

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

6.6 Mobile IP

6.7 Handling mobility in cellular networks

6.8 Mobility and higher-layer protocols

6.9 Summary

Mobile IP

❖ RFC 3344

❖ has many features we've seen:

- home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)

❖ three mainparts:

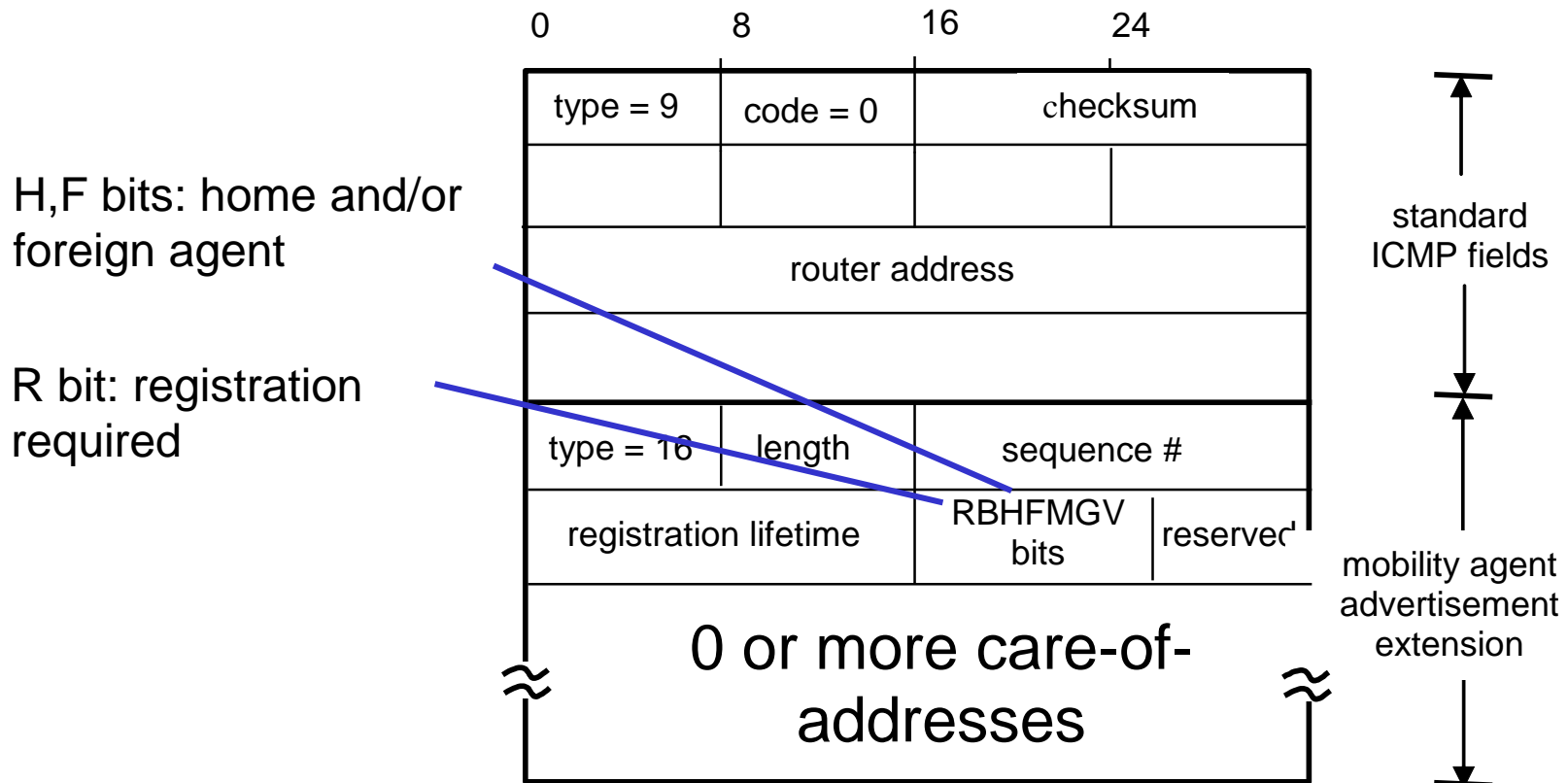
- agent discovery
- registration with home agent
- indirect routing of datagrams

