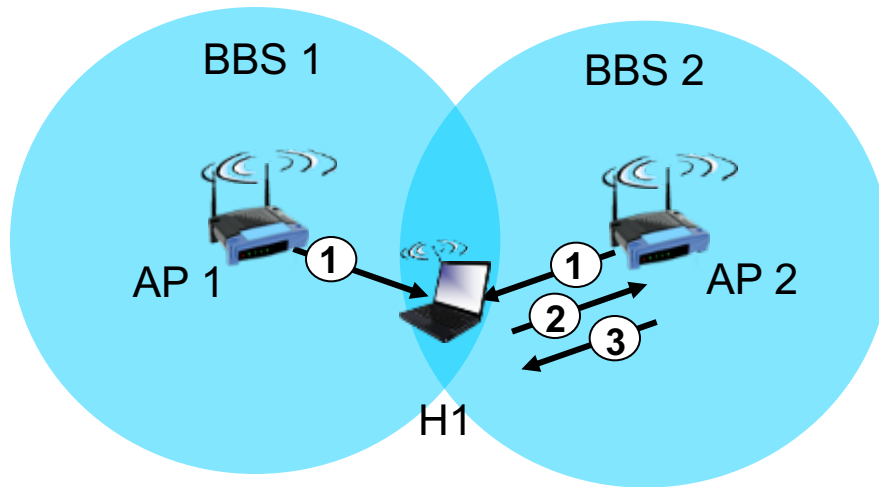


- wireless host communicates with base station
 - **base station = access point (AP)**
- **Basic Service Set (BSS)** (aka “cell”) in infrastructure mode contains:
 - wireless hosts
 - access point (AP): base station
 - ad hoc mode: hosts only

802.11: Channels, association

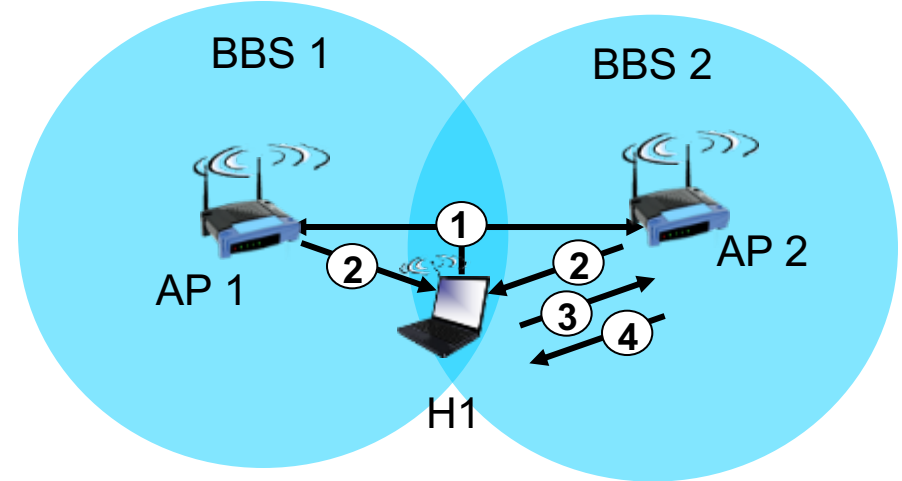
- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
 - AP admin chooses frequency for AP
 - interference possible: channel can be same as that chosen by neighboring AP!
- host: must *associate* with an AP
 - scans channels, listening for *beacon frames* containing AP's 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

802.11: passive/active scanning



passive scanning:

- (1) beacon frames sent from APs
- (2) association Request frame sent: H1 to selected AP
- (3) association Response frame sent from selected AP to H1

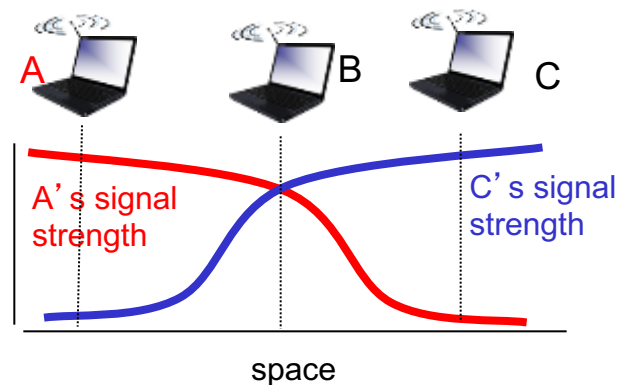
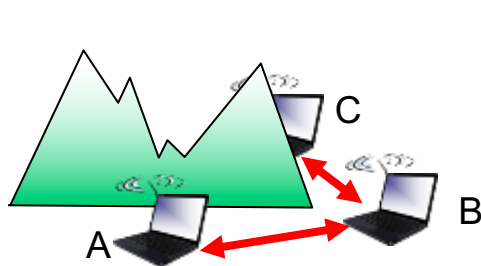


active scanning:

- (1) Probe Request frame broadcast from H1
- (2) Probe Response frames sent from APs
- (3) Association Request frame sent: H1 to selected AP
- (4) Association Response frame sent from selected AP to H1

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)



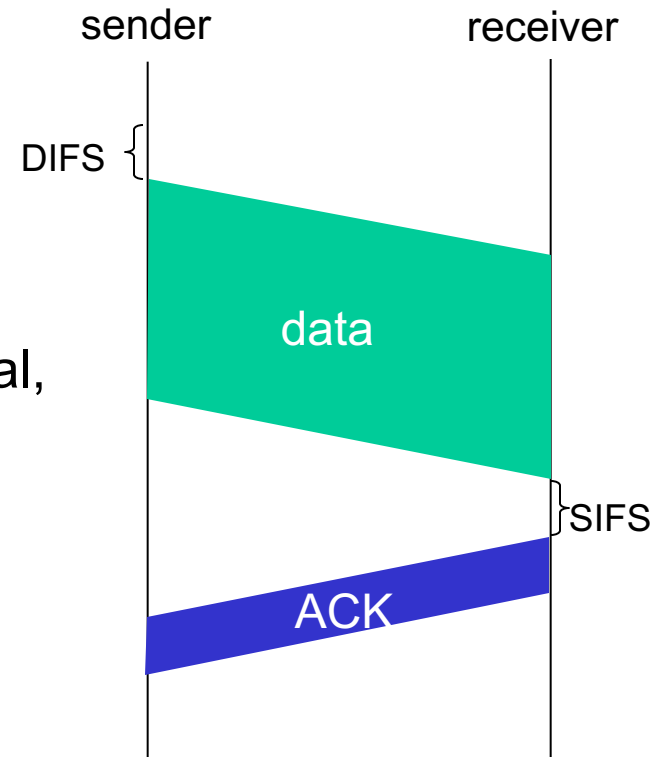
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender

- 1 if sense channel idle for **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 **SIFS** (ACK needed due to
hidden terminal problem)



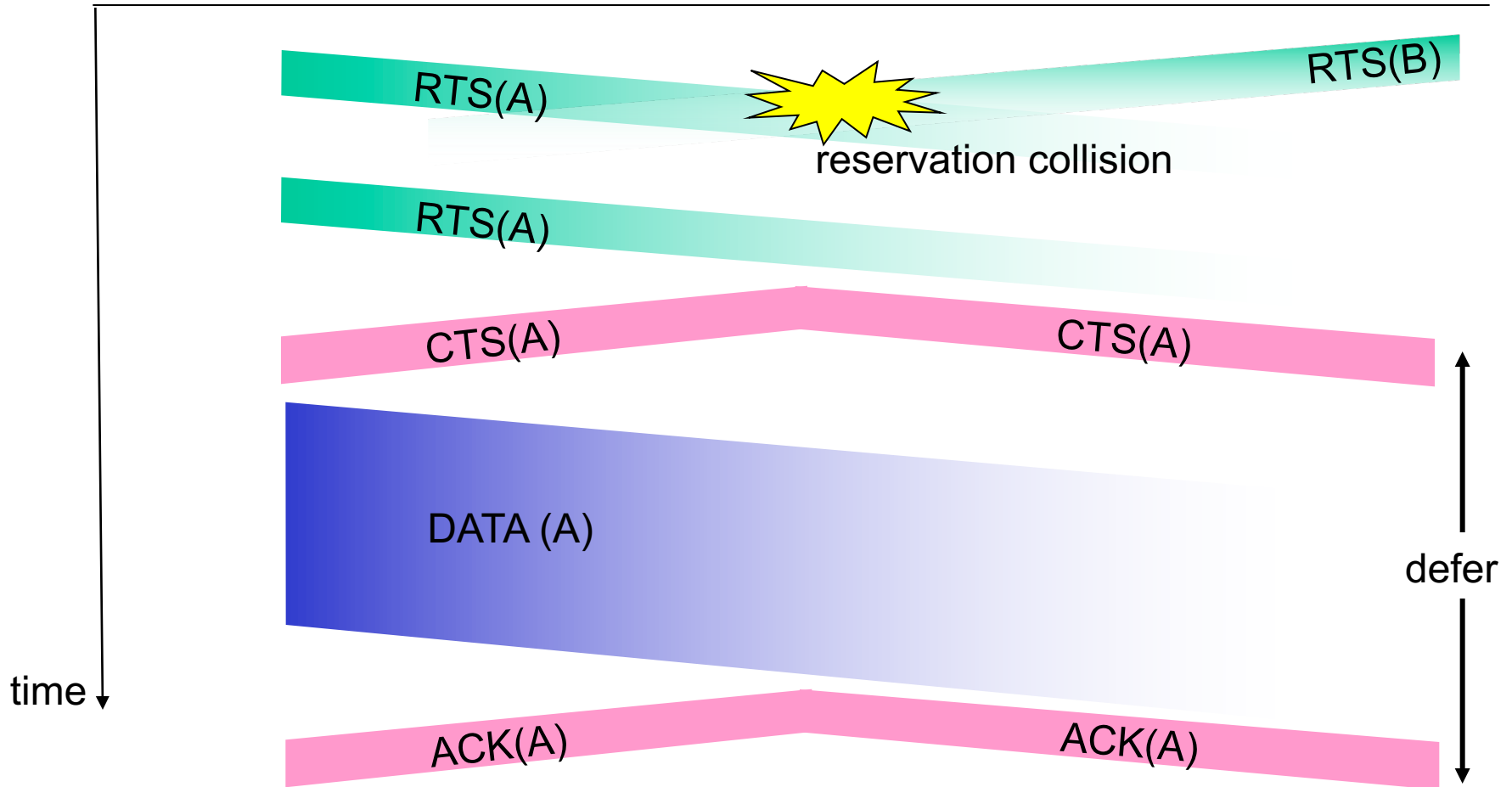
Avoiding collisions (more)

