

# 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

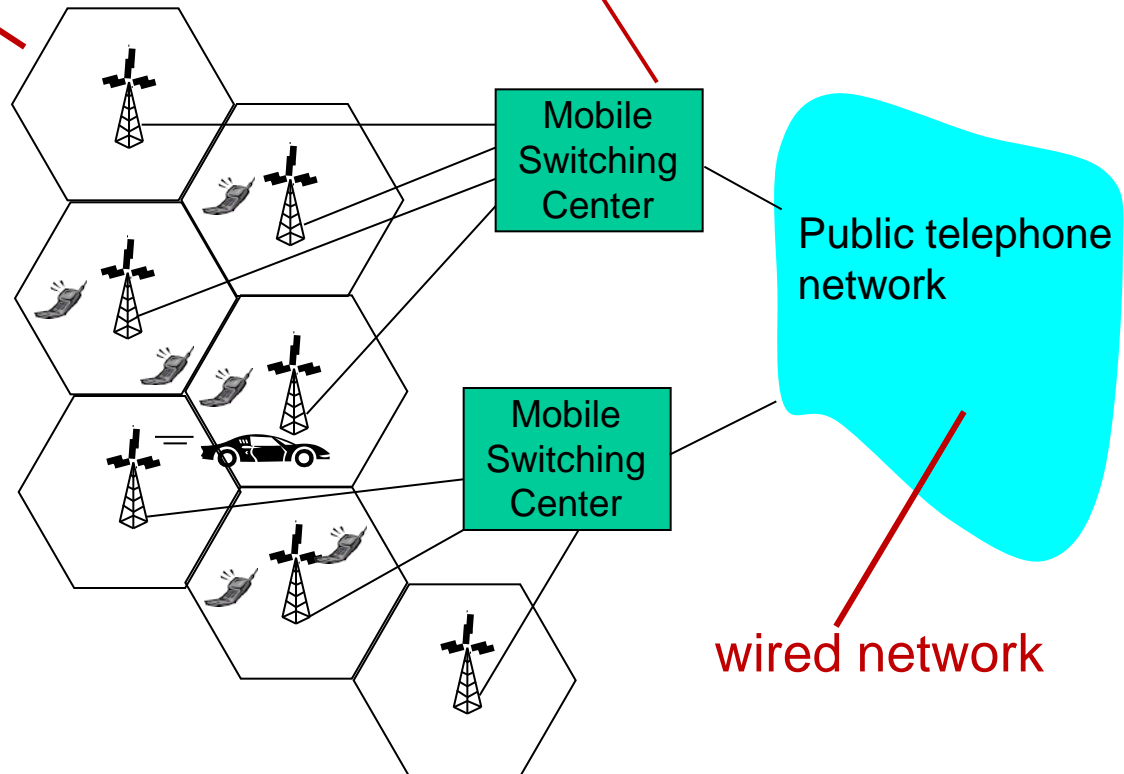
# Components of cellular network architecture

## 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

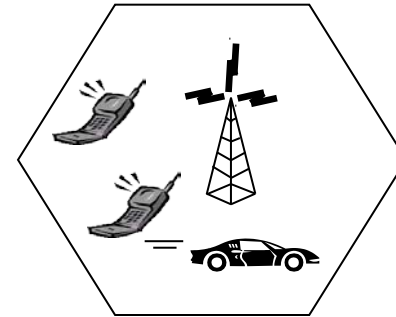
- ❖ connects cells to wired tel. net.
- ❖ manages call setup (more later!)
- ❖ handles mobility (more later!)



# Cellular networks: the first hop

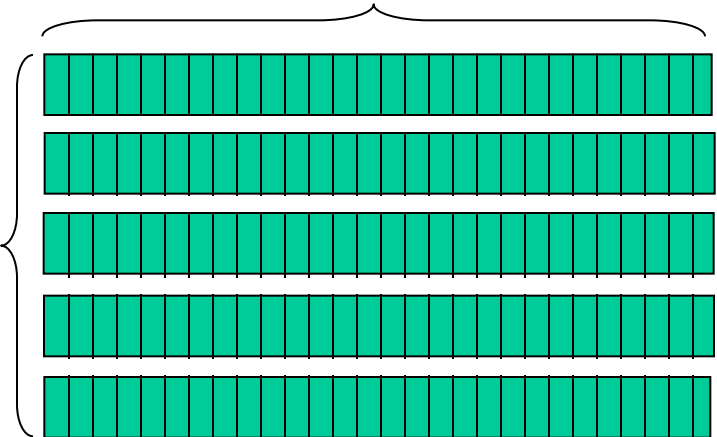
Two techniques for sharing  
mobile-to-BS radio spectrum

