What is mobility?

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

no mobility   high mobility

mobile wireless user, using same access point

mobile user, connecting/disconnecting from network using DHCP.

mobile user, passing through multiple access point while maintaining ongoing connections (like cell phone)
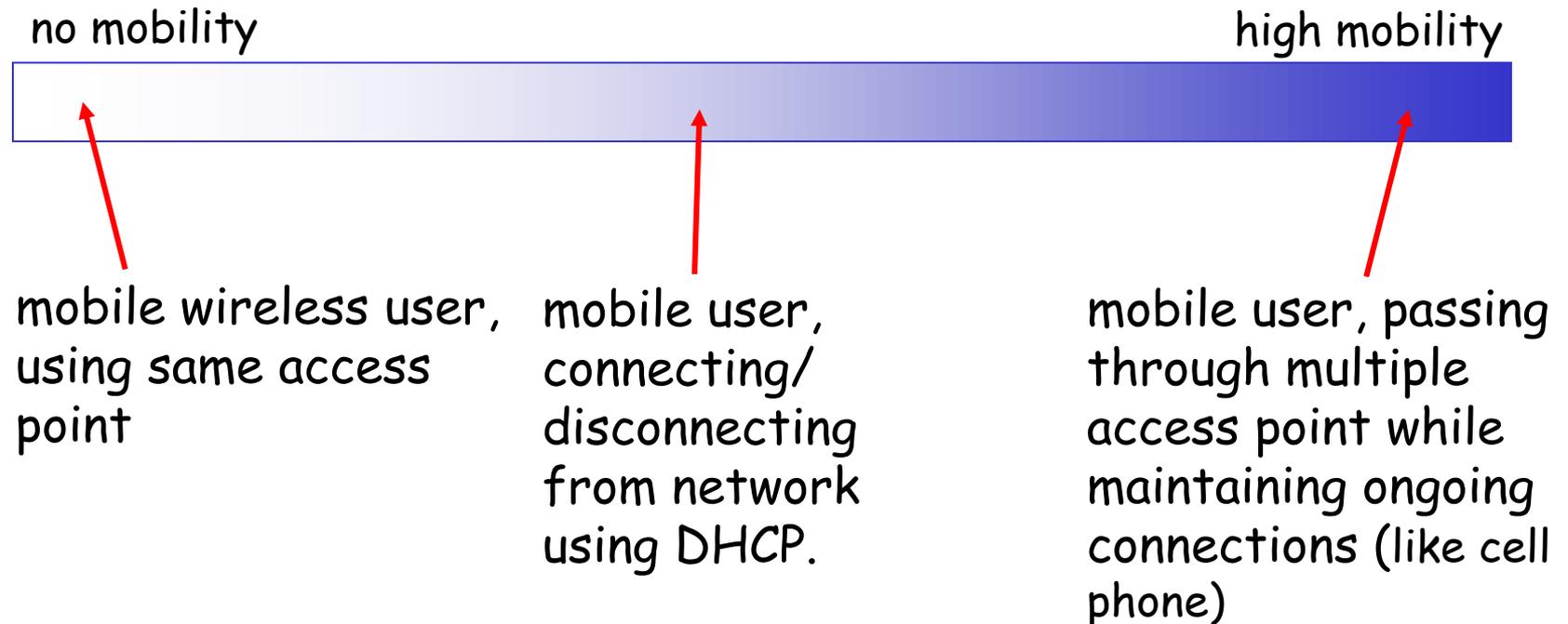
Mobility: Vocabulary

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
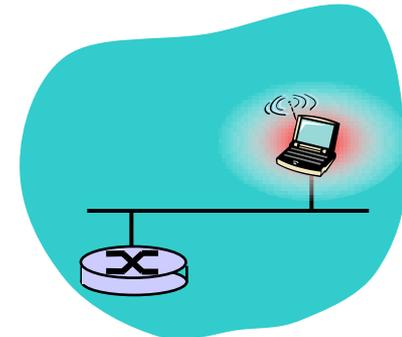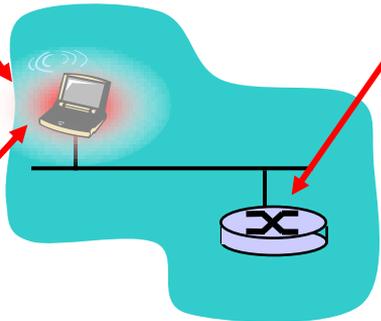
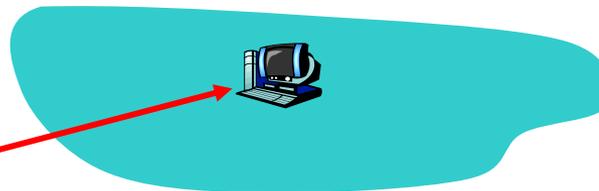correspondent