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

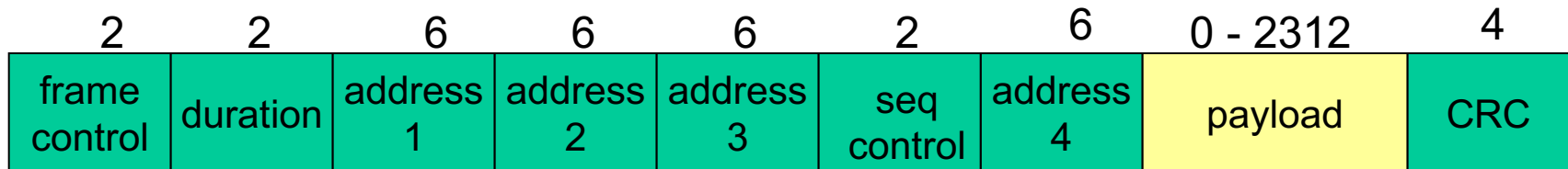
- sender first transmits *small* request-to-send (RTS) packets to BS using CSMA
 - RTSs may still collide with each other (but they’re short)
- BS broadcasts clear-to-send CTS in response to RTS
- CTS heard by all nodes
 - sender transmits data frame
 - other stations defer transmissions

*avoid data frame collisions completely
using small reservation packets!*

Collision Avoidance: RTS-CTS exchange



802.11 frame: addressing



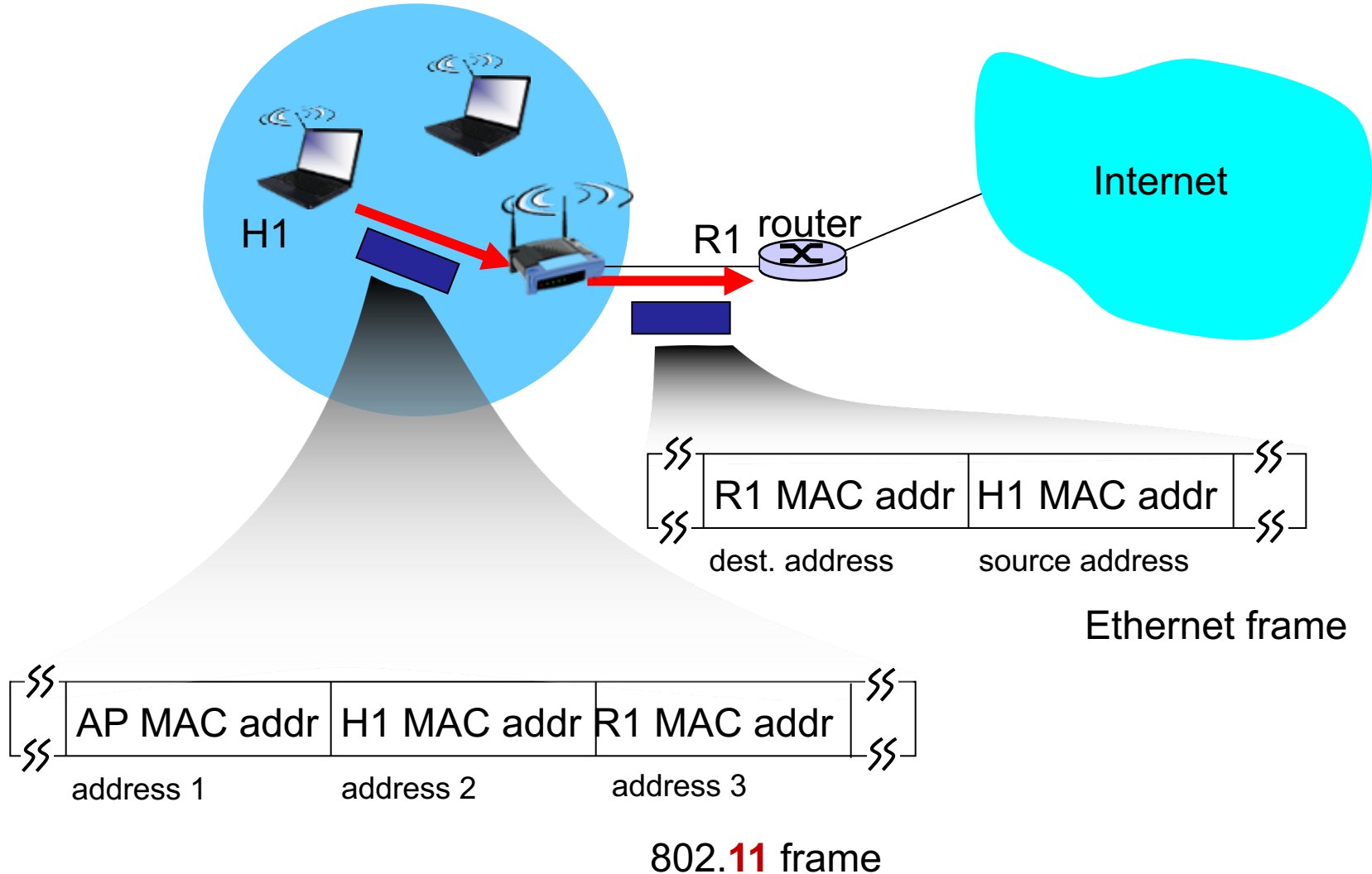
Address 1: MAC address of wireless host or AP to receive this frame

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

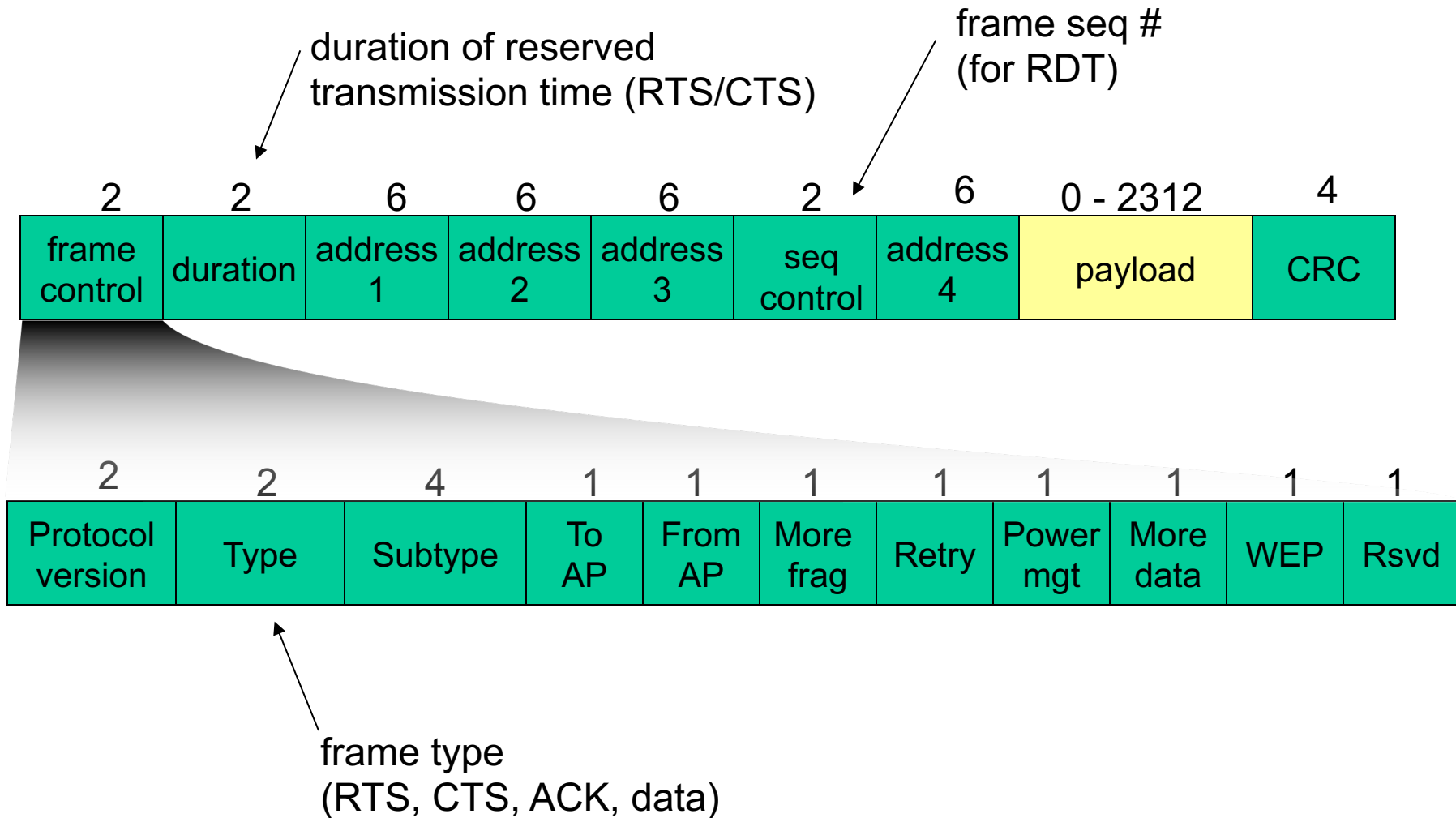
Address 3: MAC address of router interface to which AP is attached