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

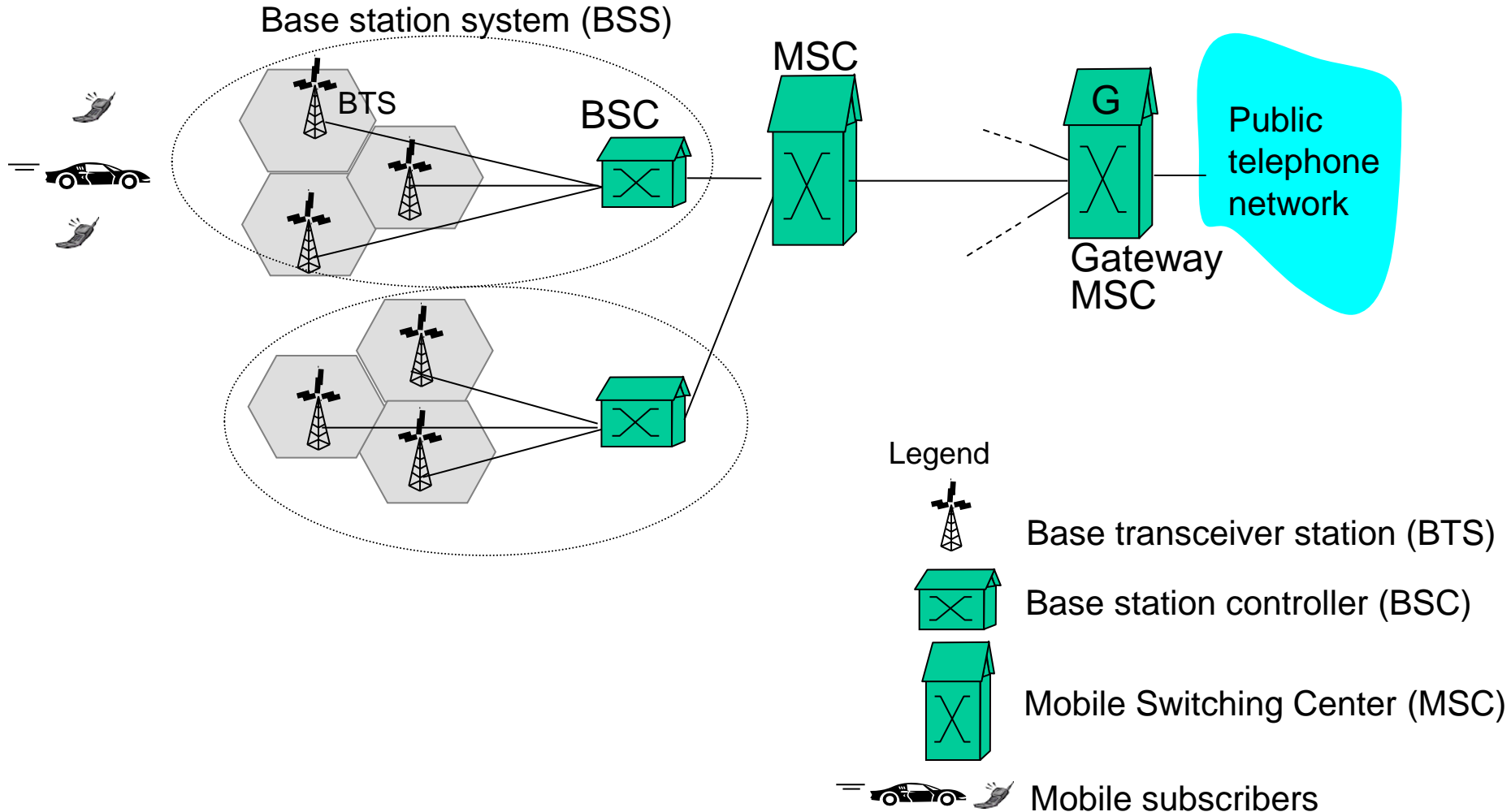


time slots

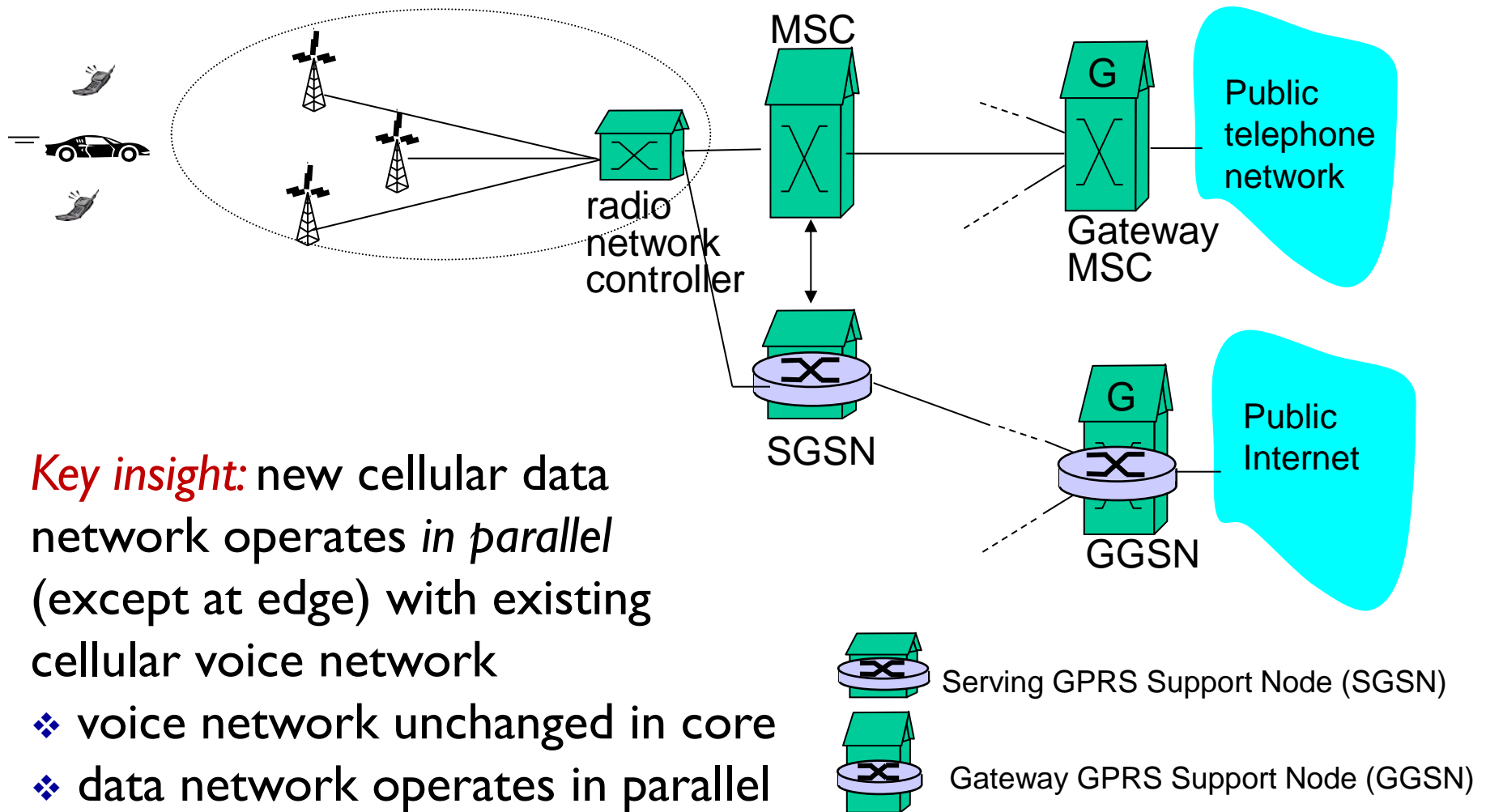
frequency  
bands



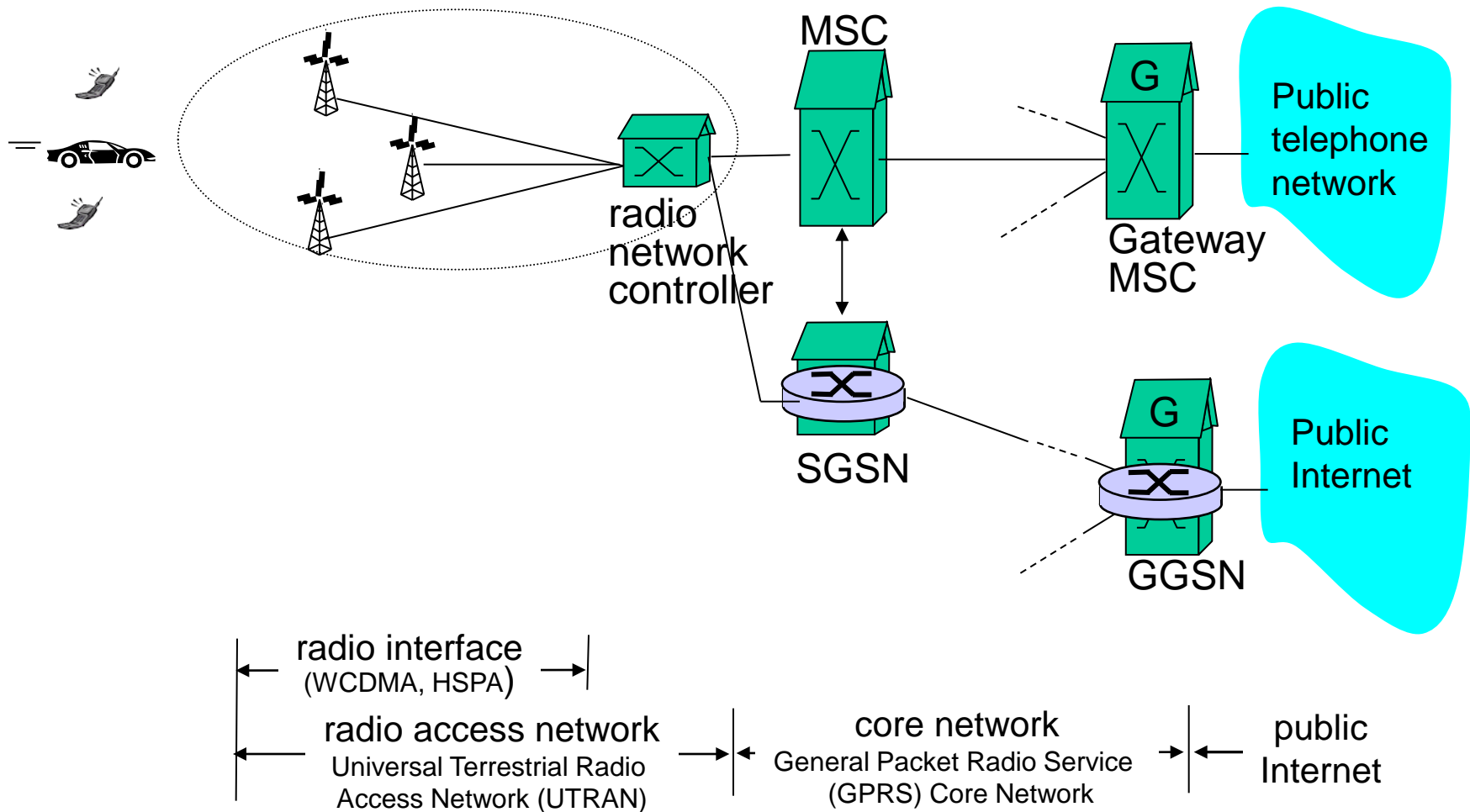
# 2G (voice) network architecture



# 3G (voice+data) network architecture



# 3G (voice+data) network architecture



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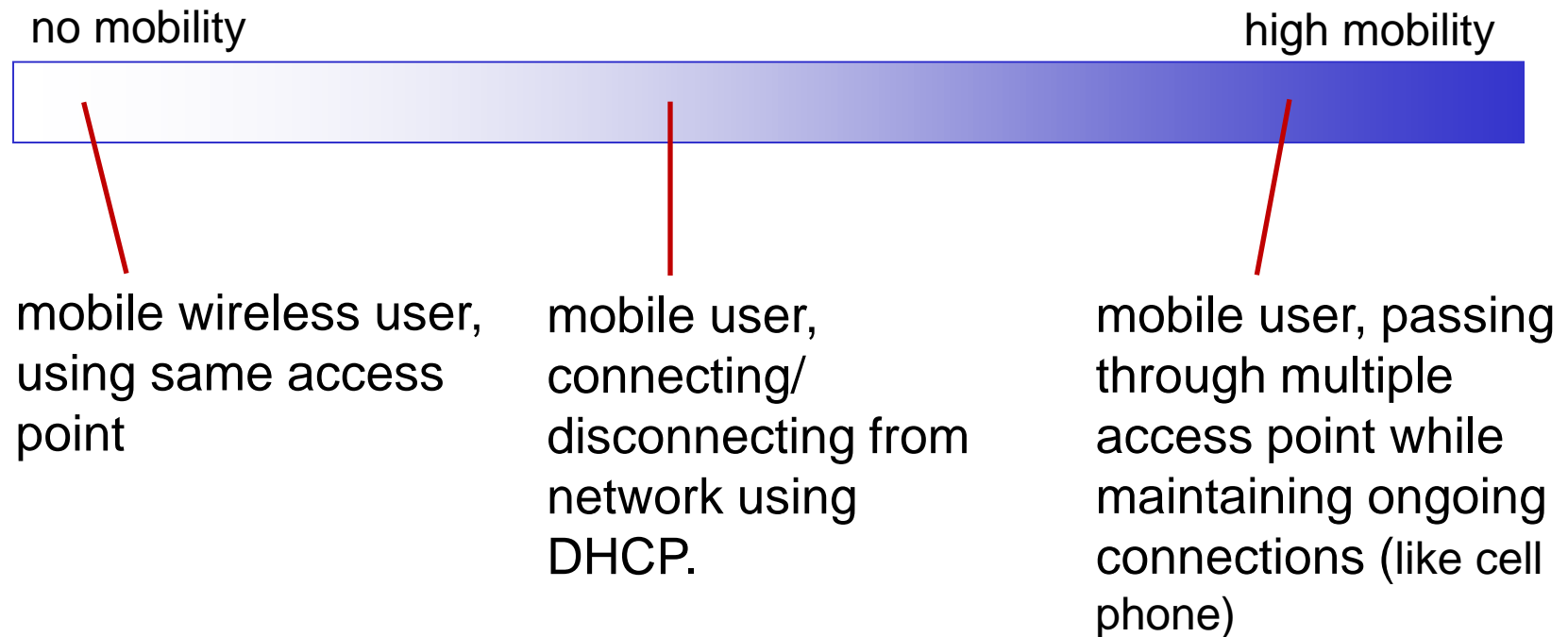
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# What is mobility?