Mobility: more vocabulary

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

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

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.
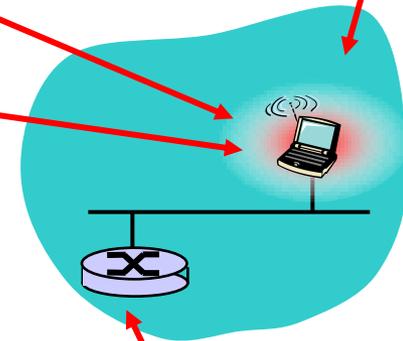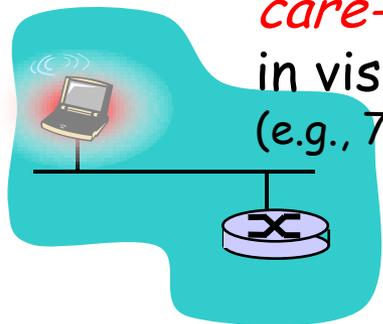
correspondent: wants to communicate with mobile

4

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?
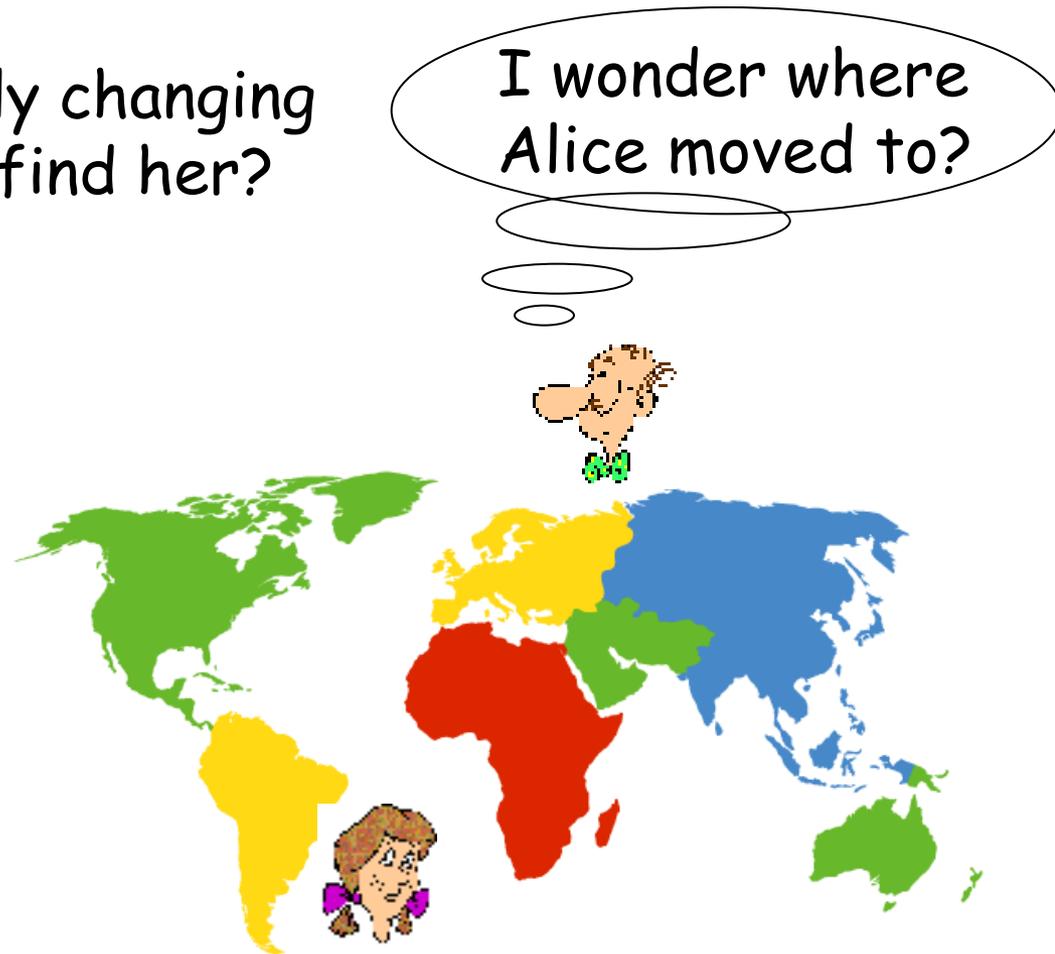
I wonder where Alice moved to?