Address 4: used only in ad hoc mode

802.11 frame: addressing

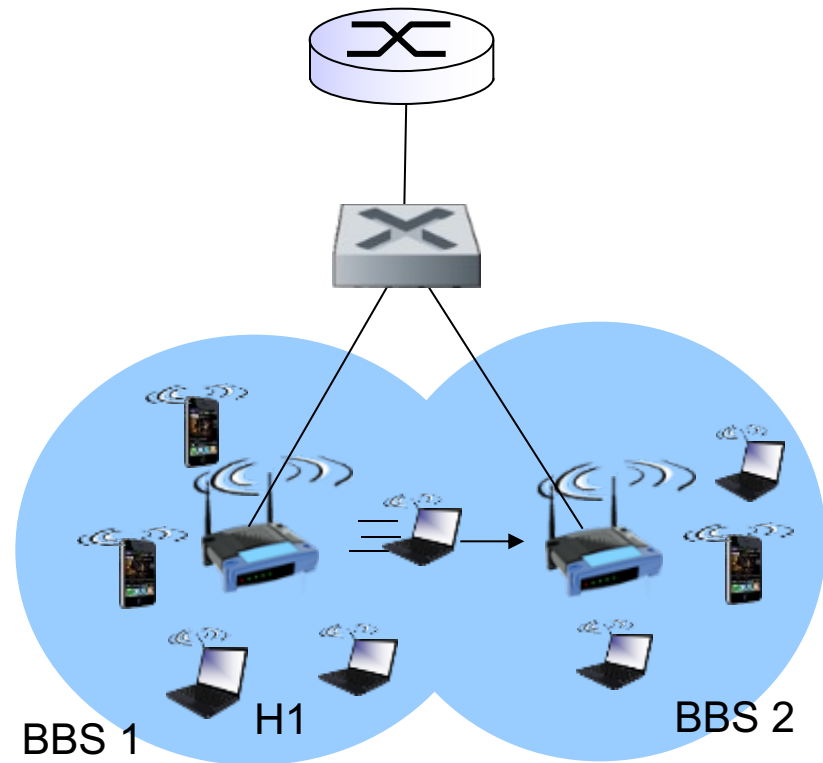


802.11 frame: more



802.11: mobility within same subnet

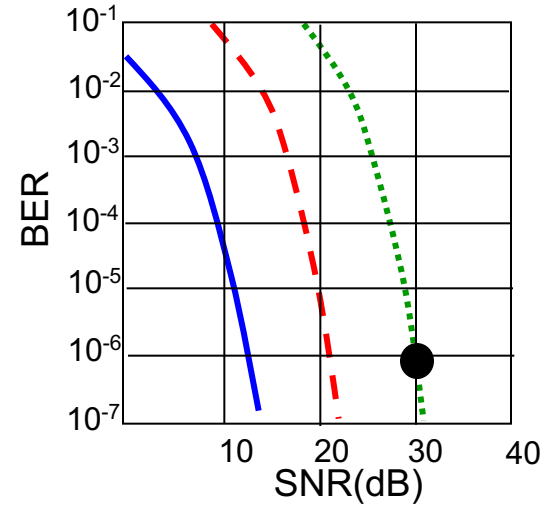
- HI remains in same IP subnet: IP address can remain same
- switch: which AP is associated with HI?
 - self-learning (Ch. 5): switch will see frame from HI and “remember” which switch port can be used to reach HI



802.11: advanced capabilities

Rate adaptation

- base station, mobile dynamically change transmission rate (physical layer modulation technique) as mobile moves, SNR varies



- QAM256 (8 Mbps)
- - - QAM16 (4 Mbps)
- BPSK (1 Mbps)
- operating point

1. SNR decreases, BER increase as node moves away from base station
2. When BER becomes too high, switch to lower transmission rate but with lower BER

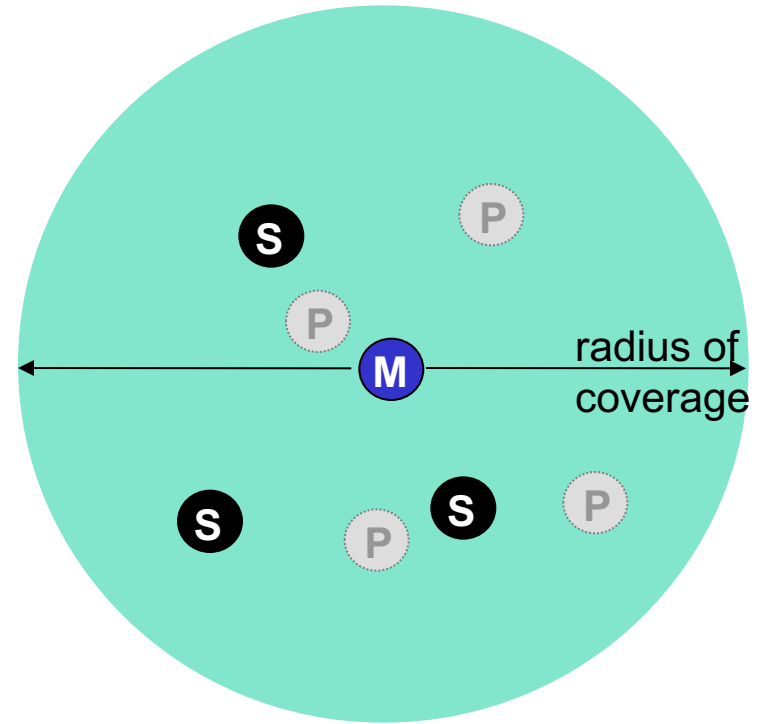
802.11: advanced capabilities

power management

- node-to-AP: “I am going to sleep until next beacon frame”
 - AP knows not to transmit frames to this node
 - node wakes up before next beacon frame
- beacon frame: contains list of mobiles with AP-to-mobile frames waiting to be sent
 - node will stay awake if AP-to-mobile frames to be sent; otherwise sleep again until next beacon frame

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



- M** Master device
- S** Slave device
- P** Parked device (inactive)

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- standards (e.g., 3G, LTE)

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7.8 Mobility and higher-layer protocols

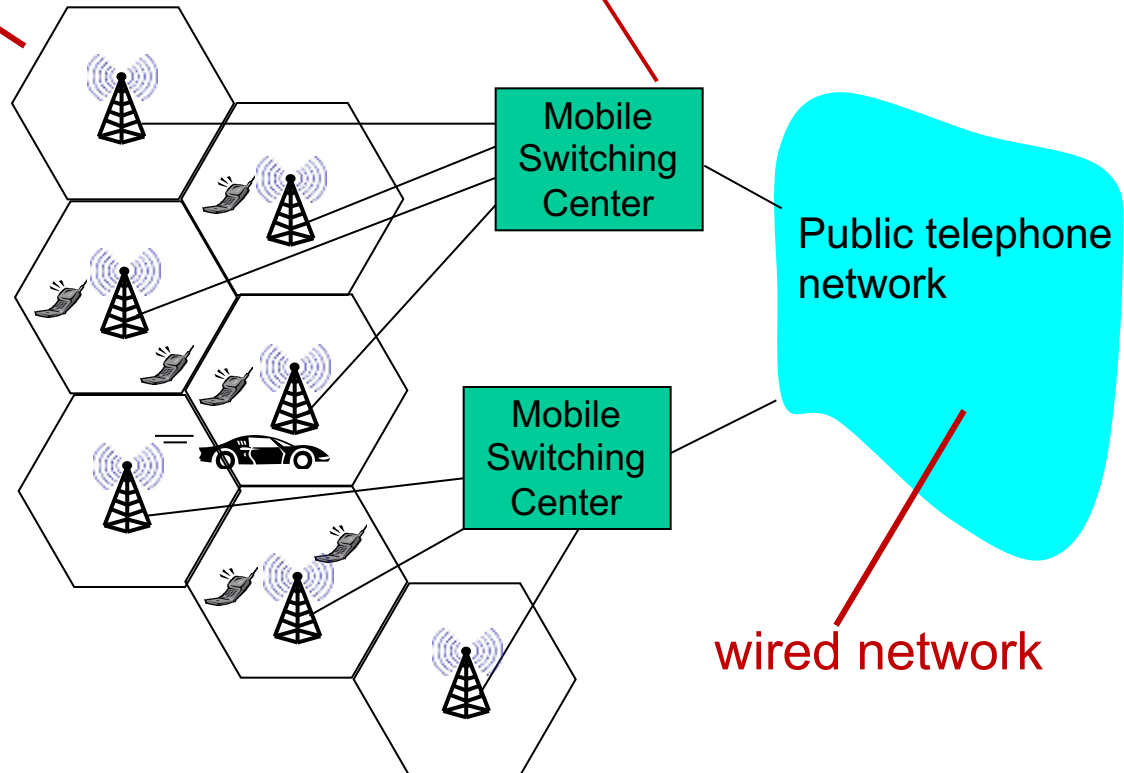
Components of cellular network architecture

cell

- ❖ covers geographical region
- ❖ *base station* (BS)
analogous to 802.11 AP
- ❖ *mobile users* attach to network through BS
- ❖ *air-interface*: physical and link layer protocol between mobile and BS

MSC

- ❖ connects cells to wired tel. net.
- ❖ manages call setup (more later!)
- ❖ handles mobility (more later!)