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



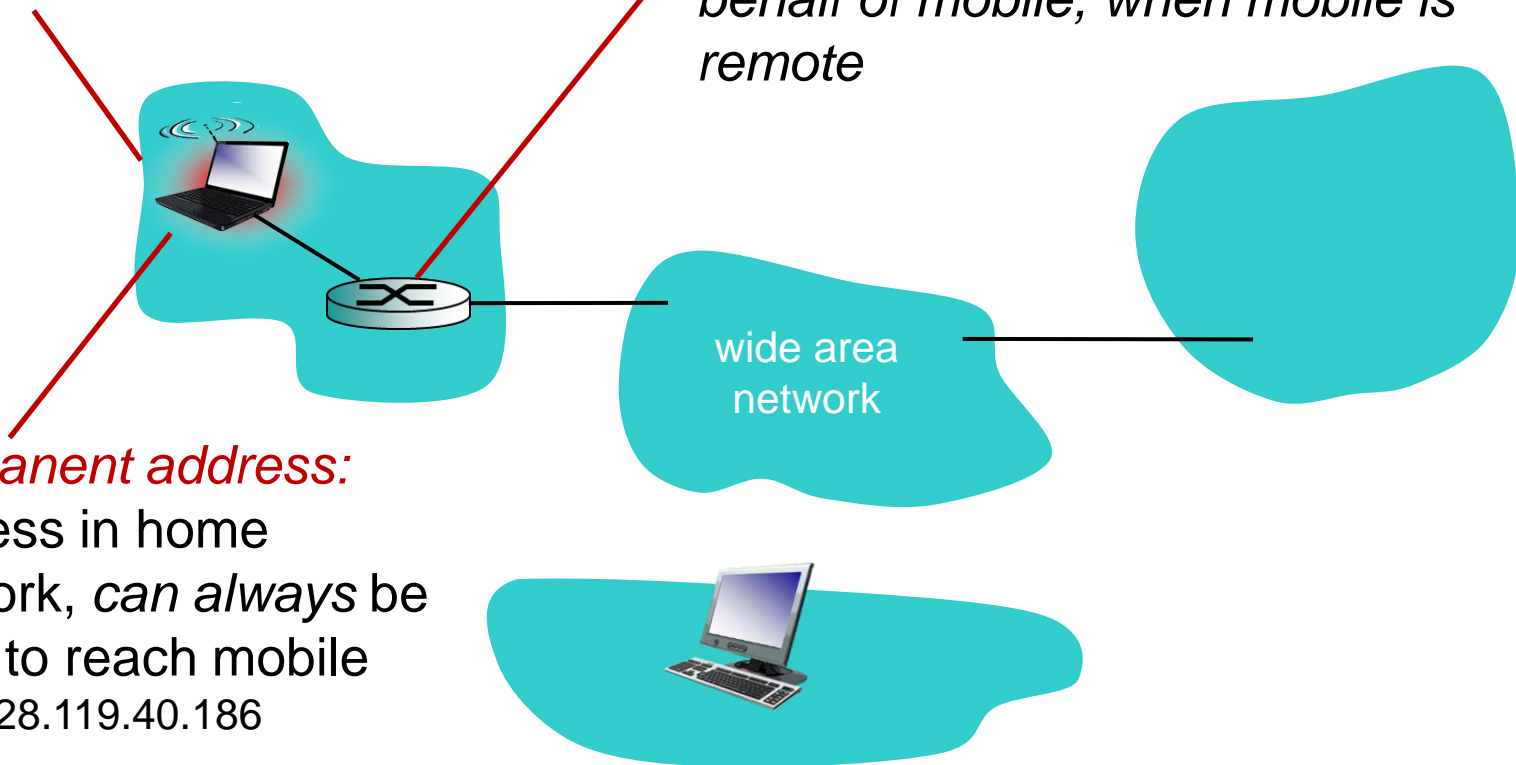


# Mobility: vocabulary

*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



# Mobility: more vocabulary

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

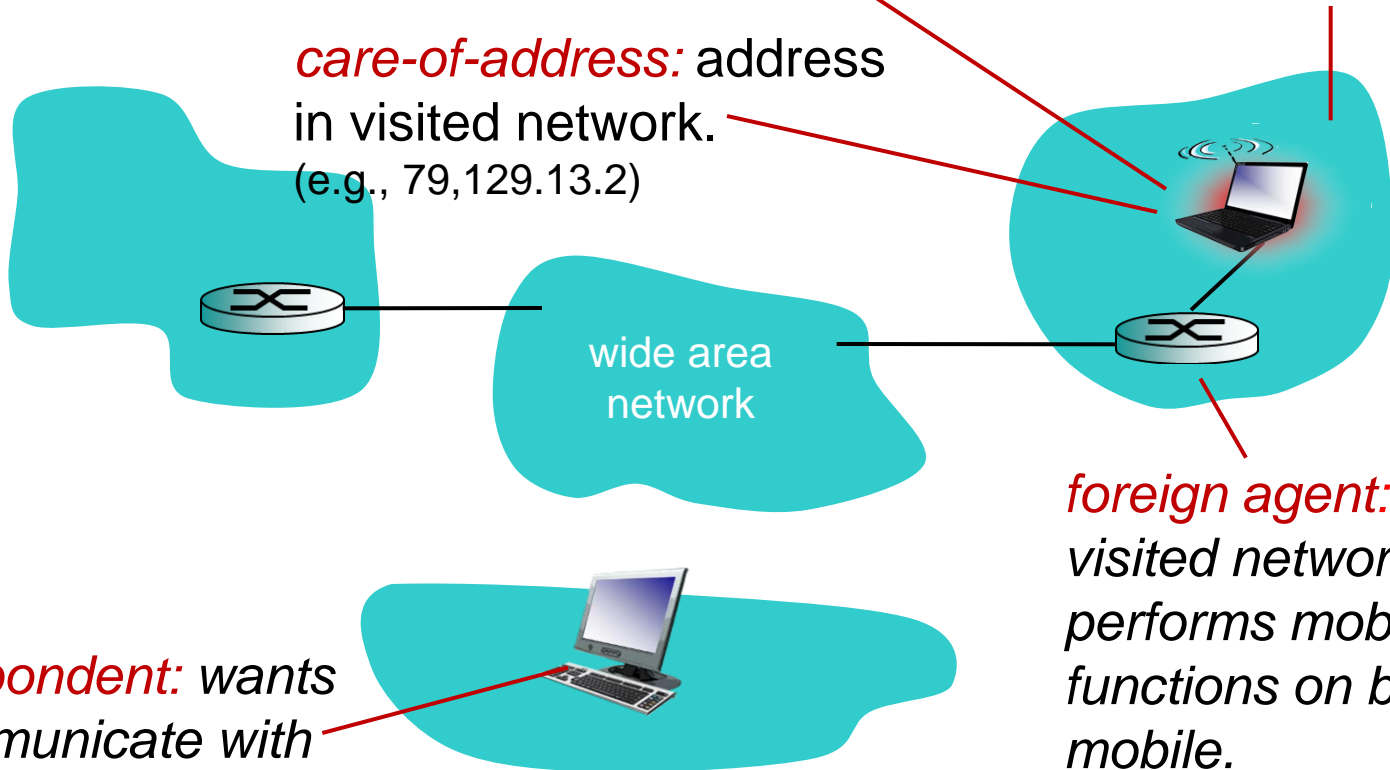
*visited network:* network in which mobile currently resides (e.g., 79.129.13/24)

*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.