Mobile IP agent discovery

- ❖ Agent discovery dictates how a mobile agent discovers information about the home or foreign agent it has just connected to

Mobile IP: agent discovery

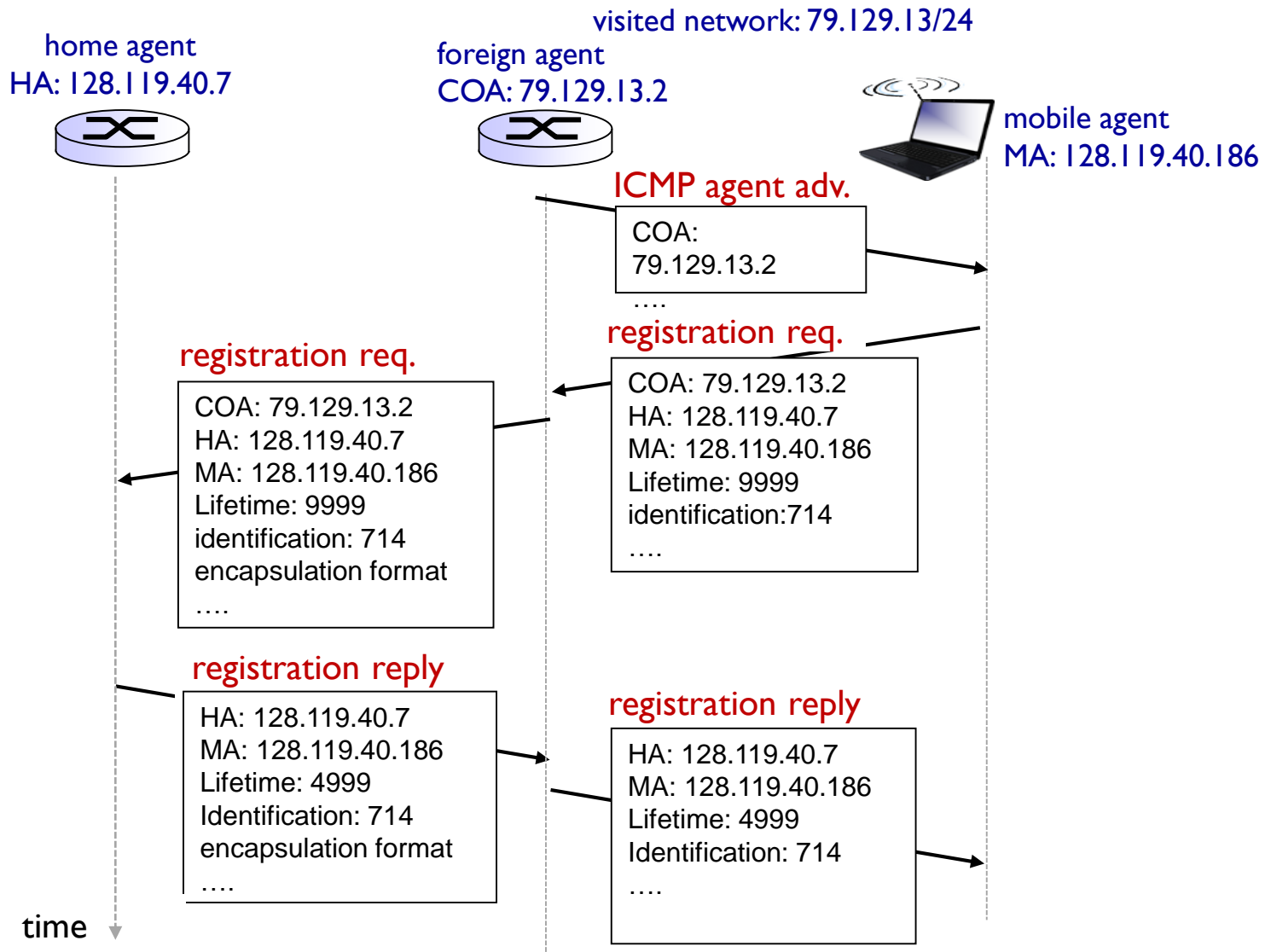
- ❖ *agent advertisement*: foreign/home agents advertise service by broadcasting ICMP messages (typefield = 9)