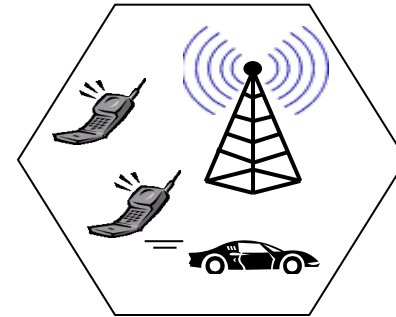


wired network

Cellular networks: the first hop

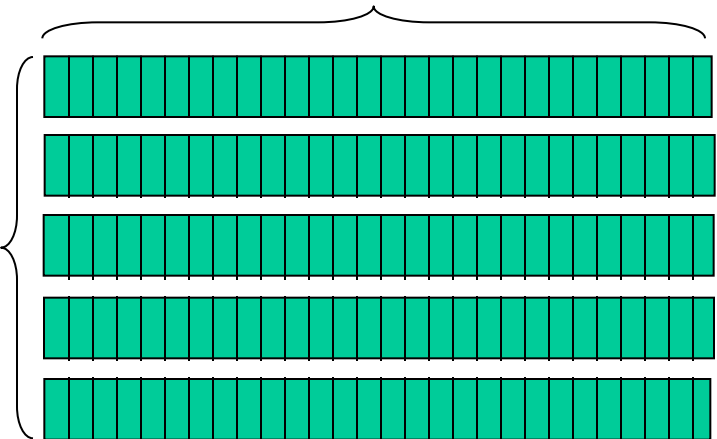
Two techniques for sharing mobile-to-BS radio spectrum