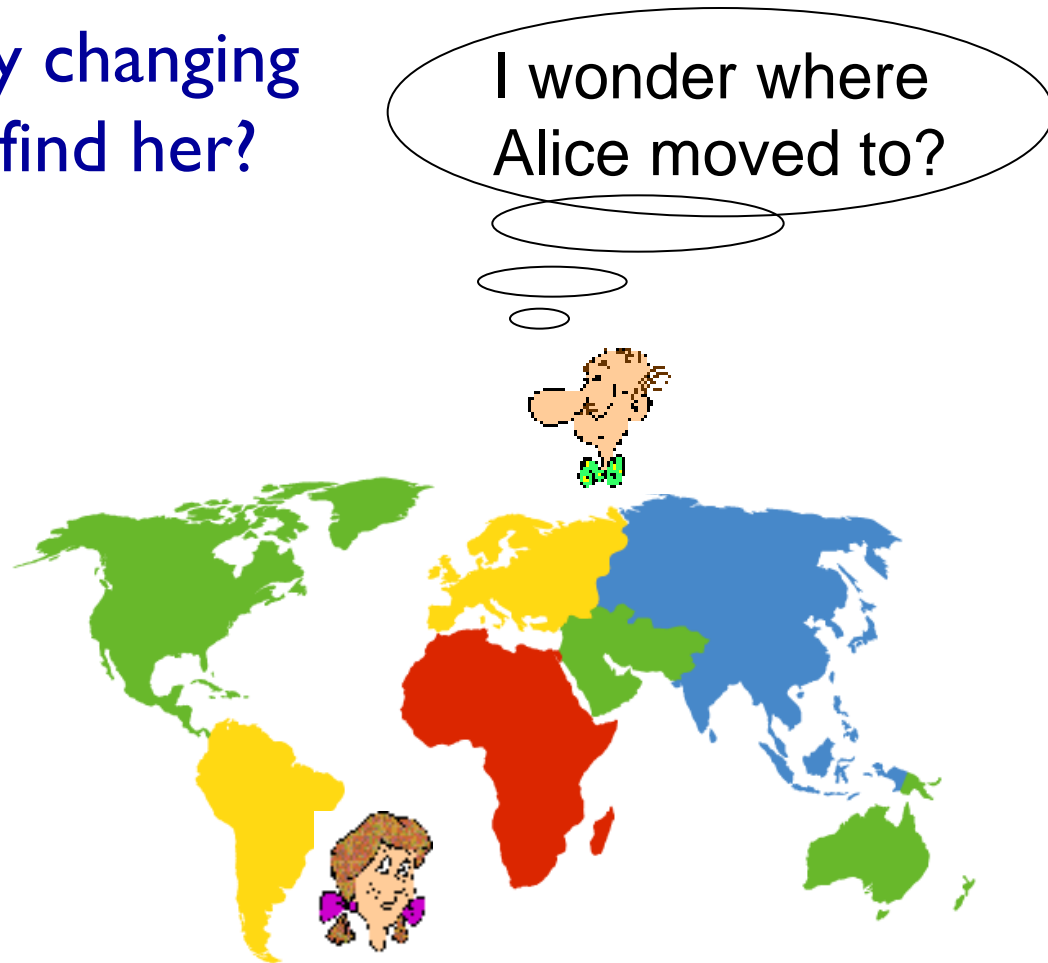
*correspondent:* wants to communicate with mobile



# 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?



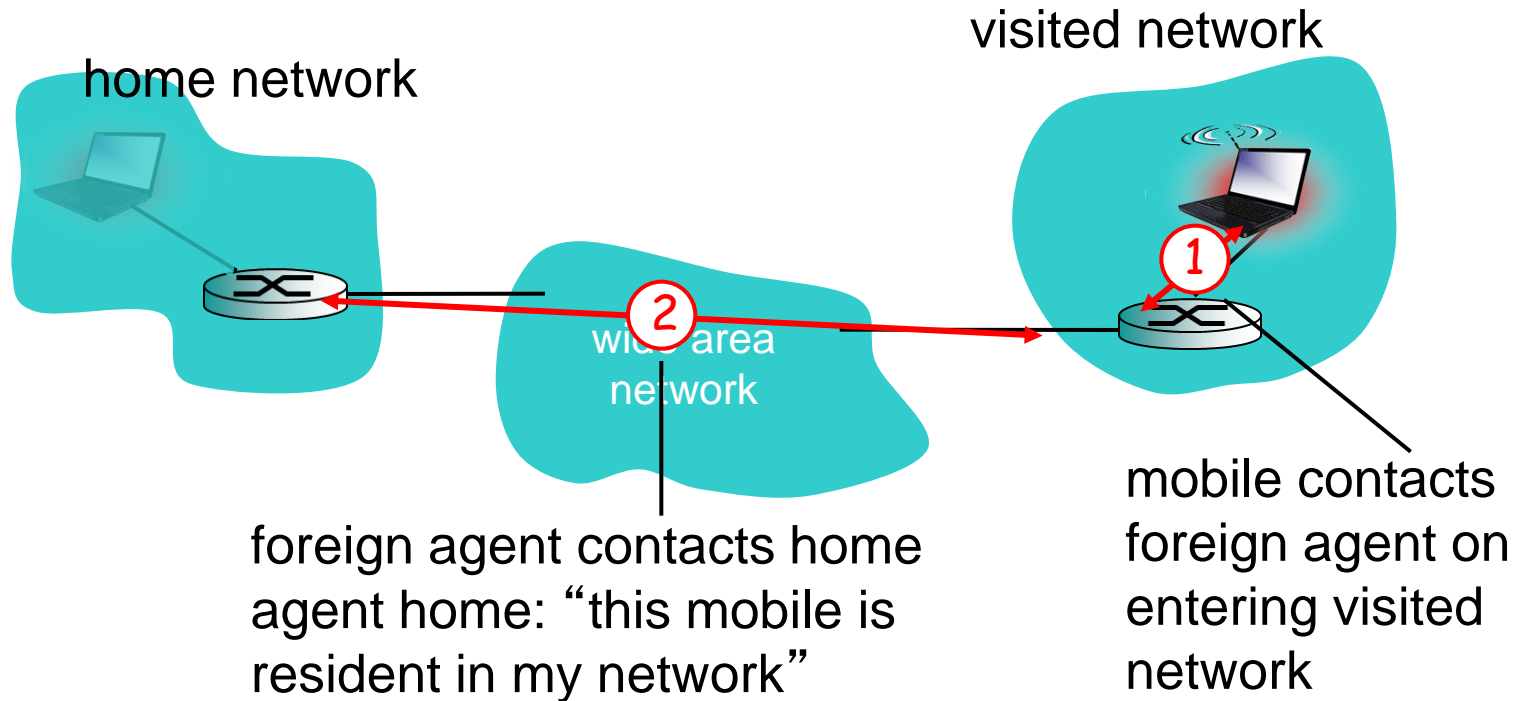
# Mobility: approaches

- ❖ *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:* route and advertise permanent address of mobile-nodes-in-range. usual routing table exchange.
  - routing tables not scalable to millions of mobiles
  - no changes to each mobile located
- ❖ *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

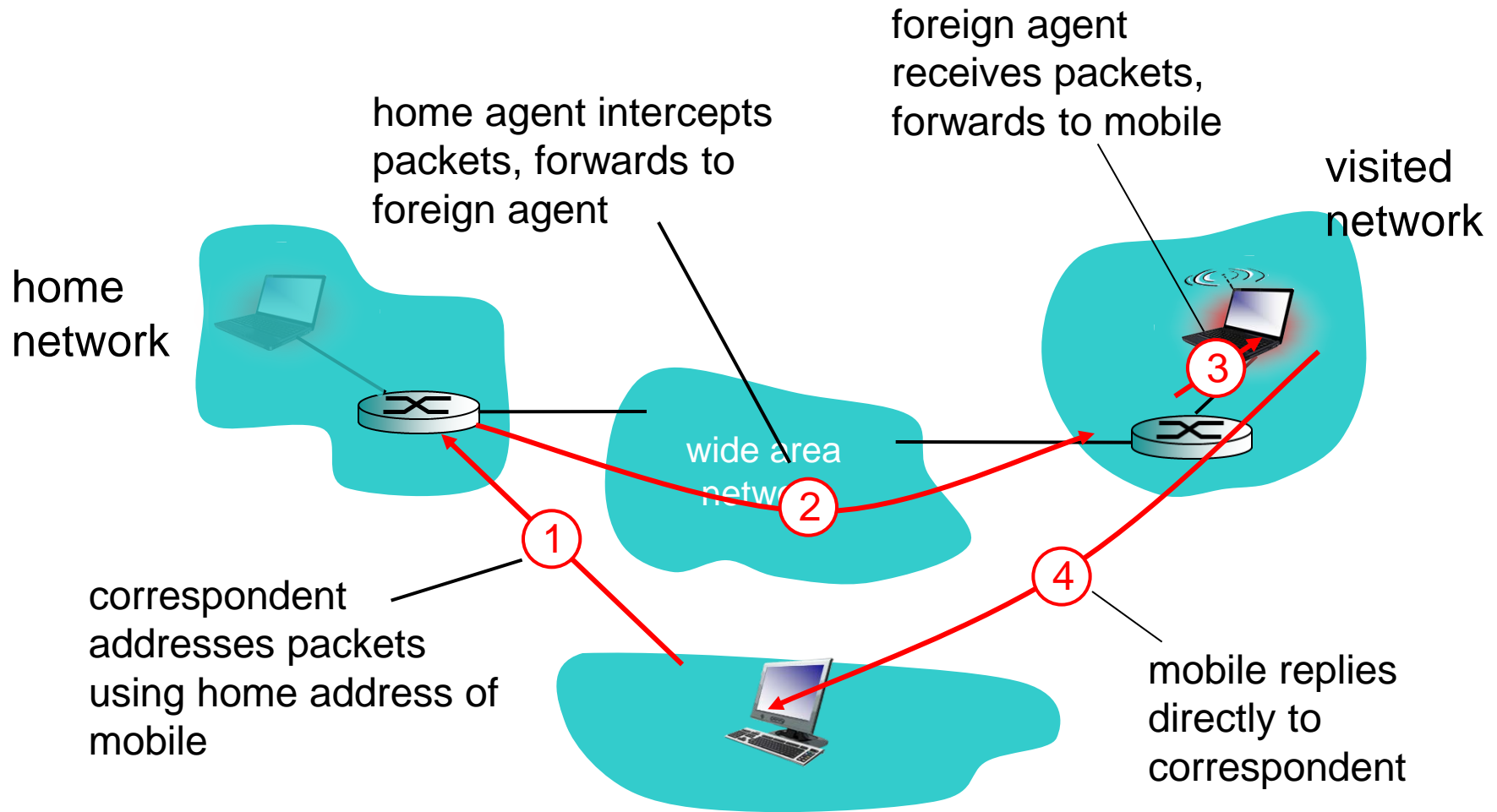
# Mobility: registration



end result:

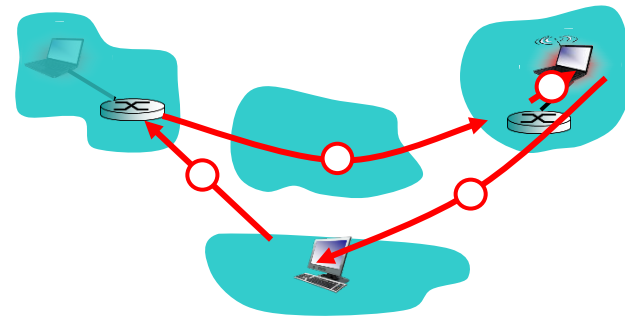
- ❖ foreign agent knows about mobile
- ❖ home agent knows location of mobile

# 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

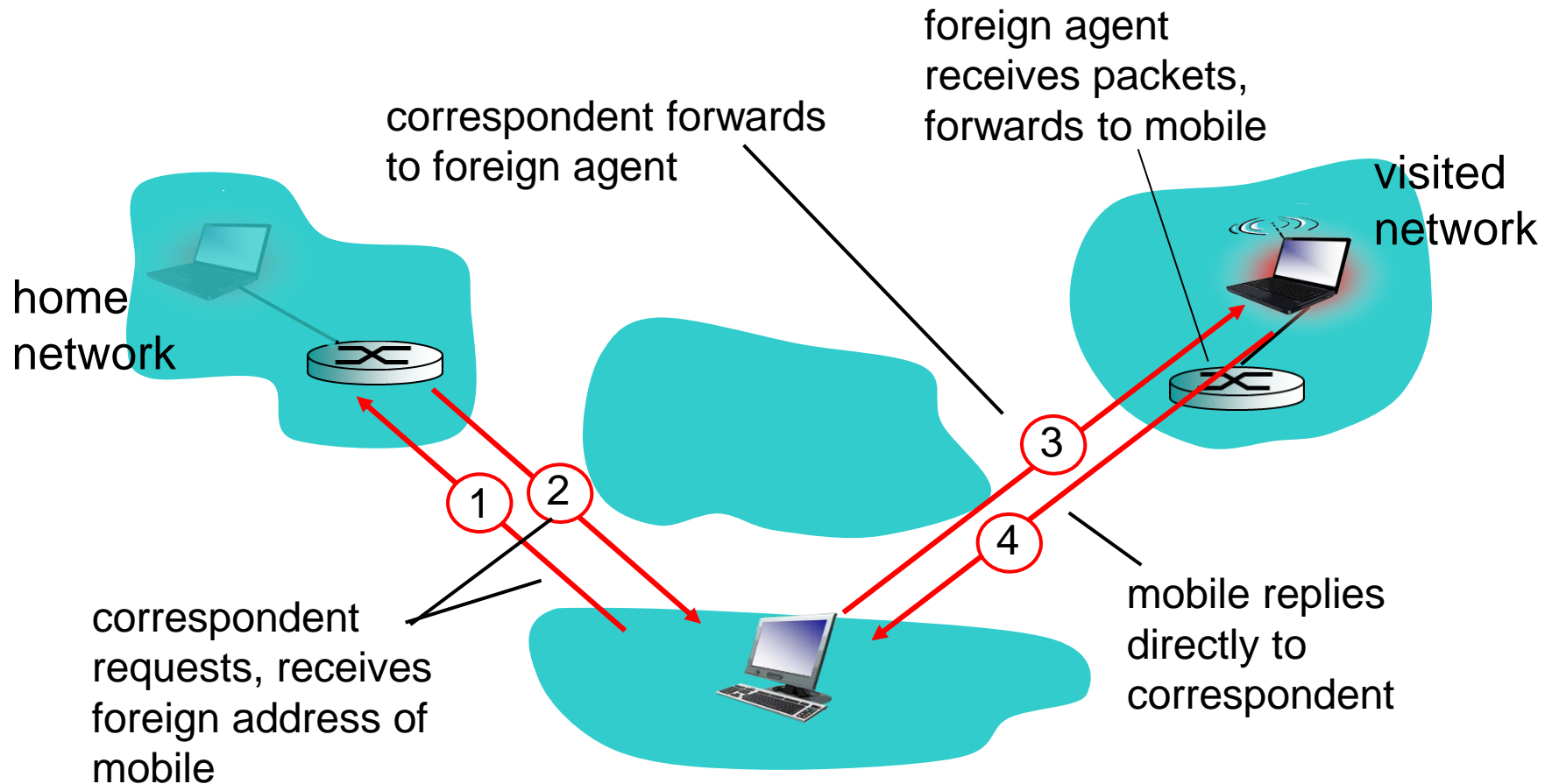




# Indirect routing: moving between networks

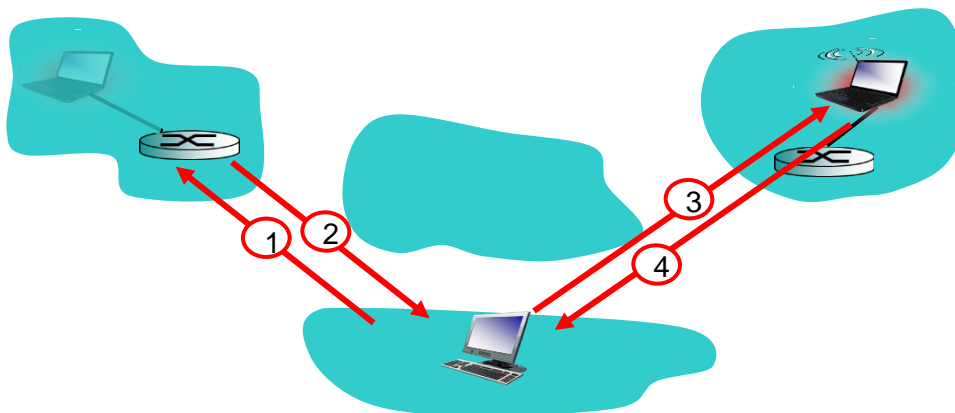
- ❖ suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)
- ❖ mobility, changing foreign networks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

# Mobility via direct routing



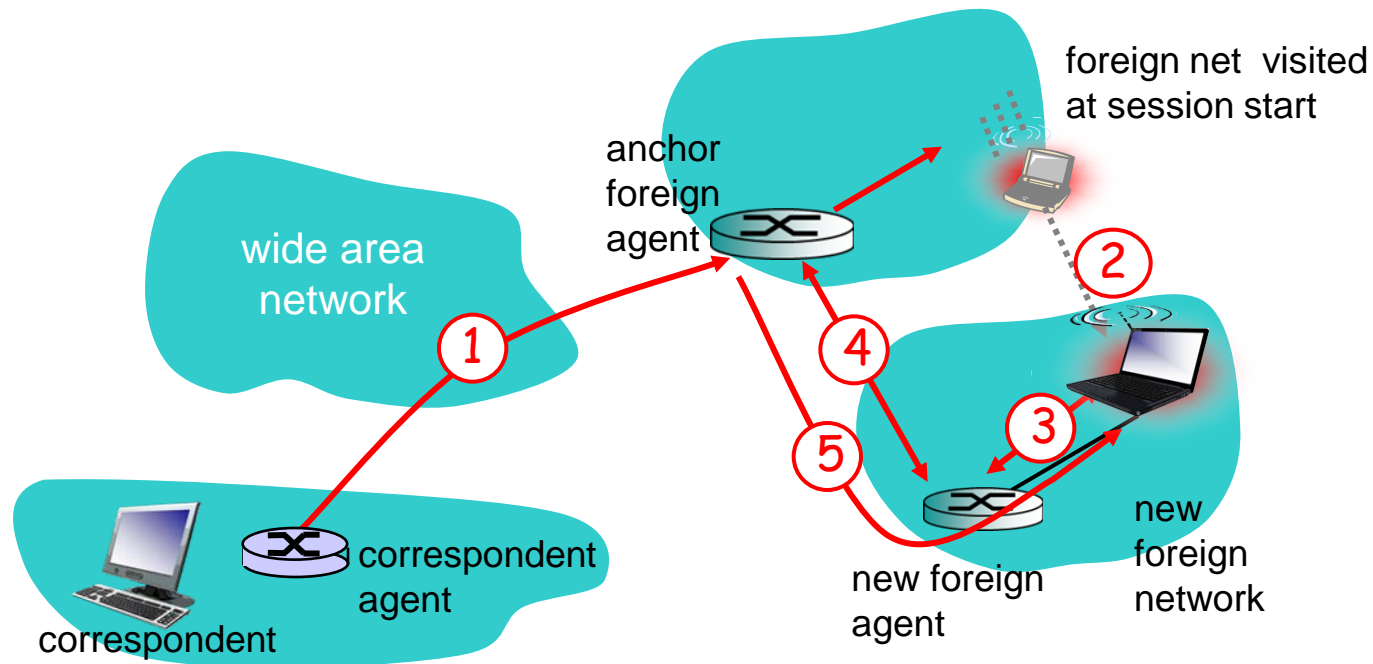
# Mobility via direct routing: comments

- ❖ 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)