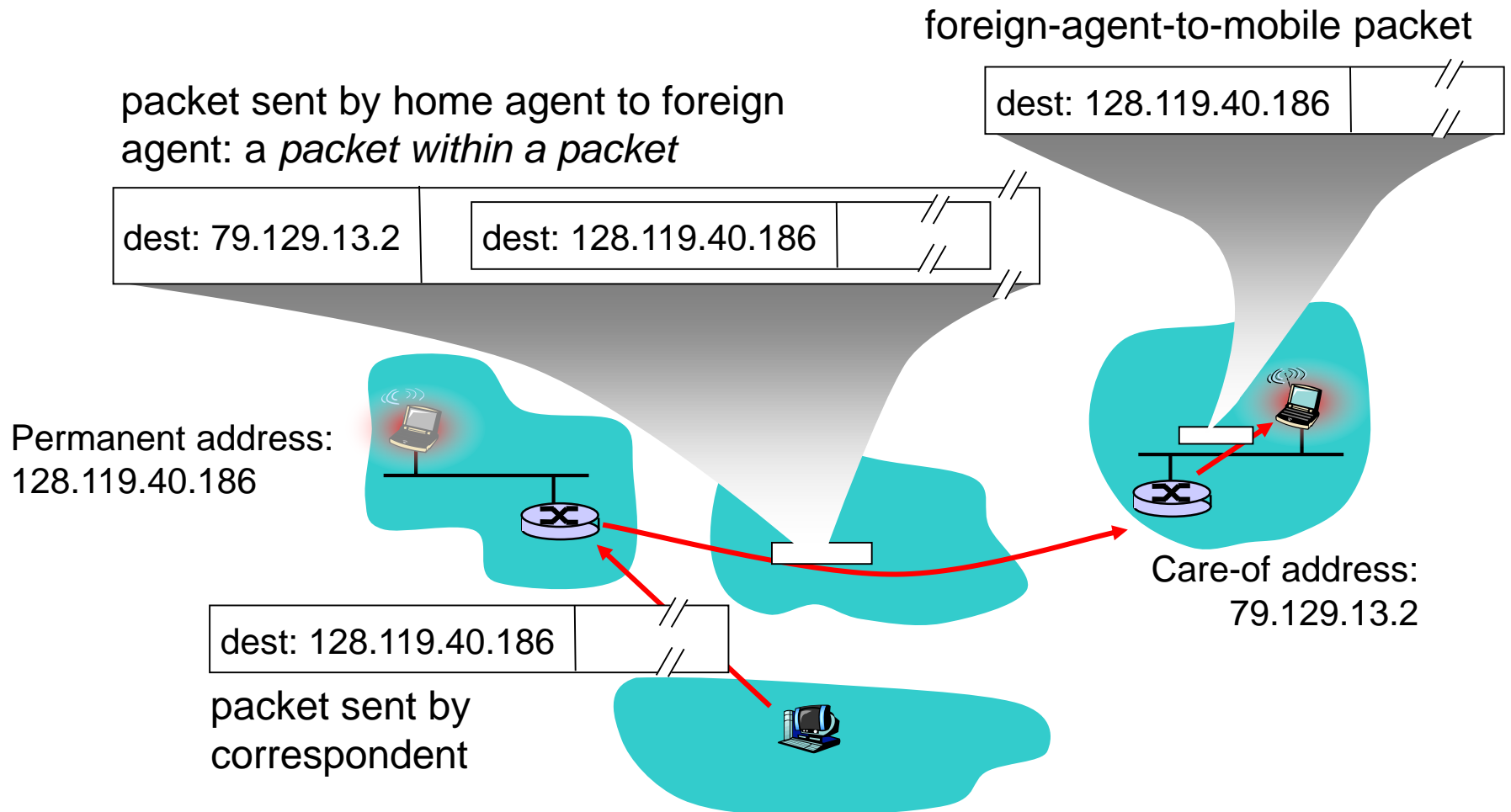
Mobile IP registration

- ❖ Agent discovery gets the mobile agent the information it needs; the next step is to phone home
- ❖ The registration process dictates how the mobile agent registers care of addresses (COAs) with its home agent.