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

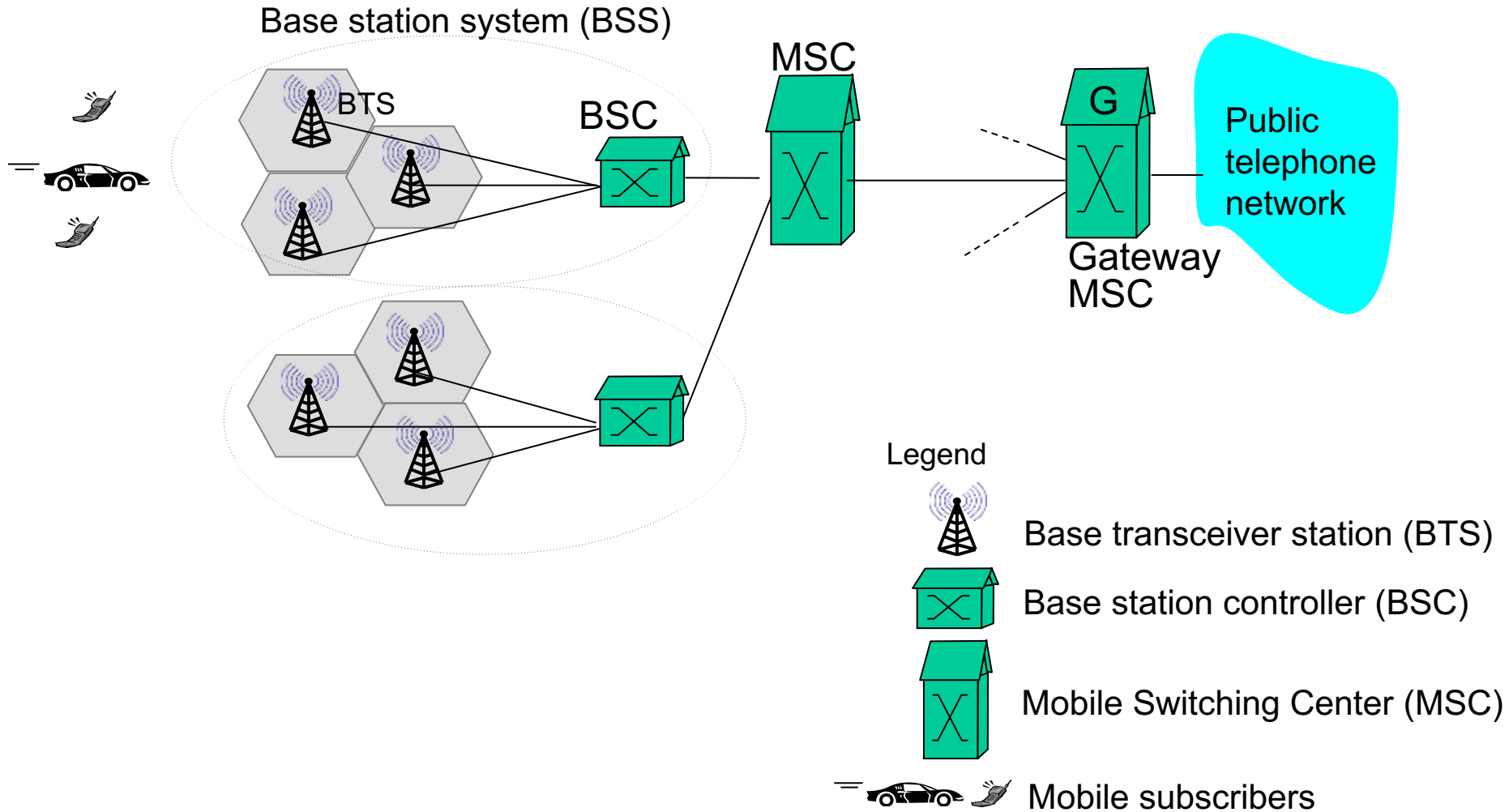


time slots

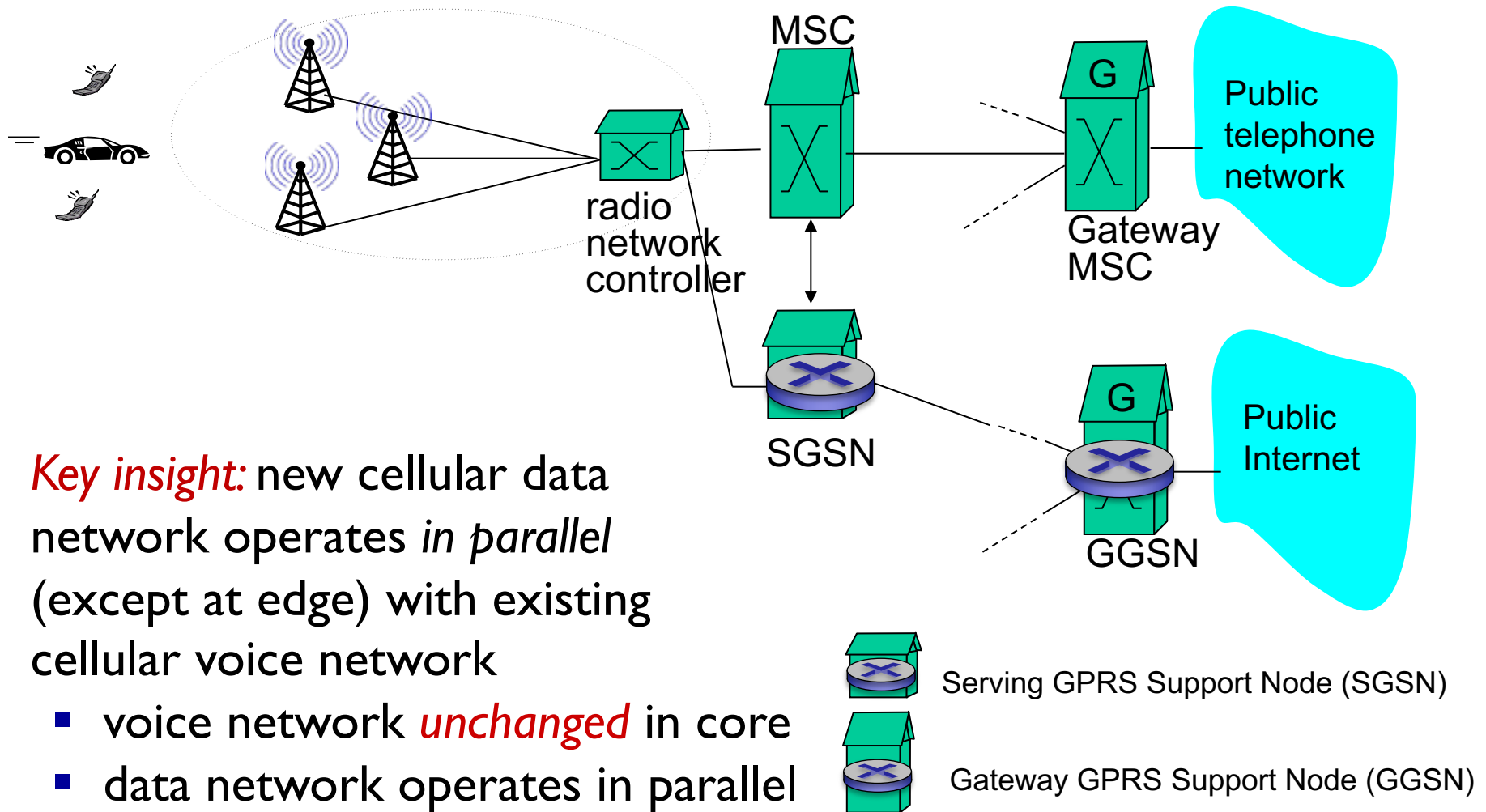
frequency bands



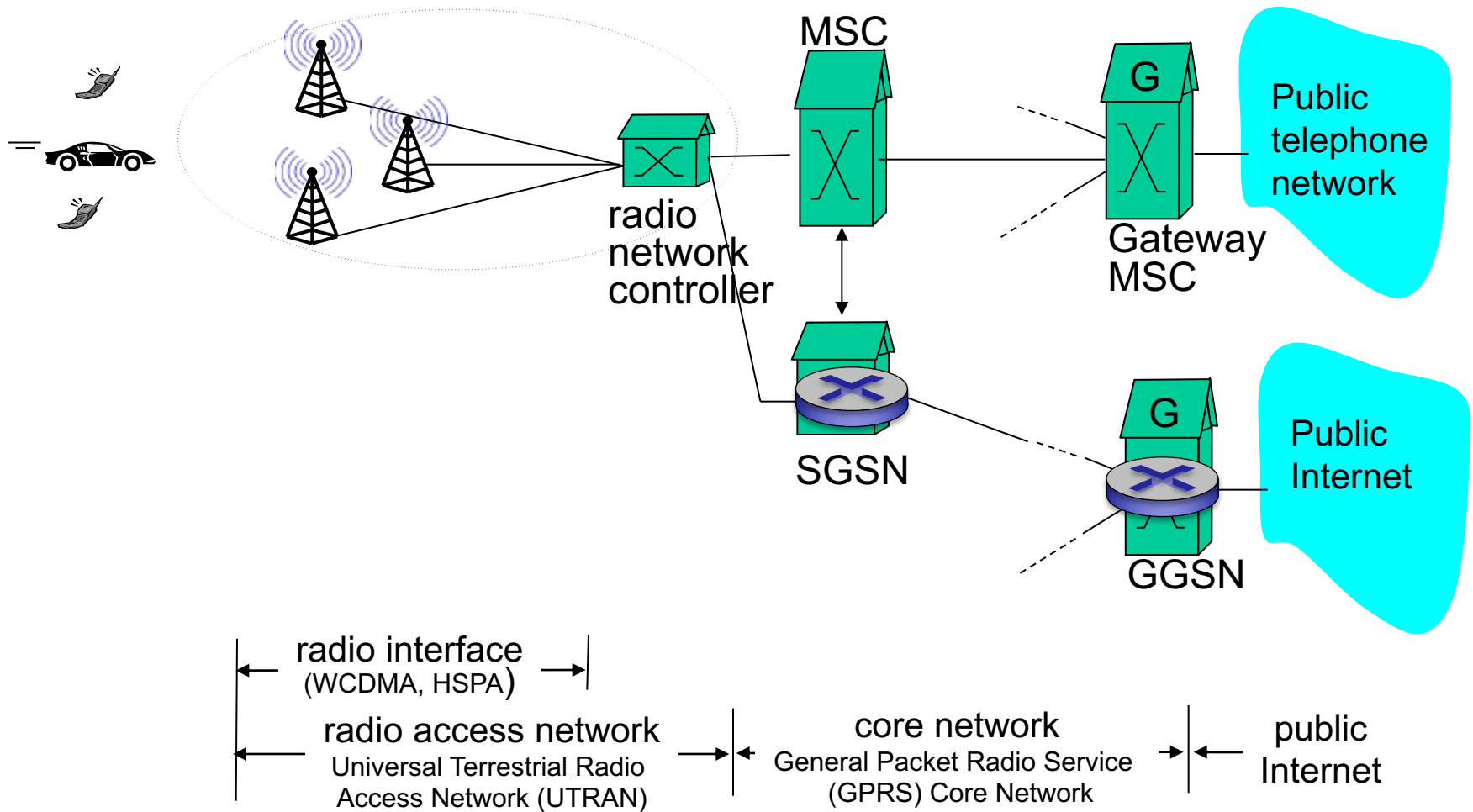
2G (voice) network architecture



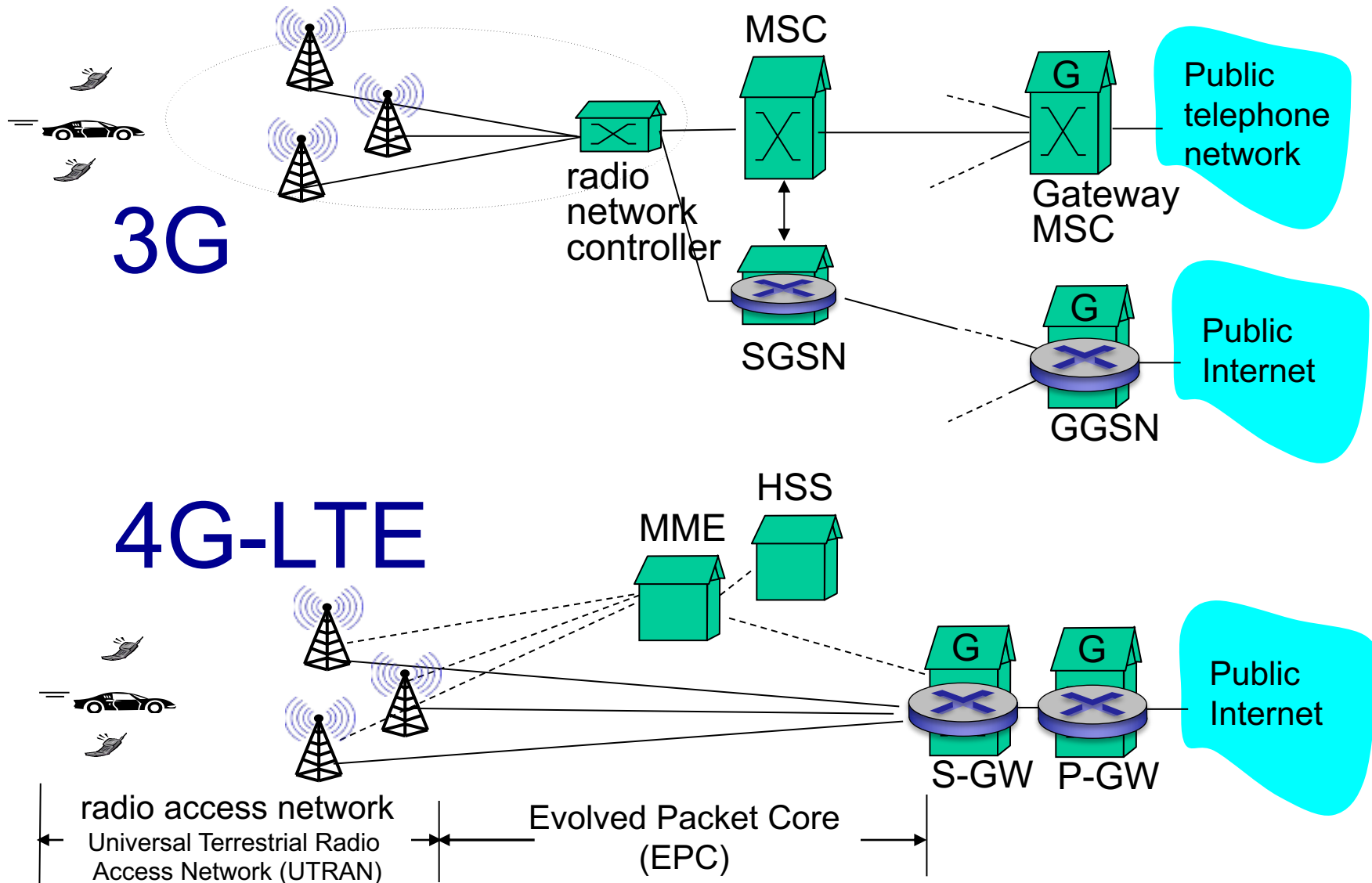
3G (voice+data) network architecture



3G (voice+data) network architecture

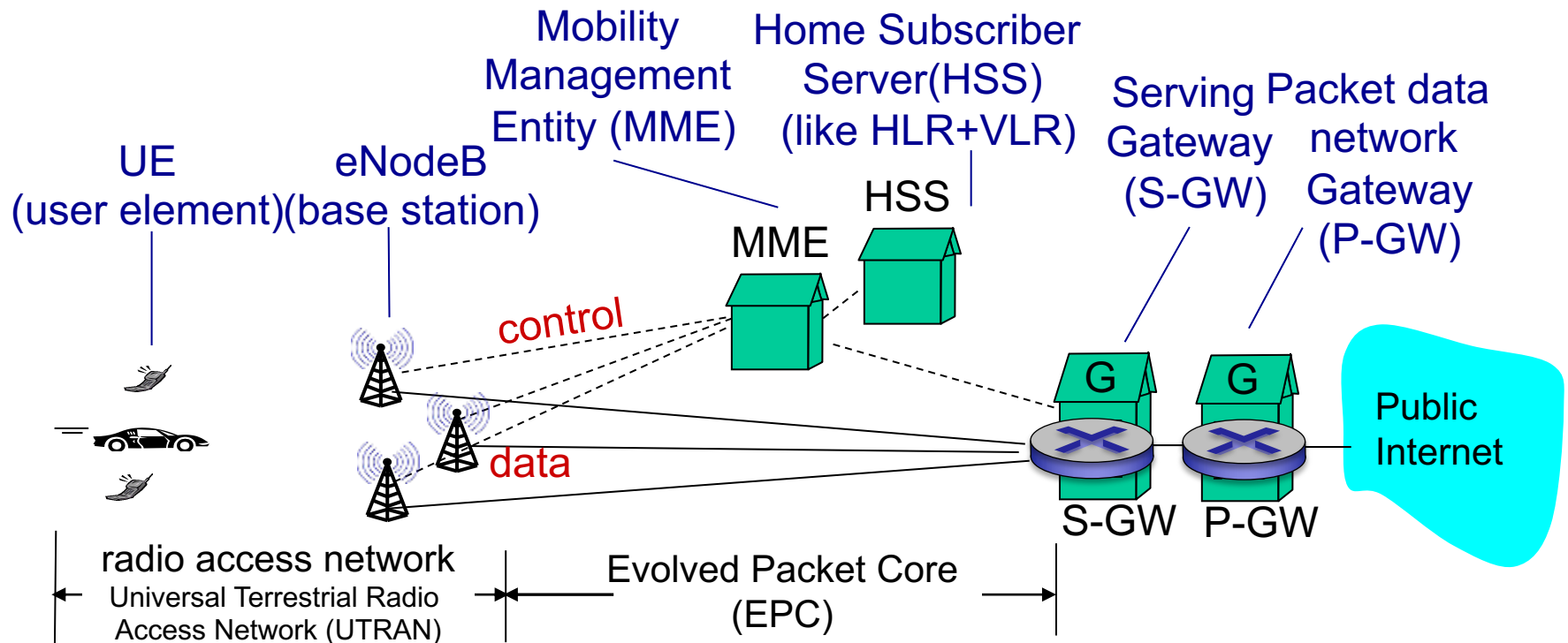


3G versus 4G LTE network architecture



4G: differences from 3G

- all IP core: IP packets tunneled (through core IP network) from base station to gateway
- no separation between voice and data – all traffic carried over IP core to gateway