5

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 via usual routing table e...

not scalable to millions of mobiles

  ○ routing table... 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: registration

visited network

home network

wide area network

2

1

foreign agent contacts home agent home: "this mobile is resident in my network"

mobile contacts foreign agent on entering visited network
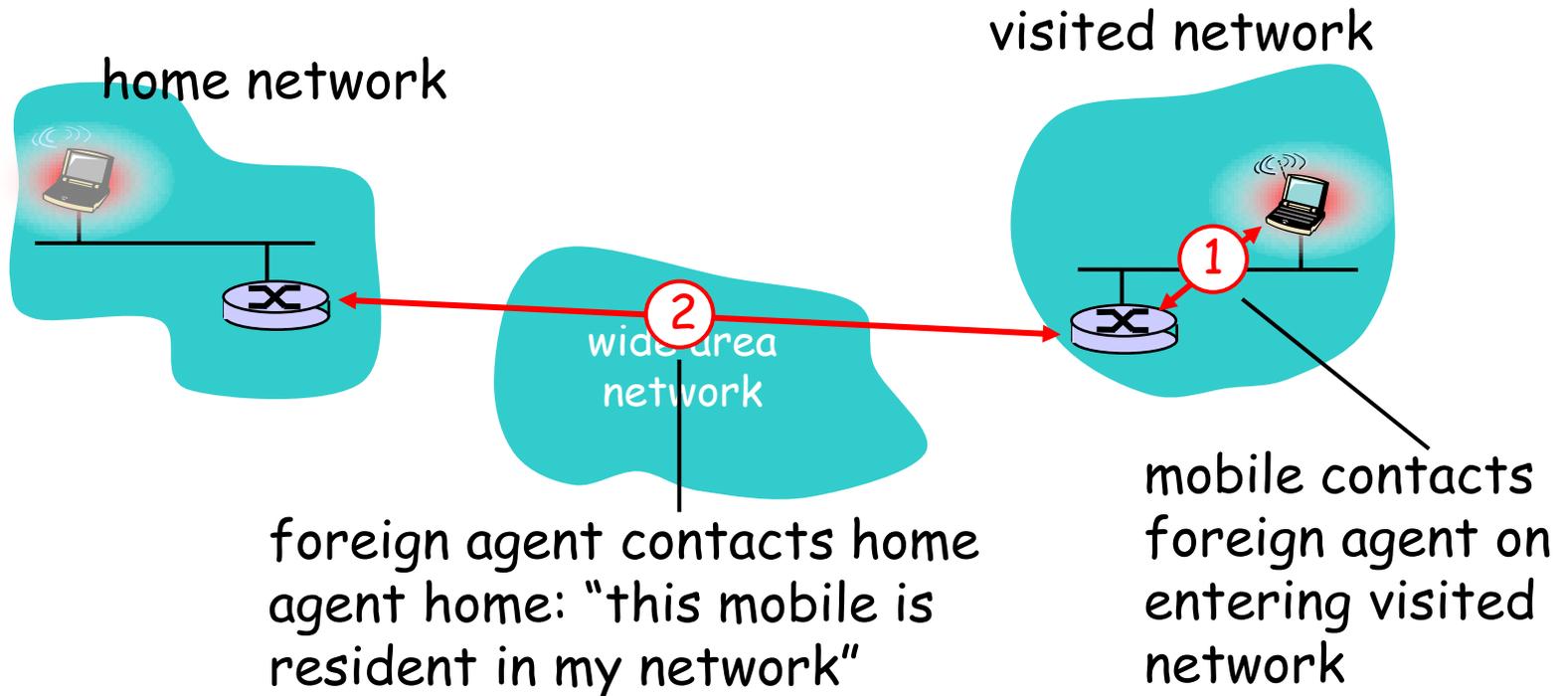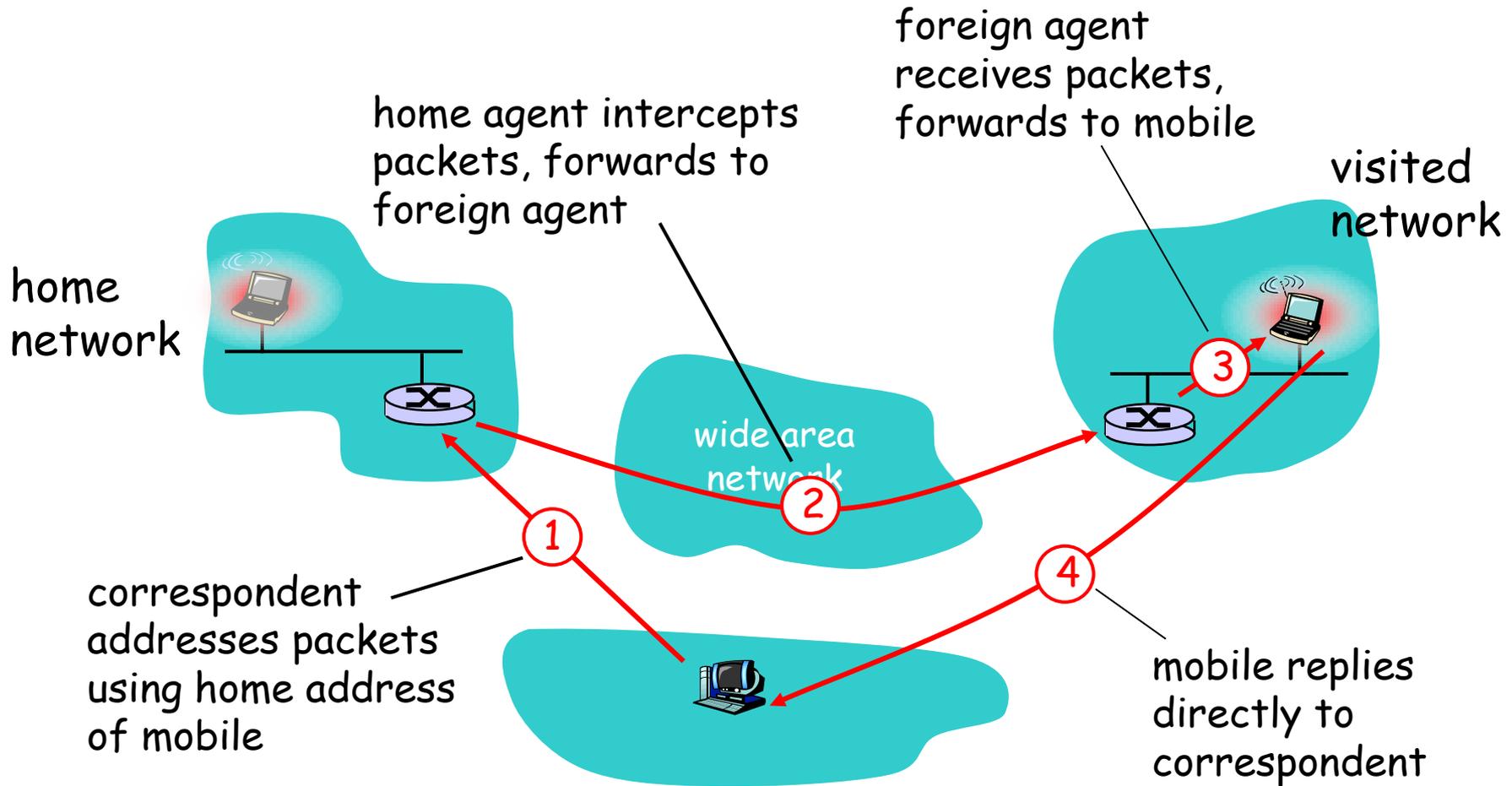
End result:
- ❒ Foreign Agent (FA) knows about mobile
- ❒ Home Agent (HA) knows location of mobile