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# Mobile IP

## ❖ RFC 3344

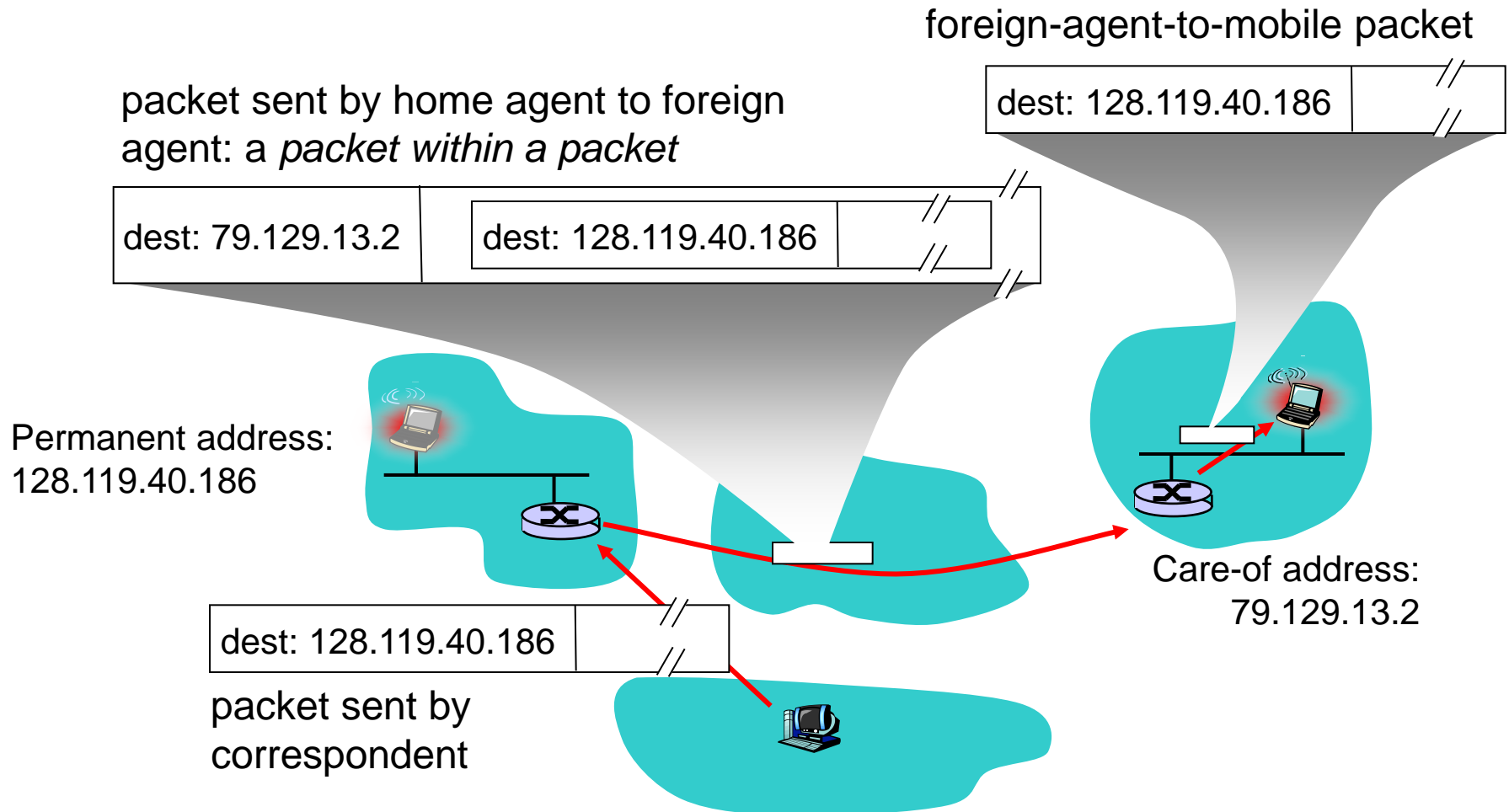
### ❖ has many features we've seen:

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

### ❖ three components to standard:

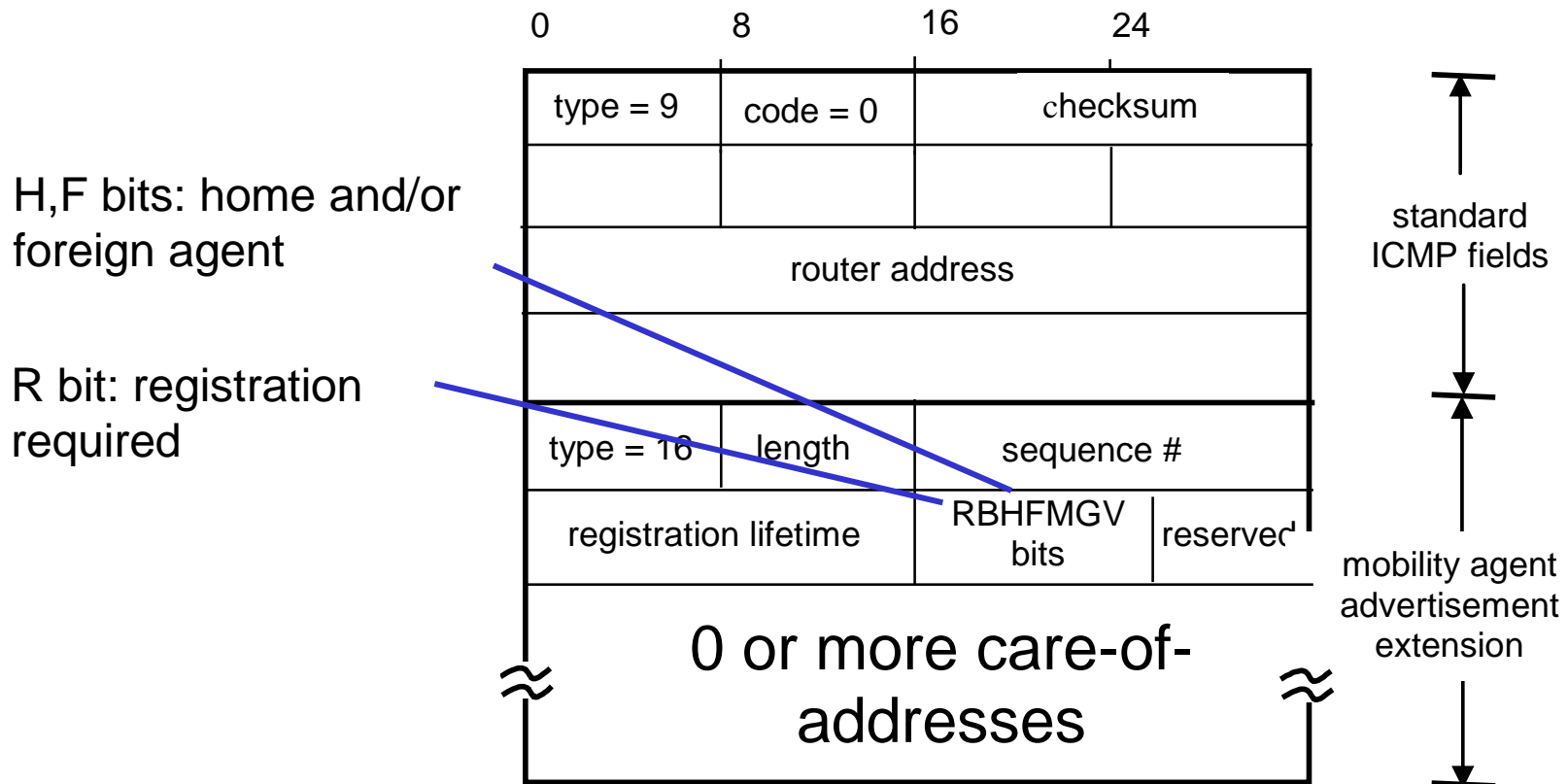
- indirect routing of datagrams
- agent discovery
- registration with home agent