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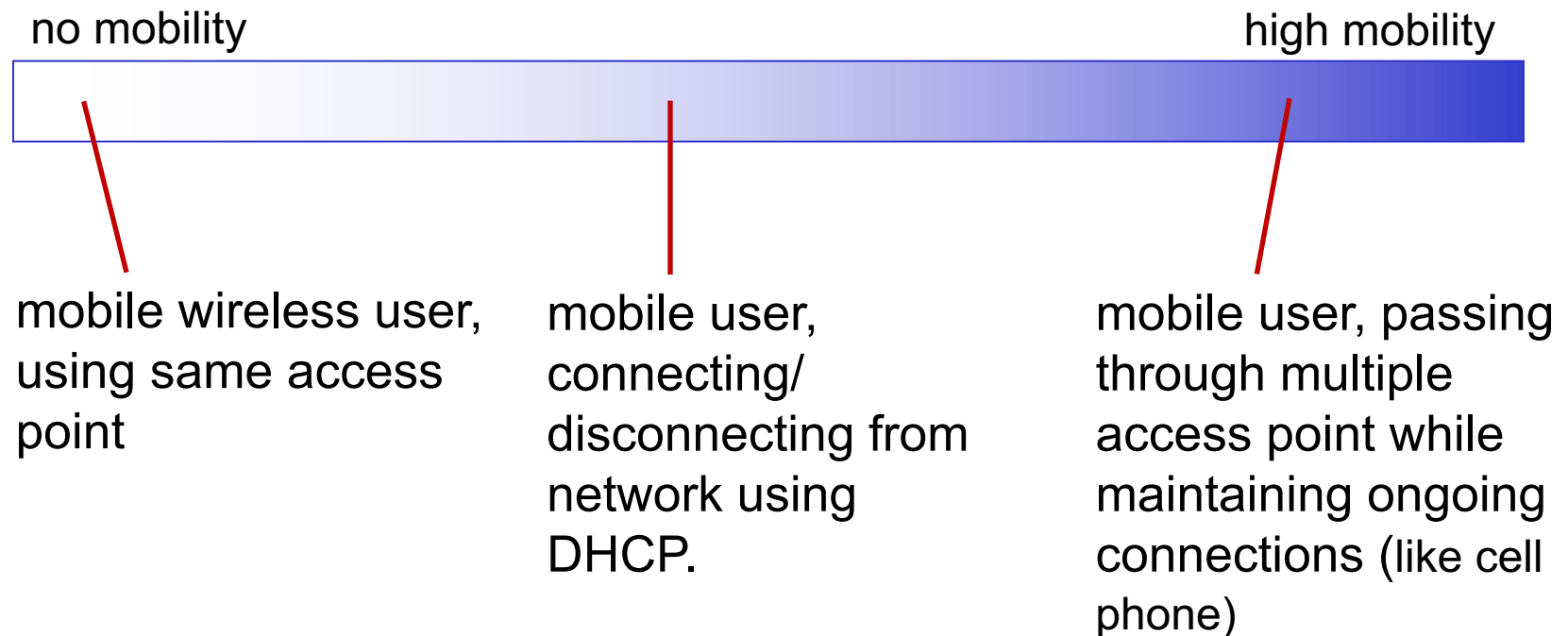
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What is mobility?

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

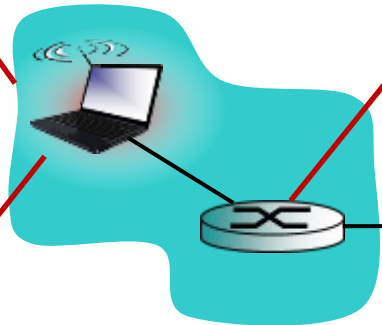


Mobility: vocabulary

home network: permanent
“home” of mobile
(e.g., 128.119.40/24)

home agent: entity that will
perform mobility functions on
behalf of mobile, when mobile is
remote

permanent address:
address in home
network, *can always* be
used to reach mobile
e.g., 128.119.40.186



wide area
network



Mobility: more vocabulary

permanent address: remains constant (e.g., 128.119.40.186)

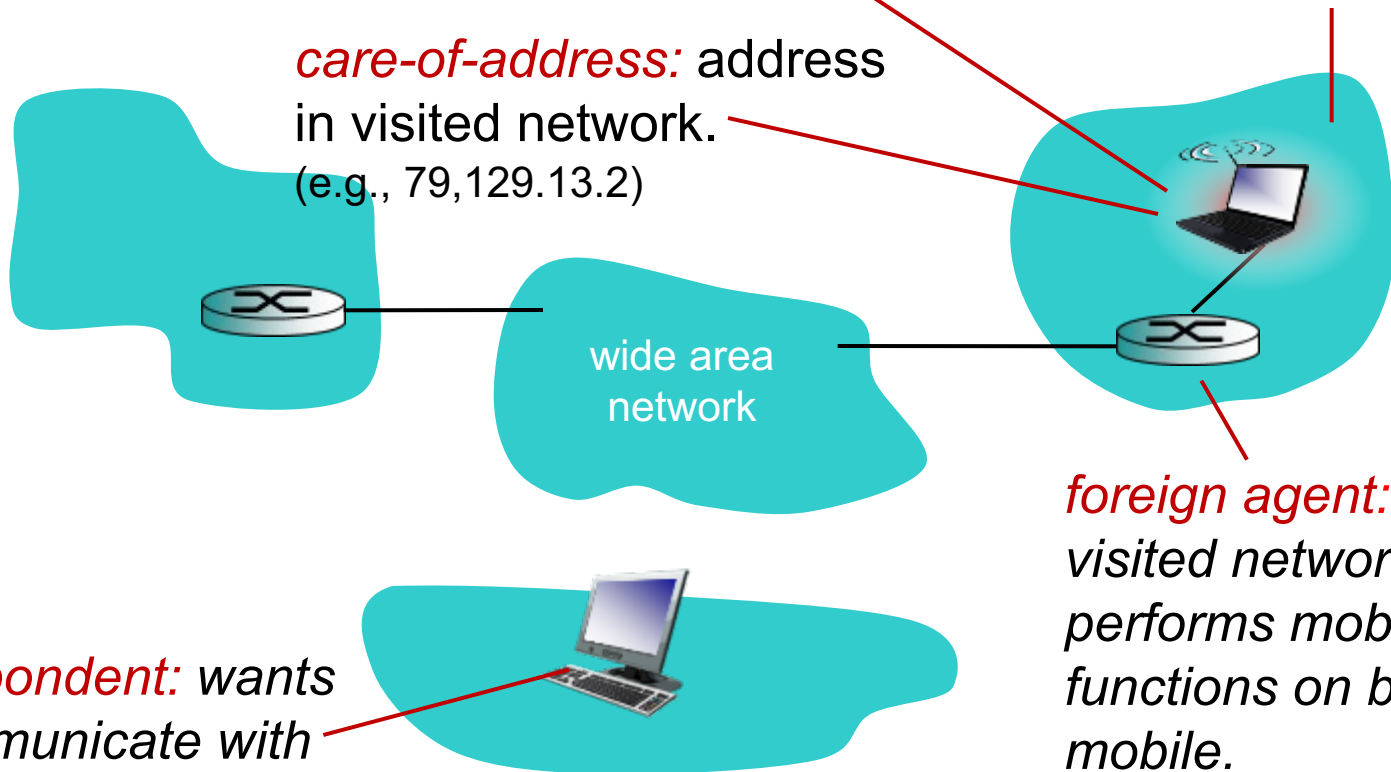
visited network: network in which mobile currently resides (e.g., 79.129.13/24)

care-of-address: address in visited network. (e.g., 79.129.13.2)

wide area network

foreign agent: entity in visited network that performs mobility functions on behalf of mobile.

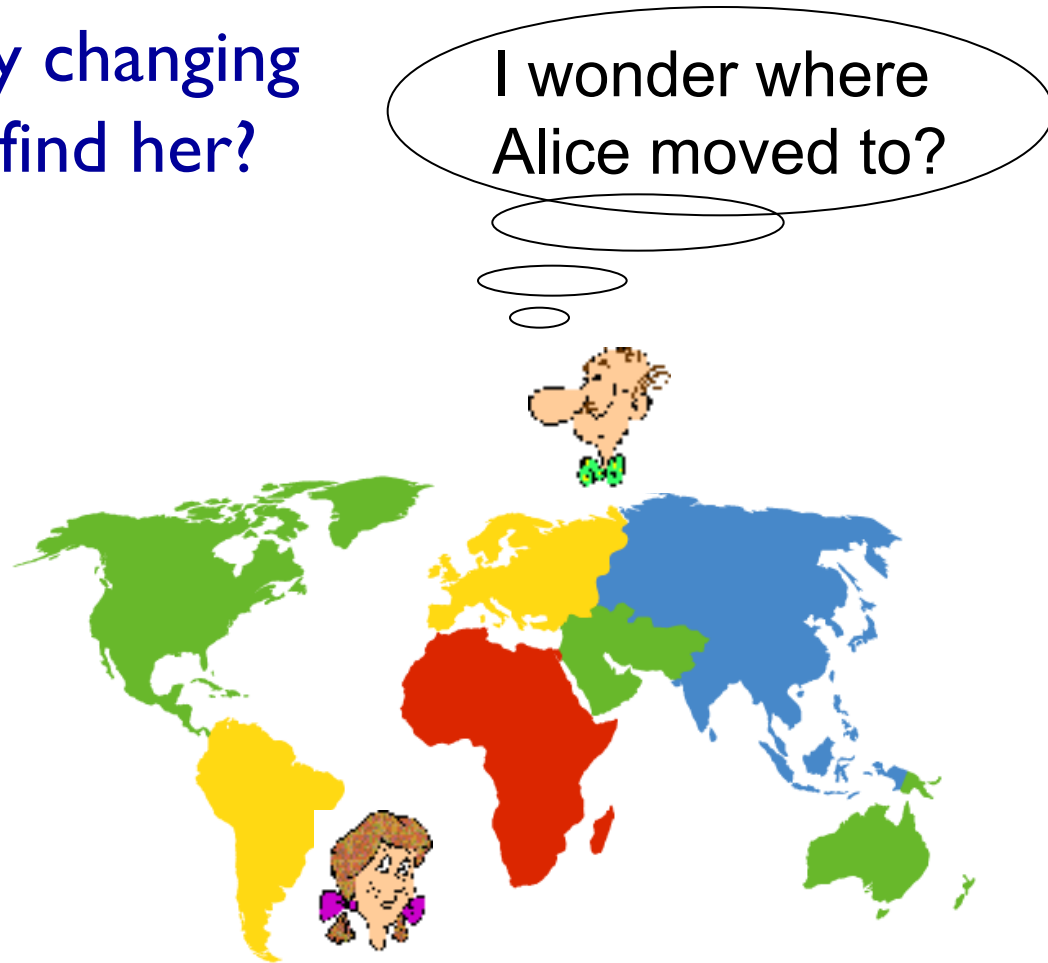
correspondent: wants to communicate with mobile