Mobile IP: registration example

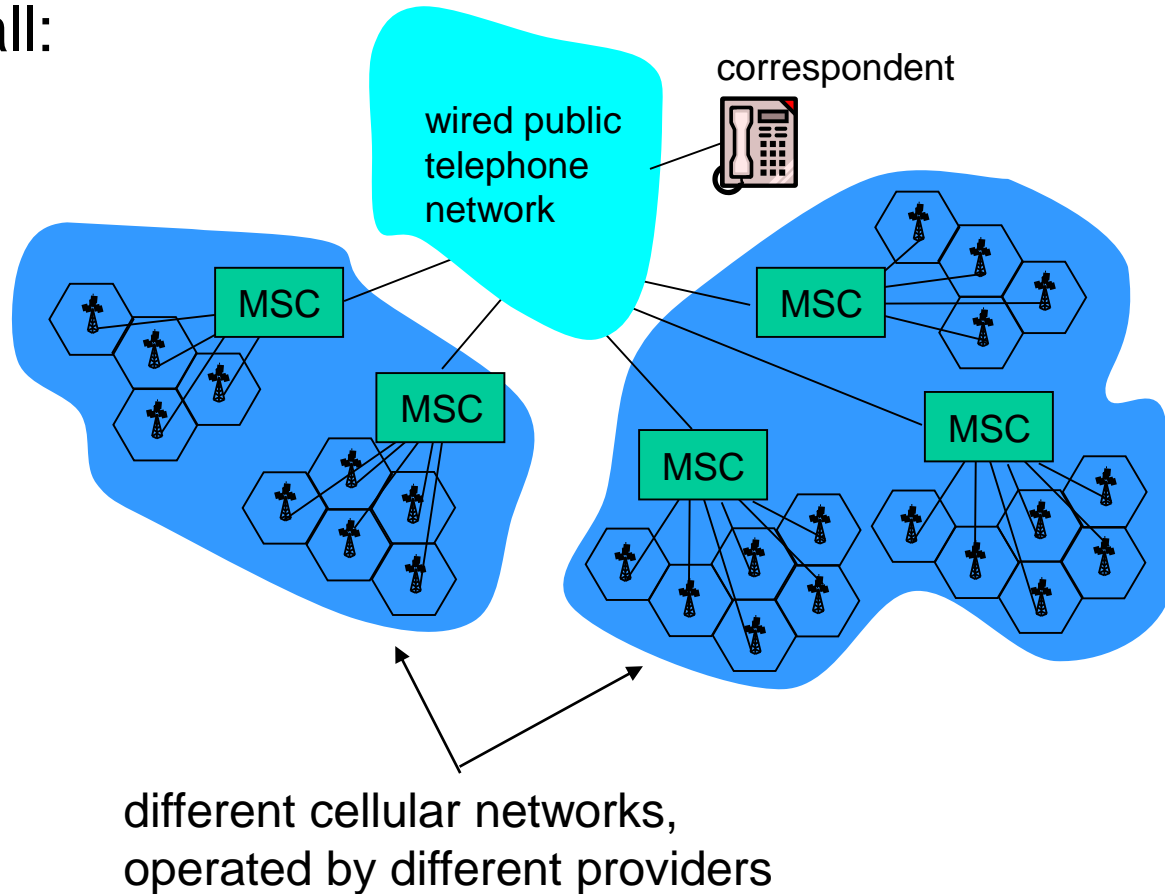


Mobile IP: indirect routing