Mobility via Indirect Routing

home network

home agent intercepts packets, forwards to foreign agent

foreign agent receives packets, forwards to mobile

visited network

wide area network

correspondent addresses packets using home address of mobile

mobile replies directly to correspondent
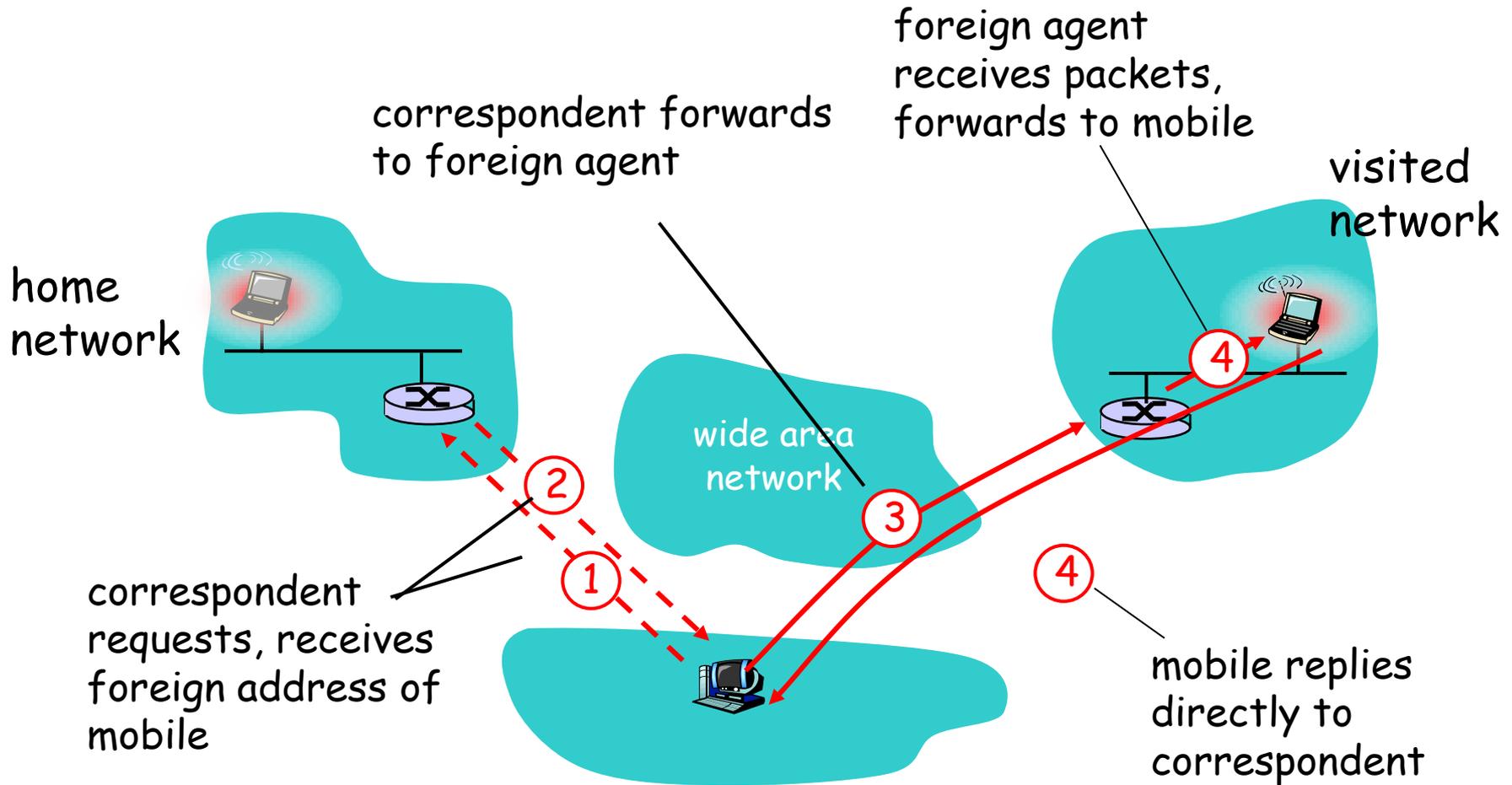
Indirect Routing: comments