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?
- Facebook!



Mobility: approaches

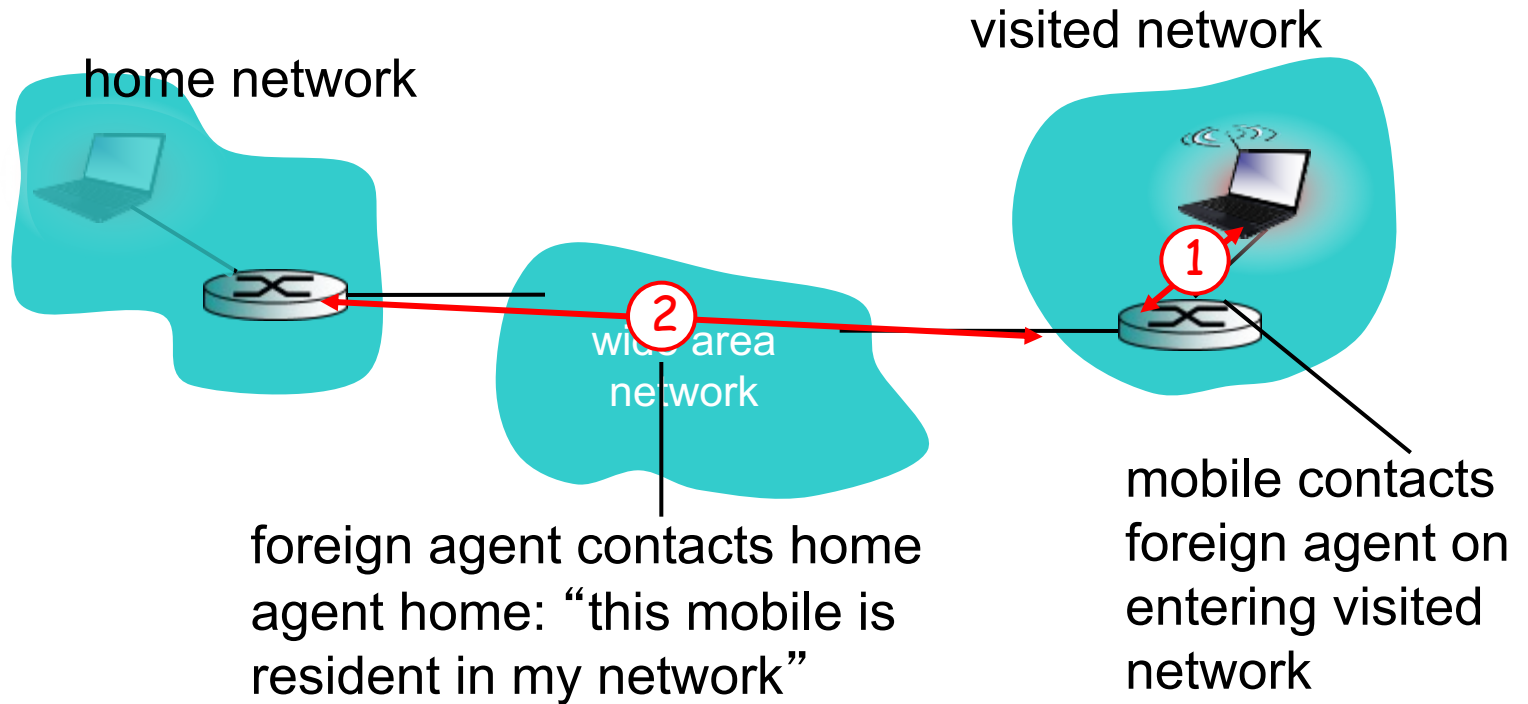
- *let routing handle it:* routers advertise permanent address of mobile-nodes-in-residence via usual routing table exchange.
 - routing tables indicate where each mobile located
 - no changes to end-systems
- *let end-systems handle it:*
 - *indirect routing:* communication from correspondent to mobile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

Mobility: approaches

- *let routing handle it:* routers advertise permanent address of mobile, mobile's residence via usual routing table exchange
 - routing table exchange where each mobile located
 - no changes to routing tables
- *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

not
scalable
to millions of
mobiles

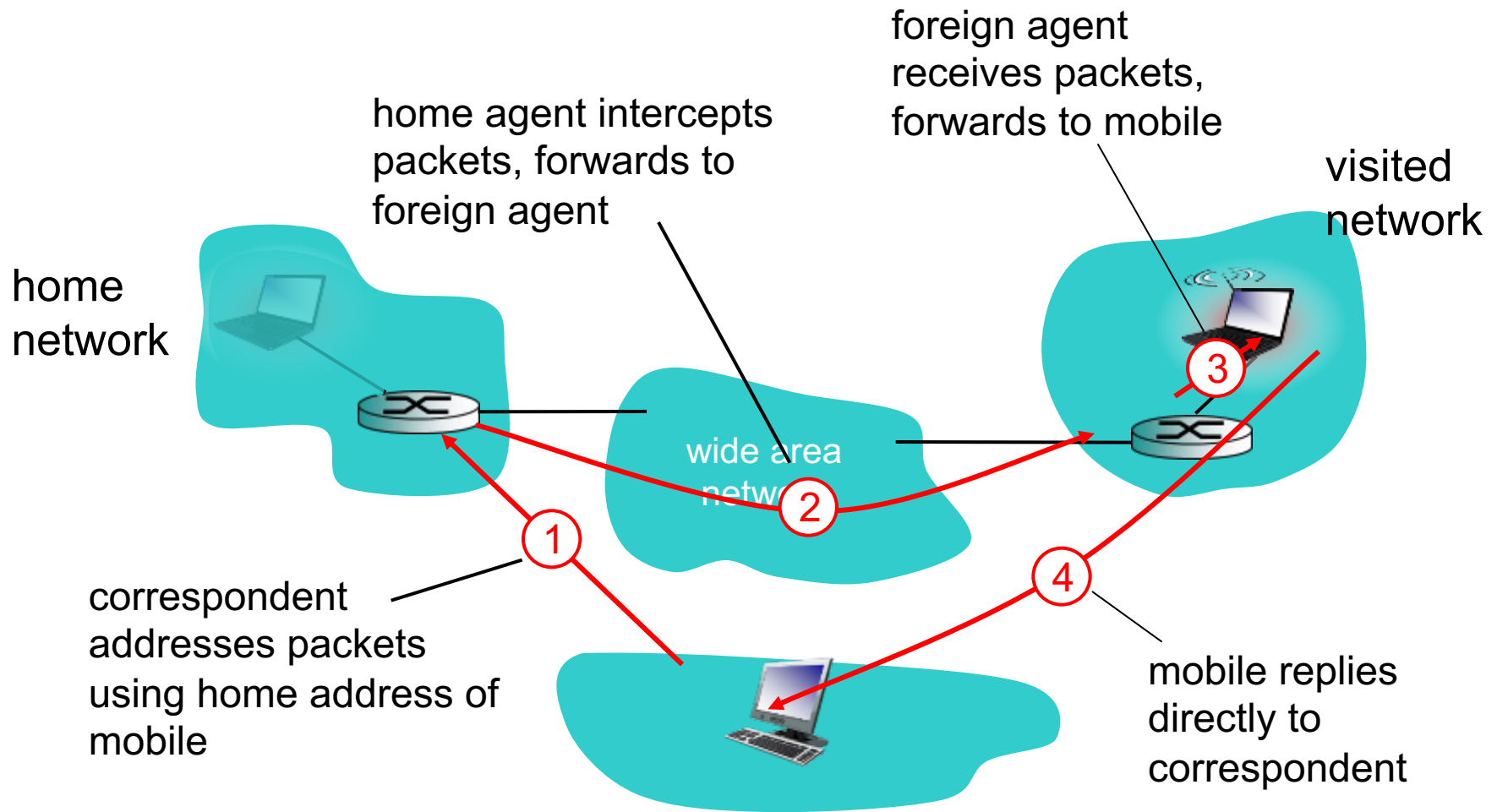
Mobility: registration



end result:

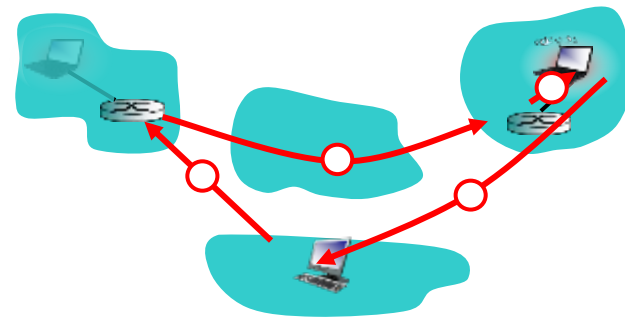
- foreign agent knows about mobile
- home agent knows location of mobile

Mobility via indirect routing



Indirect Routing: comments

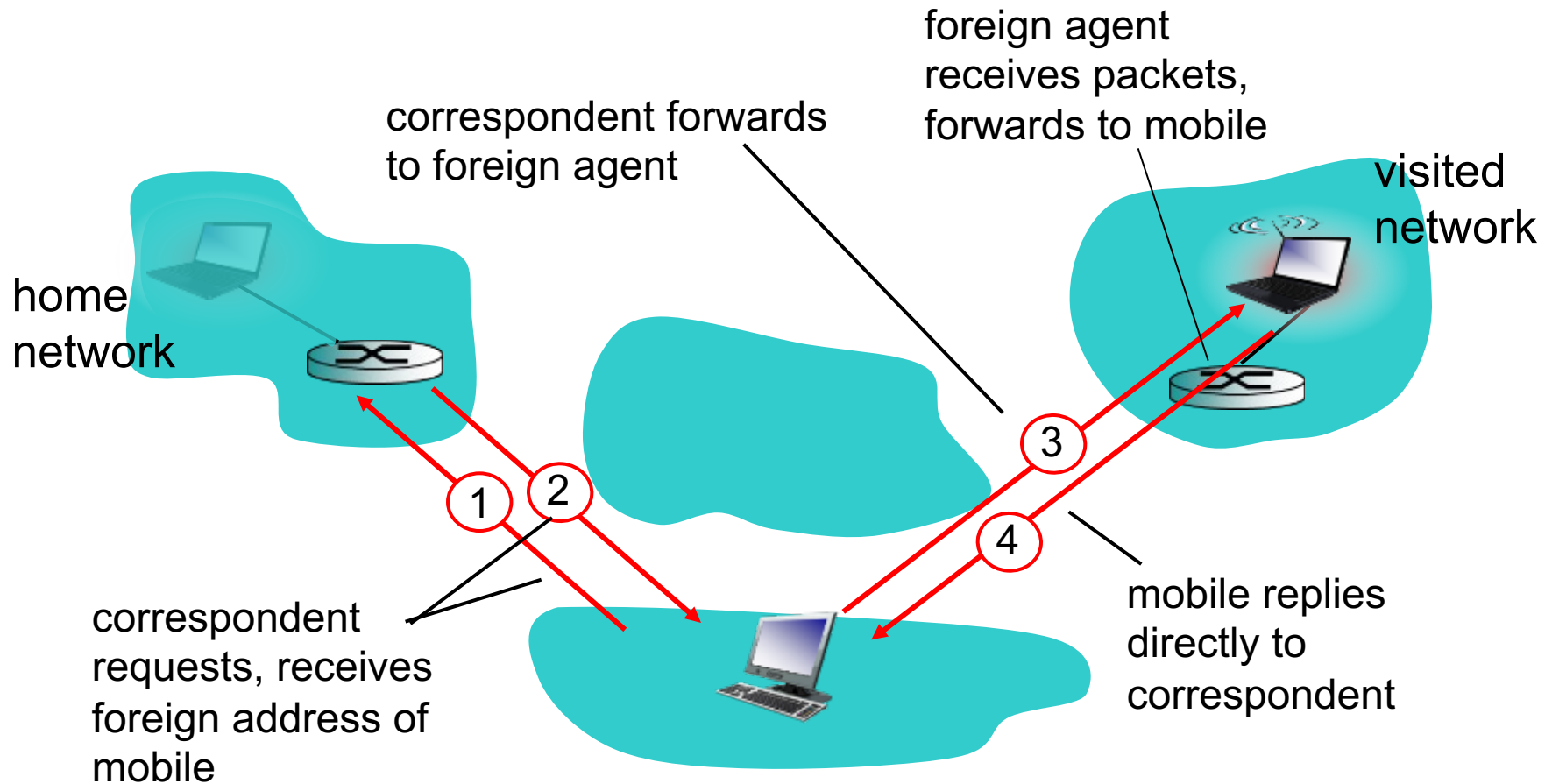
- mobile uses two addresses:
 - **permanent address**: used by correspondent (hence mobile location is *transparent* to correspondent)
 - **care-of-address**: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- **triangle routing**: correspondent-home-network-mobile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



Indirect routing: moving between networks

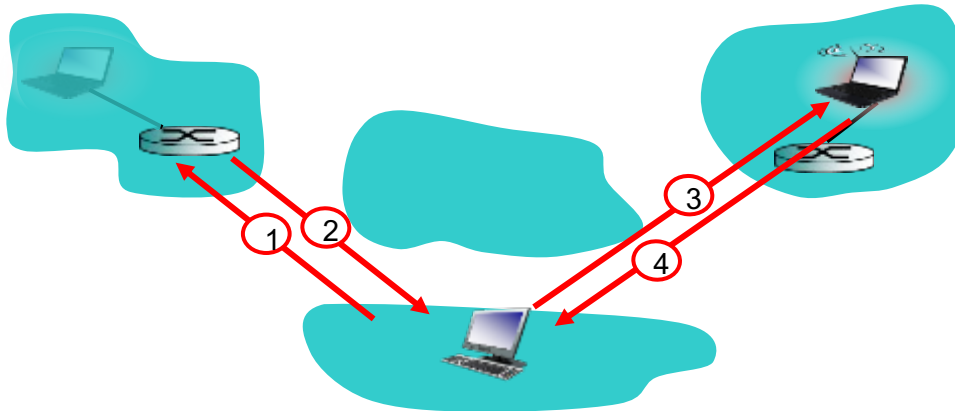
- suppose mobile user moves to another network
 - registers with new foreign agent
 - new foreign agent registers with home agent
 - home agent update care-of-address for mobile
 - packets continue to be forwarded to mobile (but with new care-of-address)
- mobility, changing foreign networks transparent: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

Mobility via direct routing



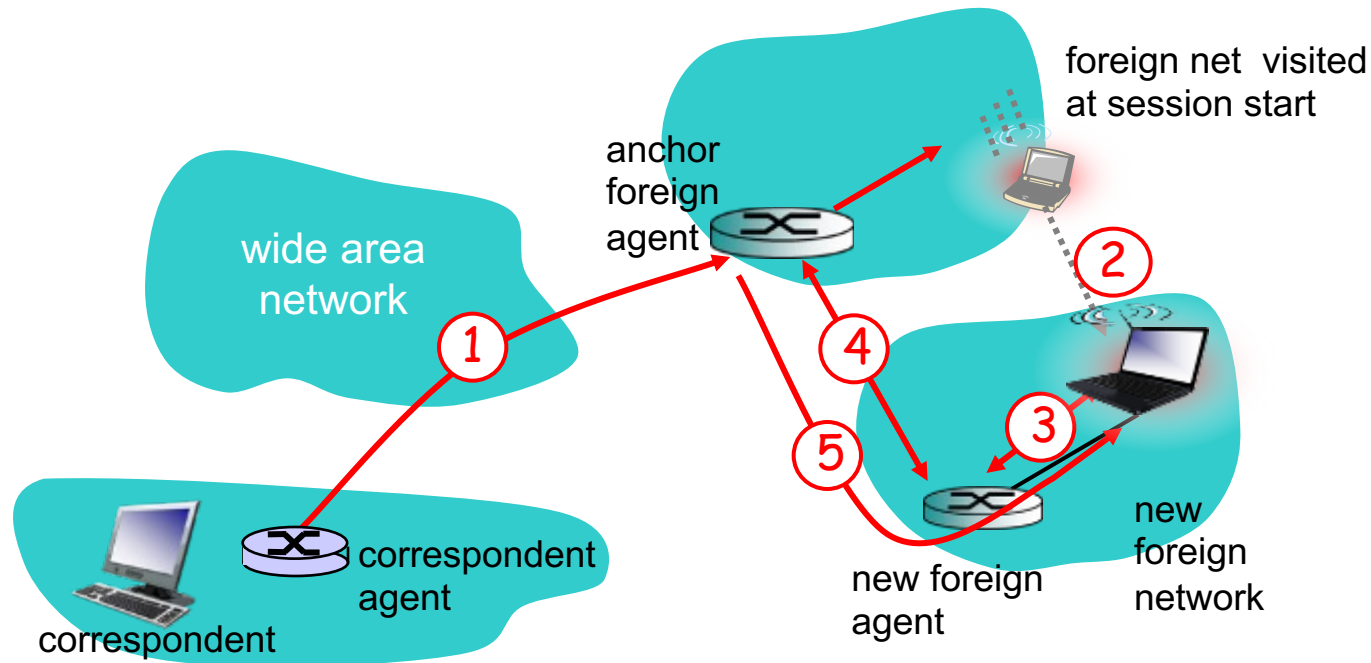
Mobility via direct routing: comments

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



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)



Chapter 7 summary

Wireless

- wireless links:
 - capacity, distance
 - channel impairments
 - CDMA
- IEEE 802.11 (“Wi-Fi”)
 - CSMA/CA reflects wireless channel characteristics
- cellular access
 - architecture
 - standards (e.g., 3G, 4G LTE)

Mobility

- principles: addressing, routing to mobile users
 - home, visited networks
 - direct, indirect routing
 - care-of-addresses

Final Exam

- 2-hours, Closed-book
- no calculator, no cheating sheet
- Covering range:
 - Chapter 3 Transport layer: true or false, multiple choices, fill in blanks
 - Chapters 4-5 Network layer; Chapters 6-7 Link layer