# Mobile IP: indirect routing



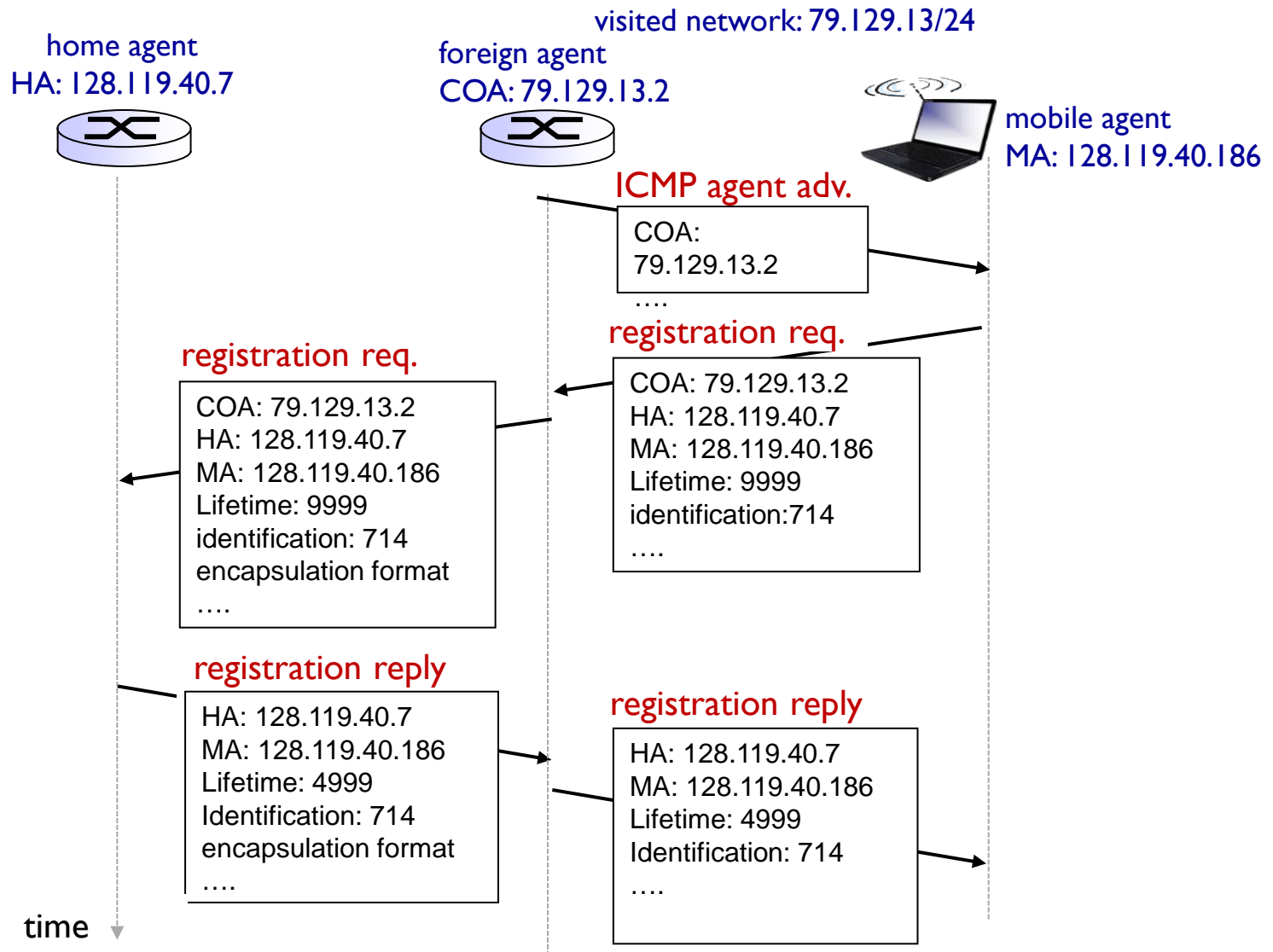
# Mobile IP: agent discovery

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



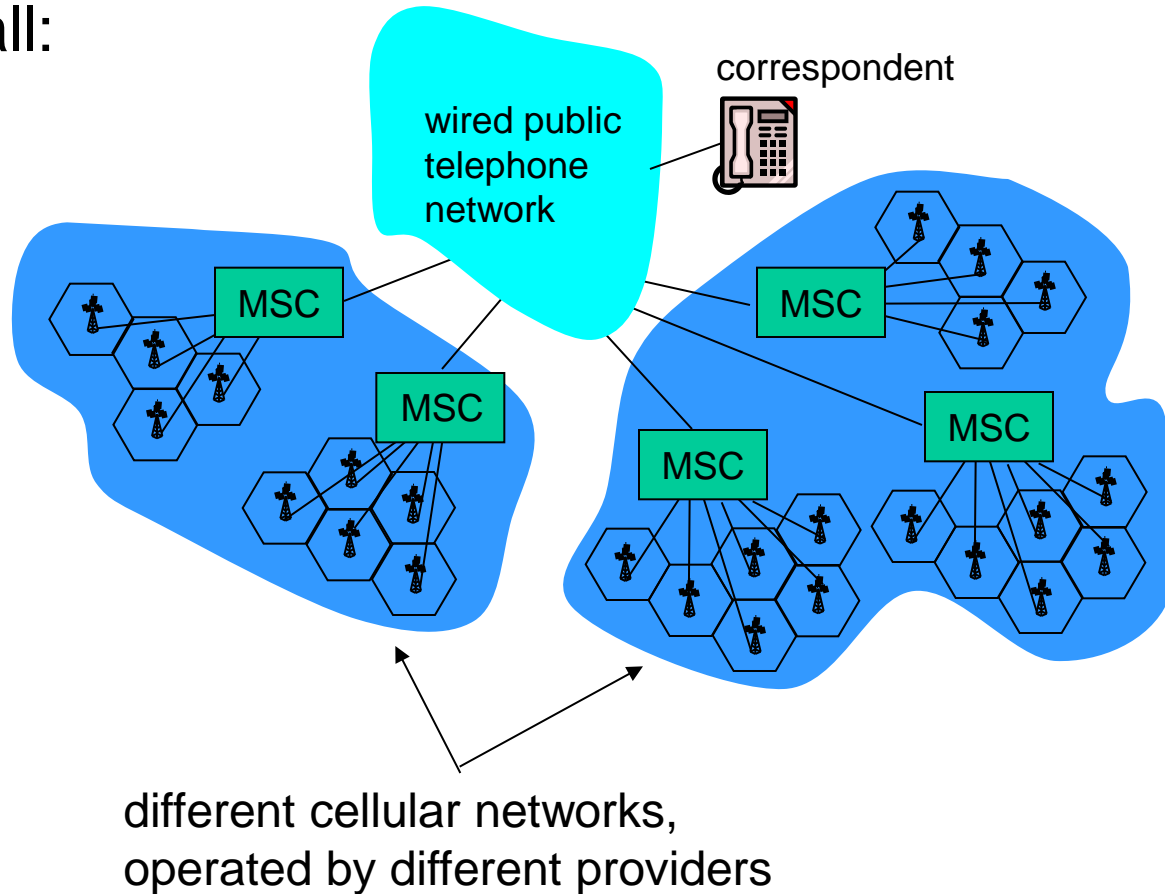


# Mobile IP: registration example



# Components of cellular network architecture

recall:

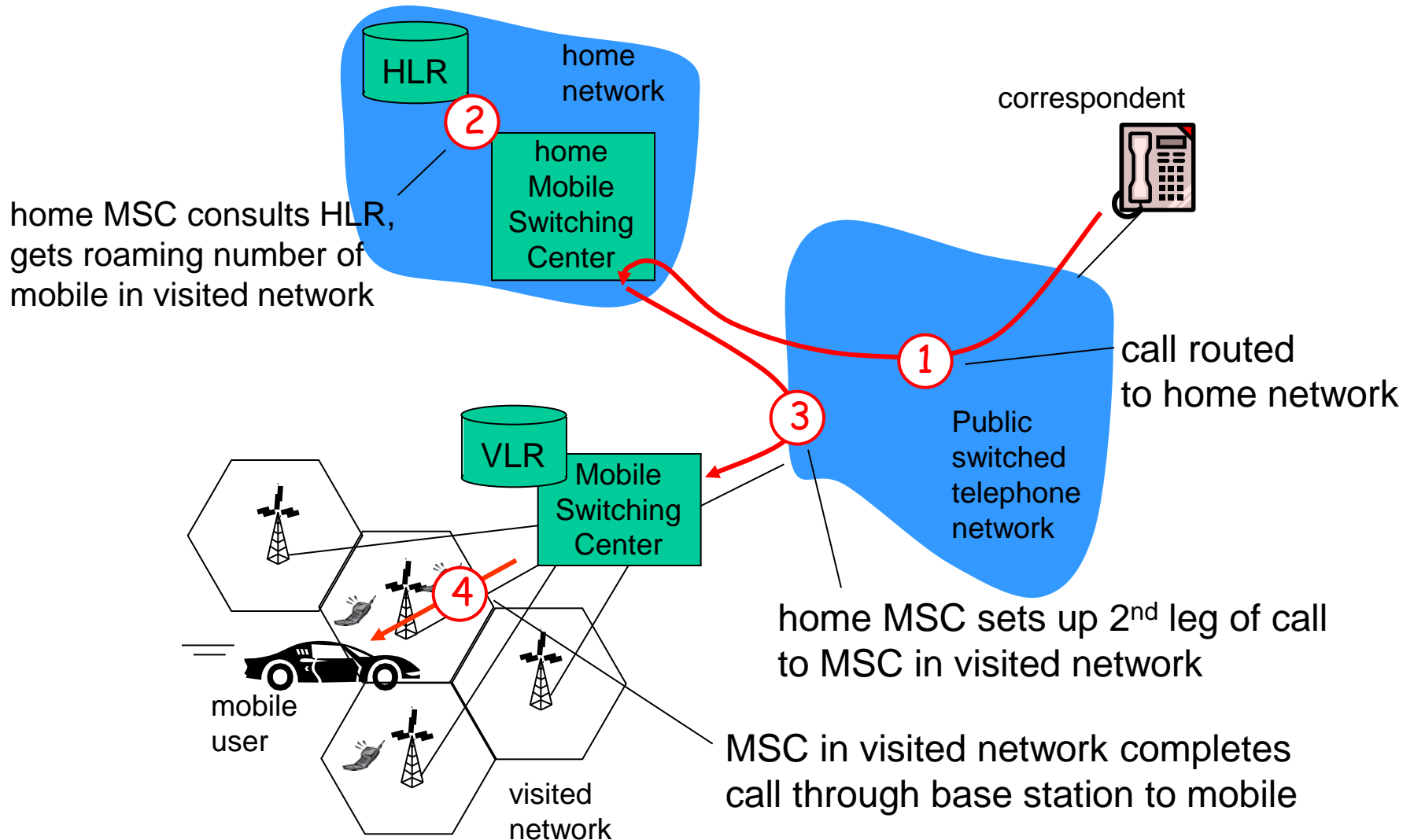


# Handling mobility in cellular networks

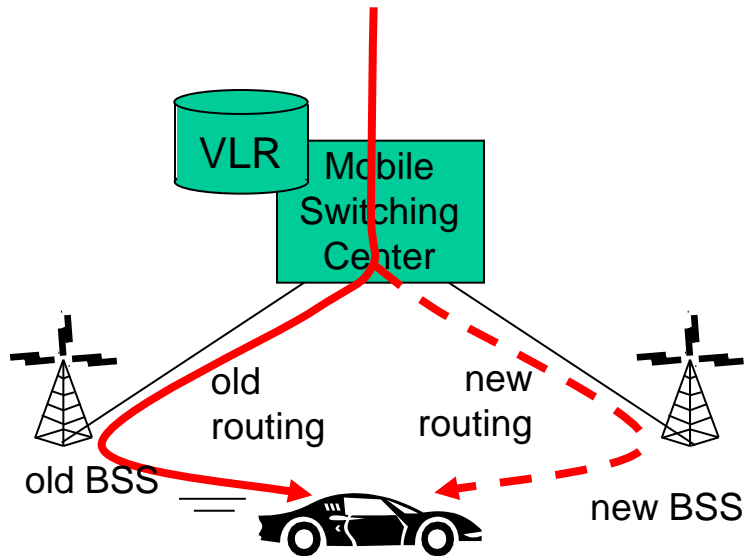
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- ❖ *home network*: network of cellular provider you subscribe to (e.g., Sprint PCS, Verizon)
  - *home location register (HLR)*: database in home network containing permanent cell phone #, profile information (services, preferences, billing), information 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

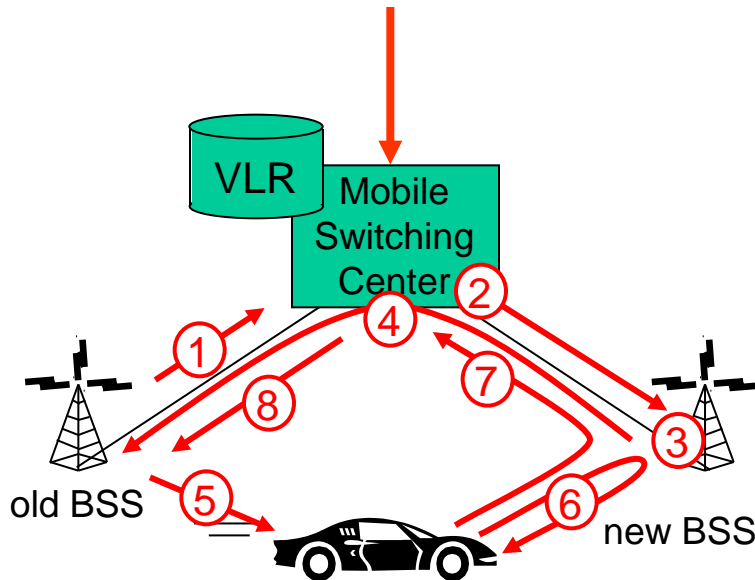


# GSM: handoff with common MSC



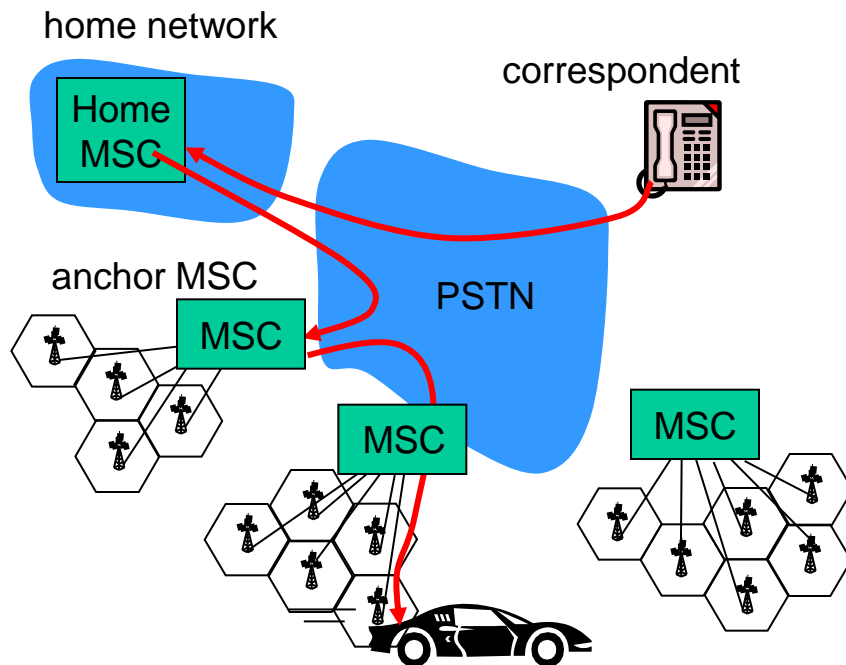
- ❖ *handoff goal*: route call via new base station (without interruption)
- ❖ reasons for handoff:
  - stronger signal to/from new BSS (continuing connectivity, less battery drain)
  - load balance: free up channel in current BSS
  - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)
- ❖ 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, old BSS: ready
5. old BSS tells mobile: perform handoff to new BSS
6. mobile, new BSS signal to activate new channel
7. mobile signals via new BSS to MSC: handoff complete. MSC reroutes call
8. MSC-old-BSS resources released

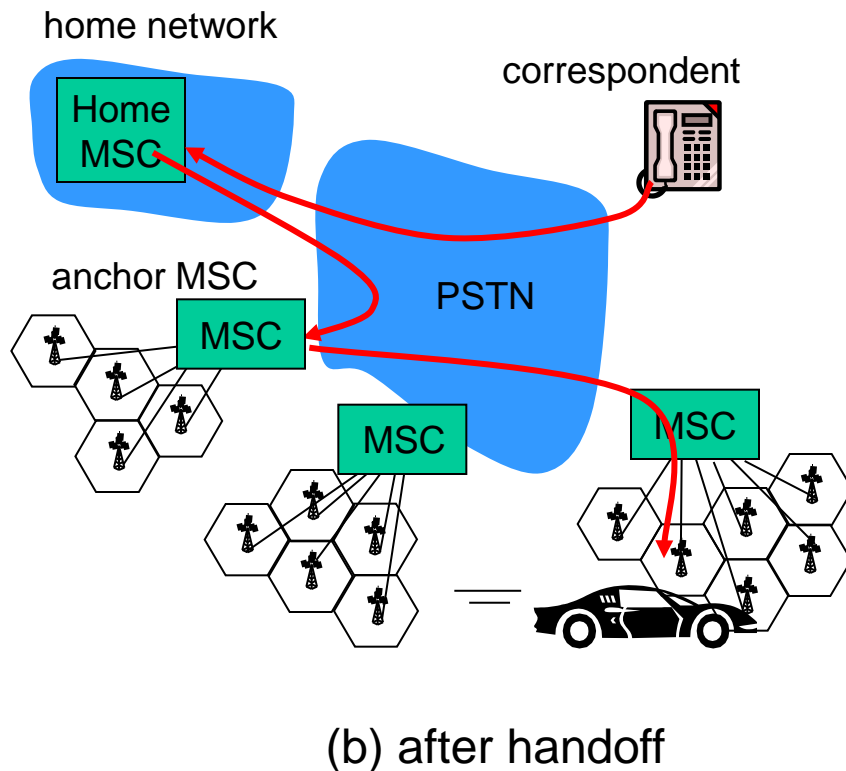
# GSM: handoff between MSCs



(a) before 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

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  - call remains routed through anchor MSC
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- ❖ optional path minimization step to shorten multi-MSC chain



# Mobility: GSM versus Mobile IP

GSM element	Comment on GSM element	Mobile IP element
<b>Home system</b>	Network to which mobile user's permanent phone number belongs	<b>Home network</b>
<b>Gateway Mobile Switching Center, or "home MSC". Home Location Register (HLR)</b>	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	<b>Home agent</b>
<b>Visited System</b>	Network other than home system where mobile user is currently residing	<b>Visited network</b>
<b>Visited Mobile services Switching Center. Visitor Location Record (VLR)</b>	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	<b>Foreign agent</b>
<b>Mobile Station Roaming Number (MSRN), or "roaming number"</b>	Routable address for telephone call segment between home MSC and visited MSC, visible to neither the mobile nor the correspondent.	<b>Care-of-address</b>

# 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 un-necessarily
  - delay impairments for real-time traffic
  - limited bandwidth of wireless links

# 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)

## *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