□ 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
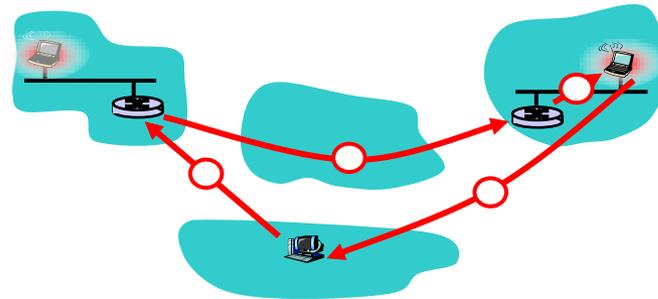
Indirect Routing: moving between networks

☐ 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: *ongoing connections can be maintained!*

Mobility via Direct Routing

correspondent forwards to foreign agent

foreign agent receives packets, forwards to mobile

visited network

home network

correspondent requests, receives foreign address of mobile

wide area network

mobile replies directly to correspondent

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?
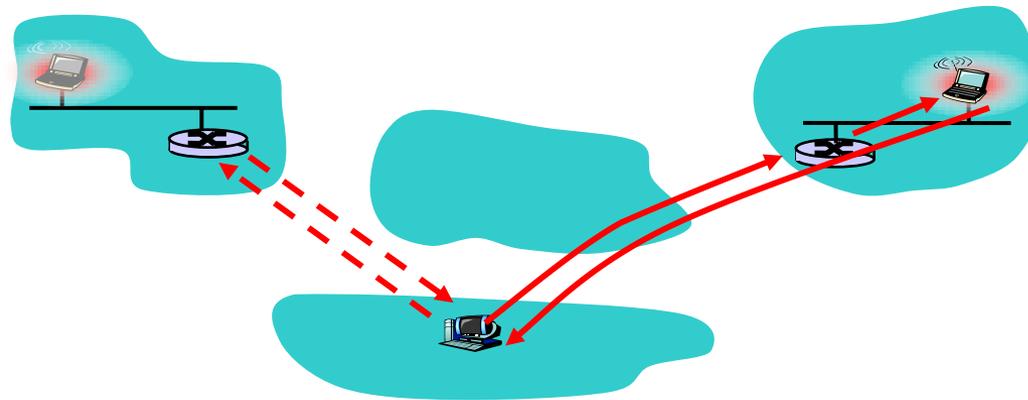
Accommodating mobility with direct routing