Components of cellular network architecture

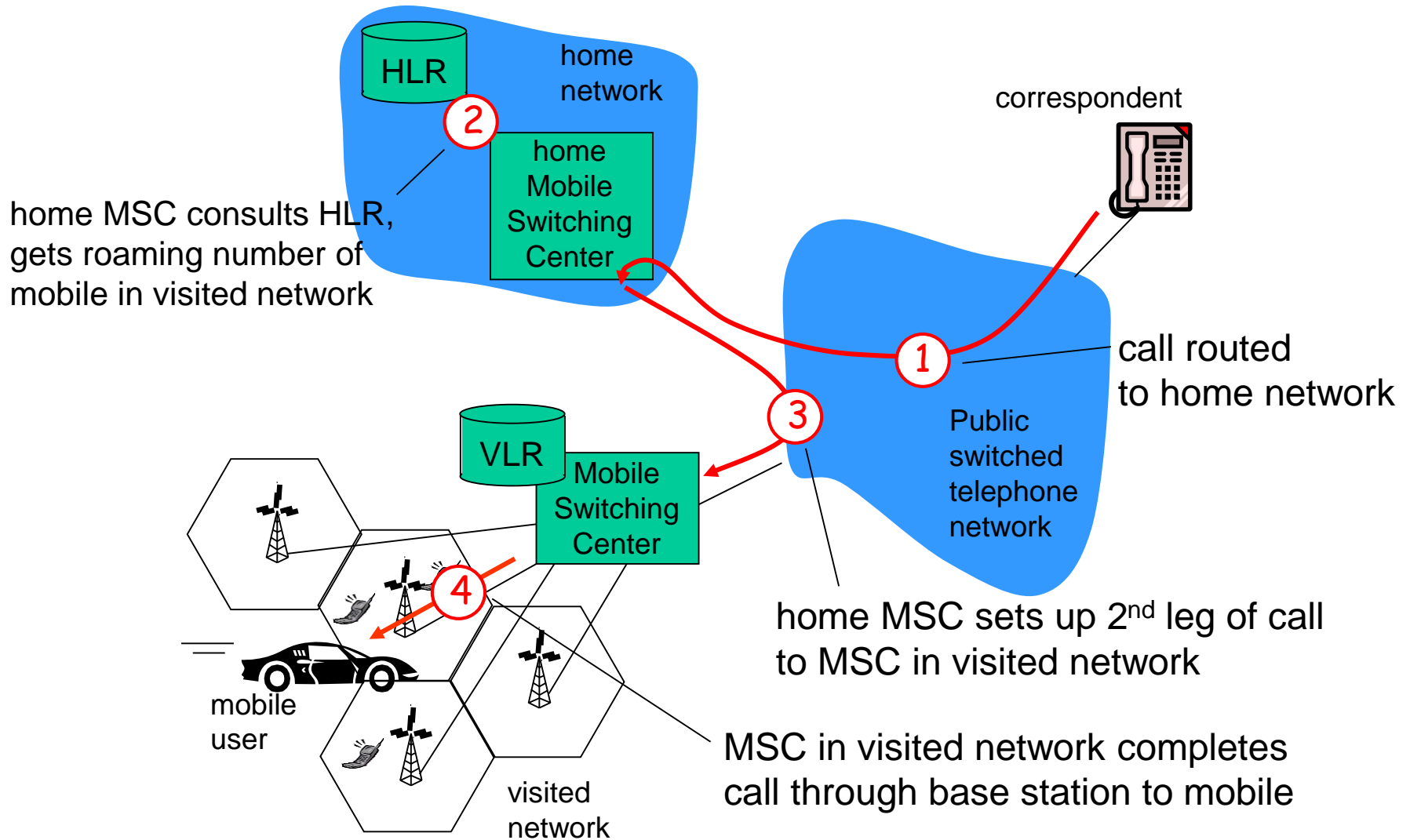
recall:



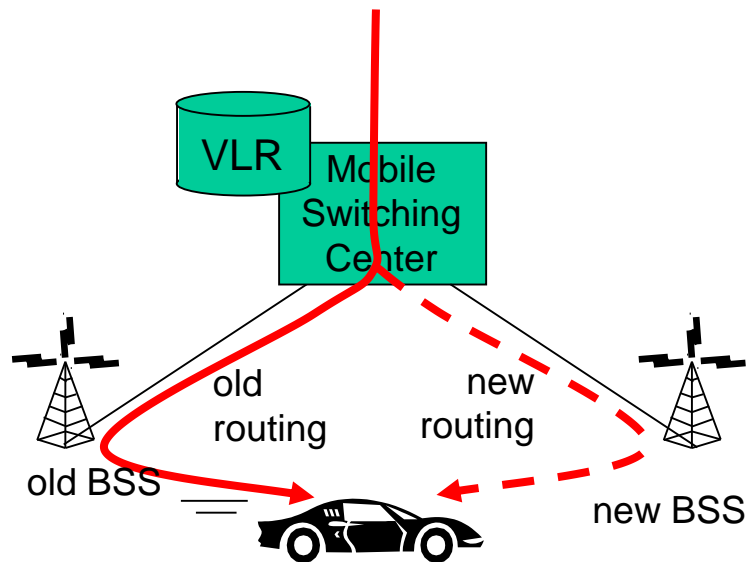
Handling mobility in cellular networks

- ❖ *home network*: network of cellular provider you subscribe to (e.g., Sprint PCS, Verizon)
 - *home location register (HLR)*: database in home network containing permanent cell phone #, profile information (services, preferences, billing), information about current location (could be in another network)
- ❖ *visited network*: network in which mobile currently resides
 - *visitor location register (VLR)*: database with entry for each user currently in network
 - could be home network