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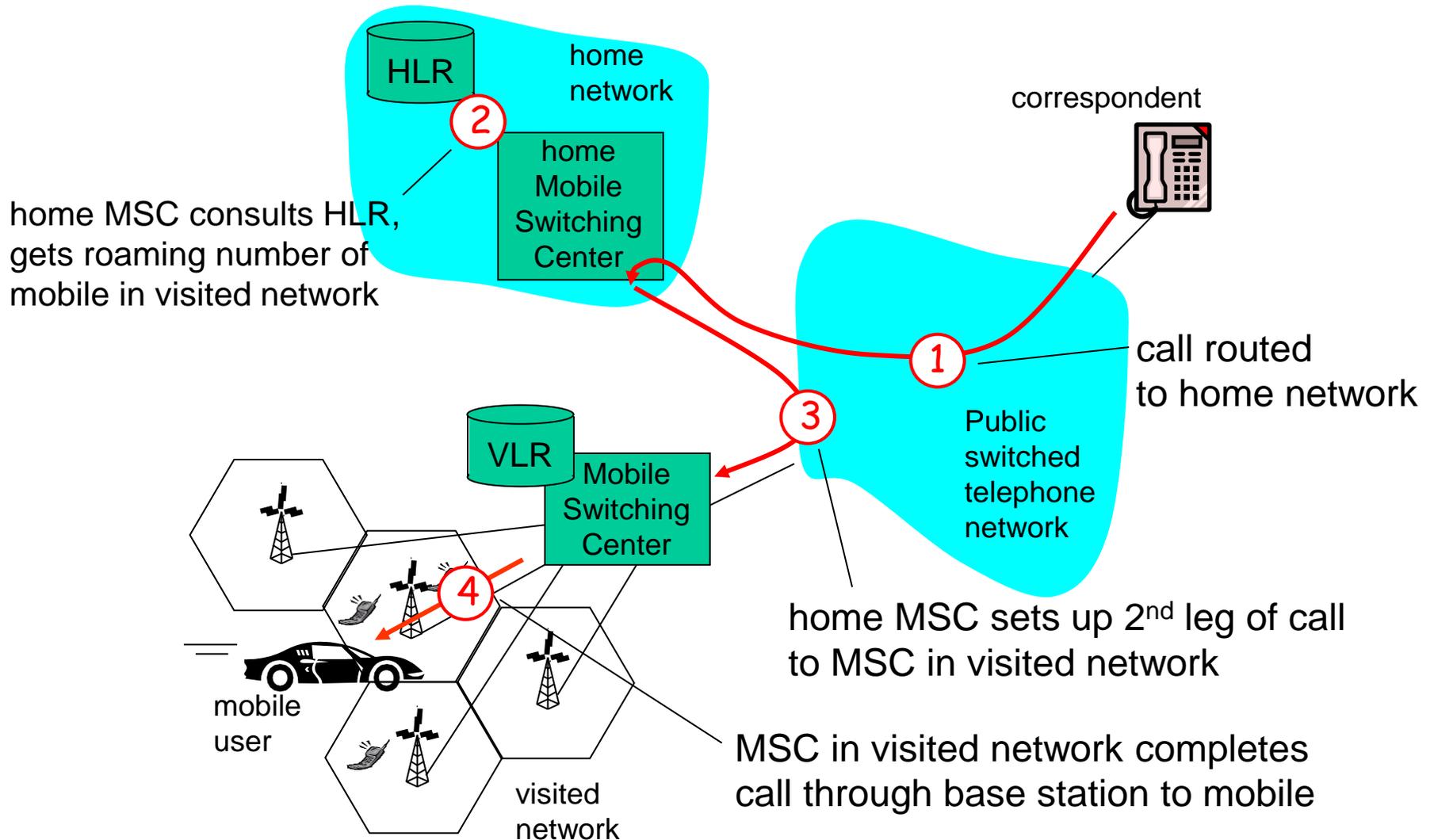- when mobile moves: new FA arranges to have data forwarded from old FA (chaining)
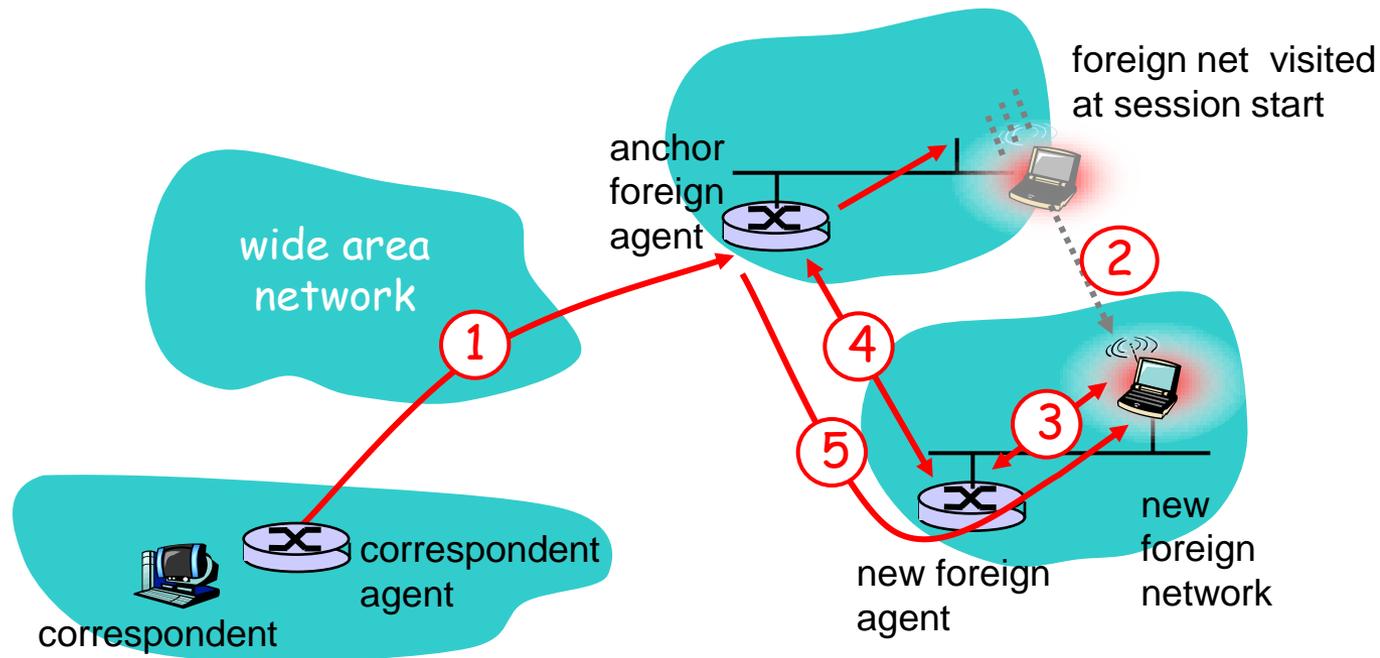
Mobile IP

□ RFC 3220

□ 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
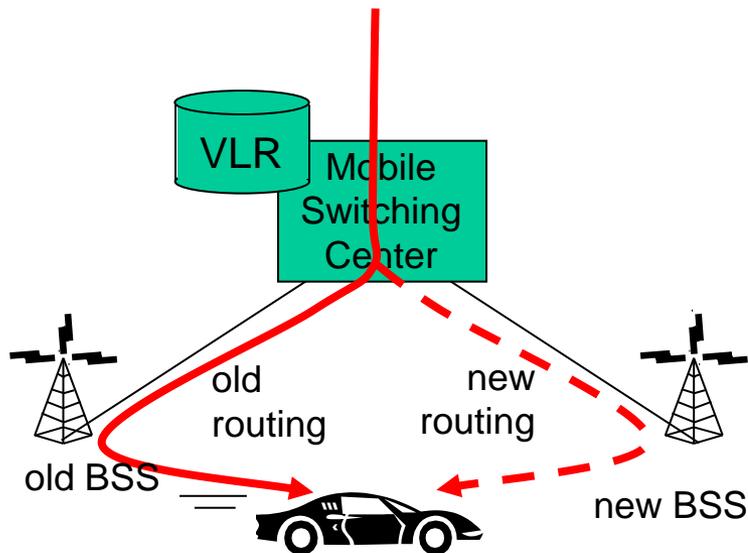 ○ agent discovery
  ○ registration with home agent