GSM: indirect routing to mobile

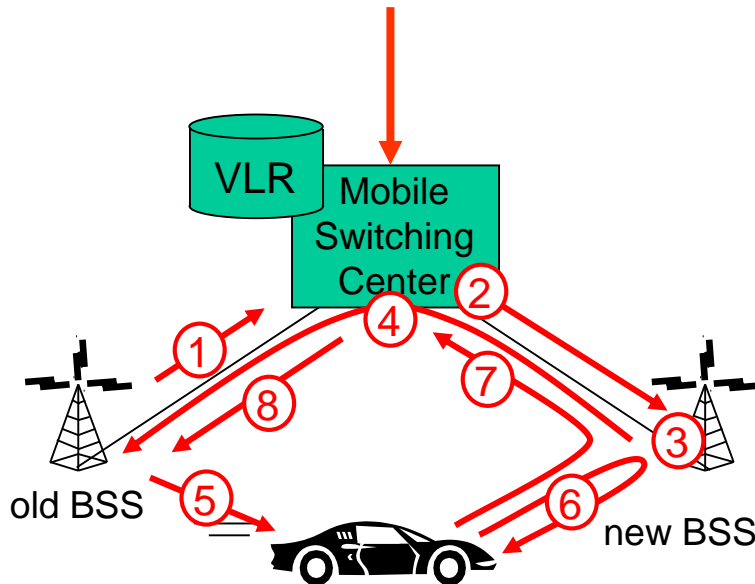


GSM: handoff with common MSC



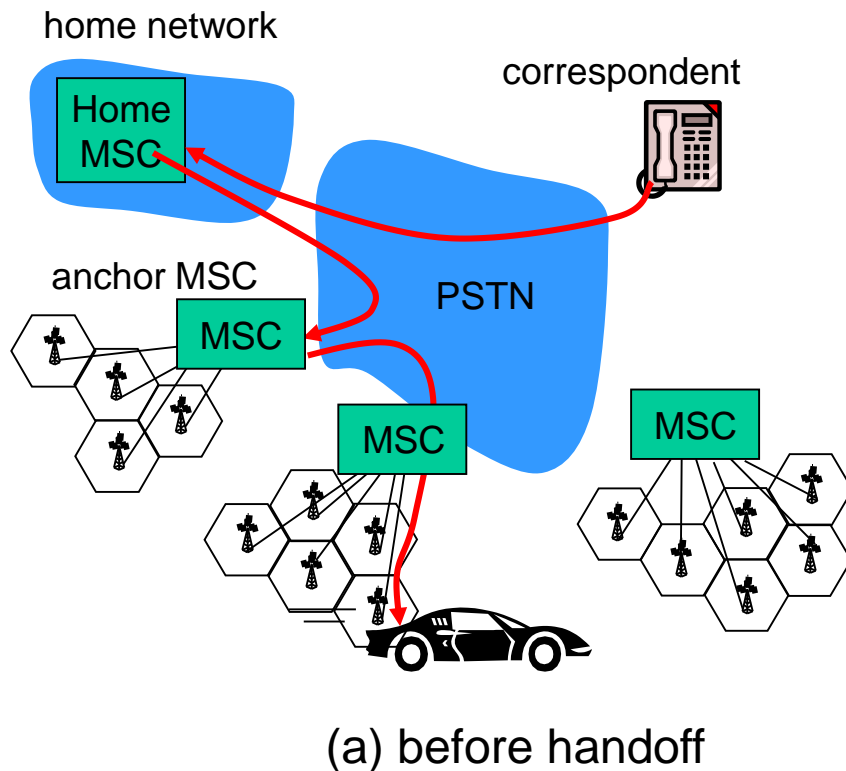
- ❖ *handoff goal*: route call via new base station (without interruption)
- ❖ reasons for handoff:
 - stronger signal to/from new BSS (continuing connectivity, less battery drain)
 - load balance: free up channel in current BSS
 - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)
- ❖ handoff initiated by old BSS

GSM: handoff with common MSC



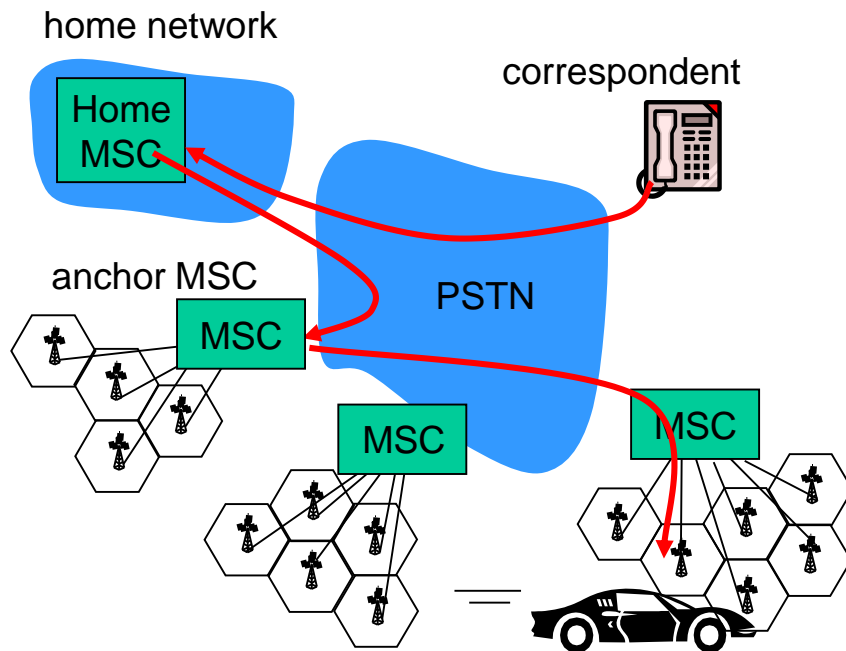
1. old BSS informs MSC of impending handoff, provides list of 1+ new BSSs
2. MSC sets up path (allocates resources) to new BSS
3. new BSS allocates radio channel for use by mobile
4. new BSS signals MSC and old BSS: ready for handoff
5. old BSS tells mobile: perform handoff to new BSS
6. mobile and new BSS communicate to activate new channel
7. mobile signals via new BSS to MSC: handoff complete. MSC reroutes call
8. MSC-old-BSS resources released

GSM: handoff between MSCs



- ❖ *anchor MSC*: first MSC visited during call
 - call remains routed through anchor MSC
- ❖ new MSCs add on to end of MSC chain as mobile moves to new MSC
- ❖ optional path minimization step to shorten multi-MSC chain

GSM: handoff between MSCs



(b) after handoff

- ❖ *anchor MSC*: first MSC visited during call
 - call remains routed through anchor MSC
- ❖ new MSCs add on to end of MSC chain as mobile moves to new MSC
- ❖ optional path minimization step to shorten multi-MSC chain

Mobility: GSM versus Mobile IP

GSM element	Comment on GSM element	Mobile IP element
Home system	Network to which mobile user's permanent phone number belongs	Home network
Gateway Mobile Switching Center, or "home MSC". Home Location Register (HLR)	Home MSC: point of contact to obtain routable address of mobile user. HLR: database in home system containing permanent phone number, profile information, current location of mobile user, subscription information	Home agent
Visited System	Network other than home system where mobile user is currently residing	Visited network
Visited Mobile services Switching Center. Visitor Location Record (VLR)	Visited MSC: responsible for setting up calls to/from mobile nodes in cells associated with MSC. VLR: temporary database entry in visited system, containing subscription information for each visiting mobile user	Foreign agent
Mobile Station Roaming Number (MSRN), or "roaming number"	Routable address for telephone call segment between home MSC and visited MSC, visible to neither the mobile nor the correspondent.	Care-of-address

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Wireless, mobility: impact on higher layer protocols

- ❖ logically, impact *should* be minimal ...
 - best effort service model remains unchanged
 - TCP and UDP can (and do) run over wireless, mobile
- ❖ ... but performance-wise:
 - packet loss/delay due to bit-errors (discarded packets, delays for link-layer retransmissions), and handoff
 - TCP interprets loss as *congestion*, will decrease congestion window unnecessarily
 - delay impairments for real-time traffic
 - limited bandwidth of wireless links

Wireless, mobility: impact on higher layer protocols

- ❖ Three broad classes of approaches to solve this unnecessary drop in transfer rate:
 - Local recovery
 - TCP sender awareness of wireless links
 - Split-connection approaches

Wireless, mobility: Local recovery

- ❖ Attempts to solve the local bit errors that occur before “alerting” TCP to their presence by sending or dropping mangled packets
 - 802.11 ARQ : Automatic Repeat reQuest
 - Allows the *link-layer nodes* to request retransmissions similar to TCP
 - Uses a sliding window of packets under consideration – places limits on number of packets being communicated at once
- ❖ Hardware has to be specifically built for this

Wireless, mobility: TCP sender awareness

- ❖ Hosts are explicitly aware of wireless links, and are tolerant of the different types of losses
- ❖ Distinguishes between congestion losses, and corruption/loss events

Wireless, mobility: Split-connection approaches

- ❖ Splits up a TCP connection into two segments: the wired component, and the wireless component
- ❖ The original sender and destination are unaware of the packet manipulation going on
- ❖ The segment over the wireless link can be either a TCP connection or a specially-crafted error recovery protocol on top of UDP
 - Q: What does error recovery on top of UDP look like?

Congratulations!

- ❖ You made it!
- ❖ Next lecture: Final Review
- ❖ Consider taking:
 - CS312: Linux System Administration
 - CS344 (probably already taken this...)
 - CS476 Advanced Computer Networking
 - CS478 Network Security

Chapter 6 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., GSM, 3G, 4G LTE)
- ❖ Low bandwidth implications

Mobility

- ❖ principles: addressing, routing to mobile users
 - home, visited networks
 - direct, indirect routing
 - care-of-addresses
- ❖ case studies
 - mobile IP
 - mobility in GSM
- ❖ impact on higher-layer protocols