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

HLR

home network

correspondent

2

home MSC consults HLR, gets roaming number of mobile in visited network

home Mobile Switching Center

1

call routed to home network

3

Public switched telephone network

VLR

Mobile Switching Center

4

home MSC sets up 2nd leg of call to MSC in visited network

mobile user

visited network

MSC in visited network completes call through base station to mobile

GSM: handoff with common MSC


VLR

Mobile Switching Center
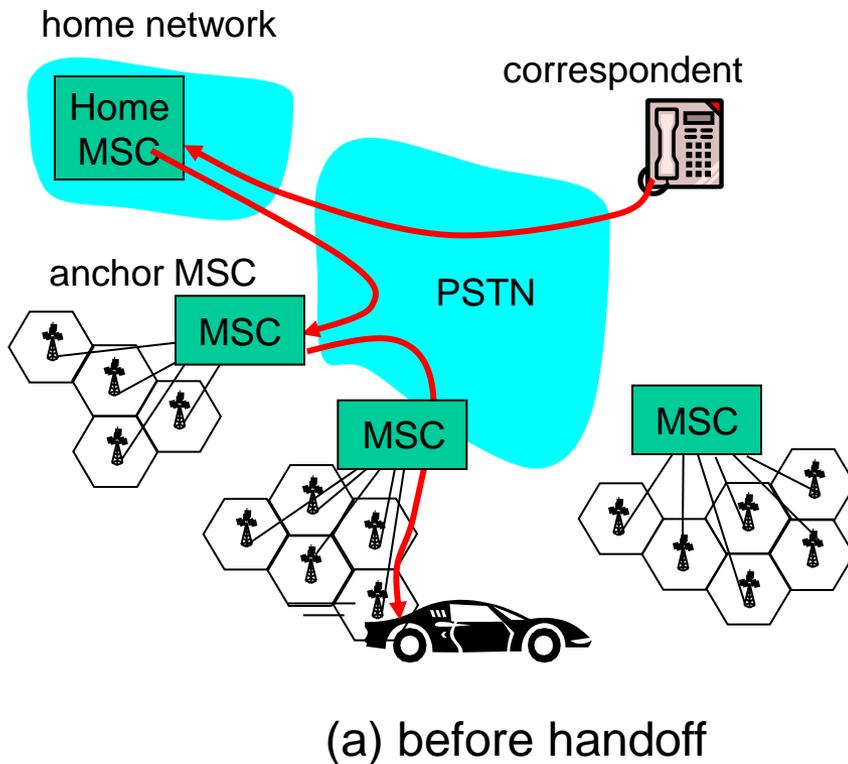
old routing

new routing

old BSS

new BSS

- ❒ 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
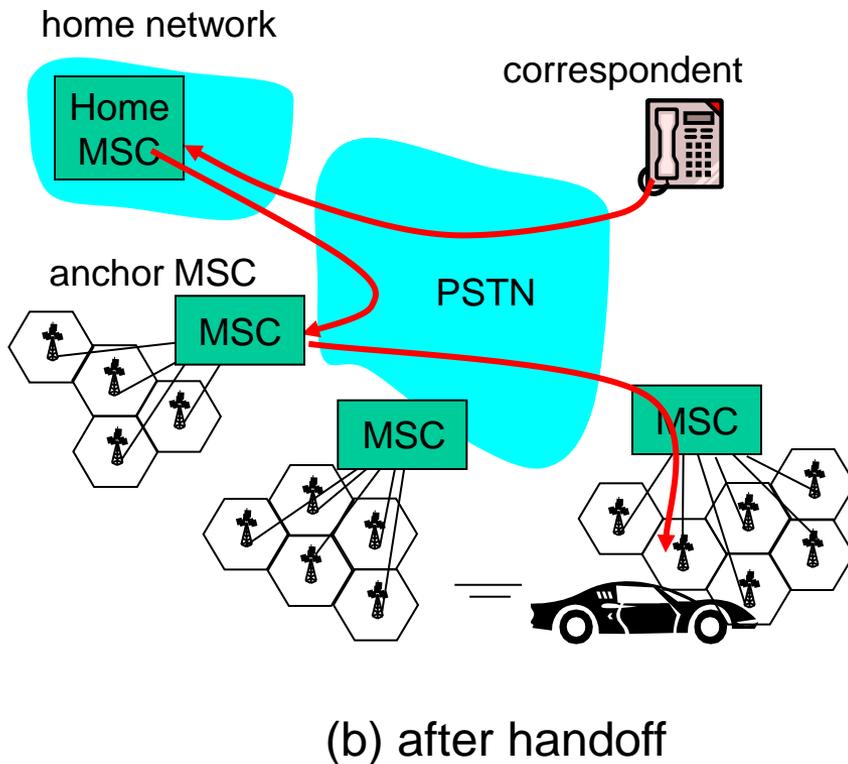
GSM: handoff with common MSC
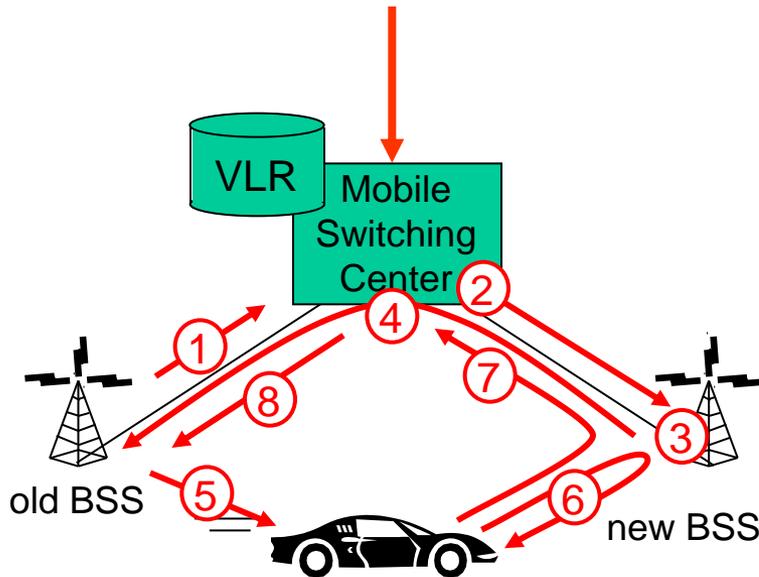
1. old BSS informs MSC of impending handoff, provides list of 1$^+$ new BSSs

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

home network

correspondent

Home MSC

anchor MSC

MSC

PSTN

MSC

MSC

(a) before handoff

□ *anchor MSC:* first MSC visited during cal
  ○ call remains routed through anchor MSC
□ new MSCs add on to end of MSC chain as mobile moves to new MSC
□ IS-41 allows optional path minimization step to shorten multi-MSC chain

GSM: handoff between MSCs

home network

correspondent

anchor MSC

Home MSC

MSC

PSTN

MSC

MSC

(b) after handoff

- *anchor MSC:* first MSC visited during cal
  - call remains routed through anchor MSC
- new MSCs add on to end of MSC chain as mobile moves to new MSC
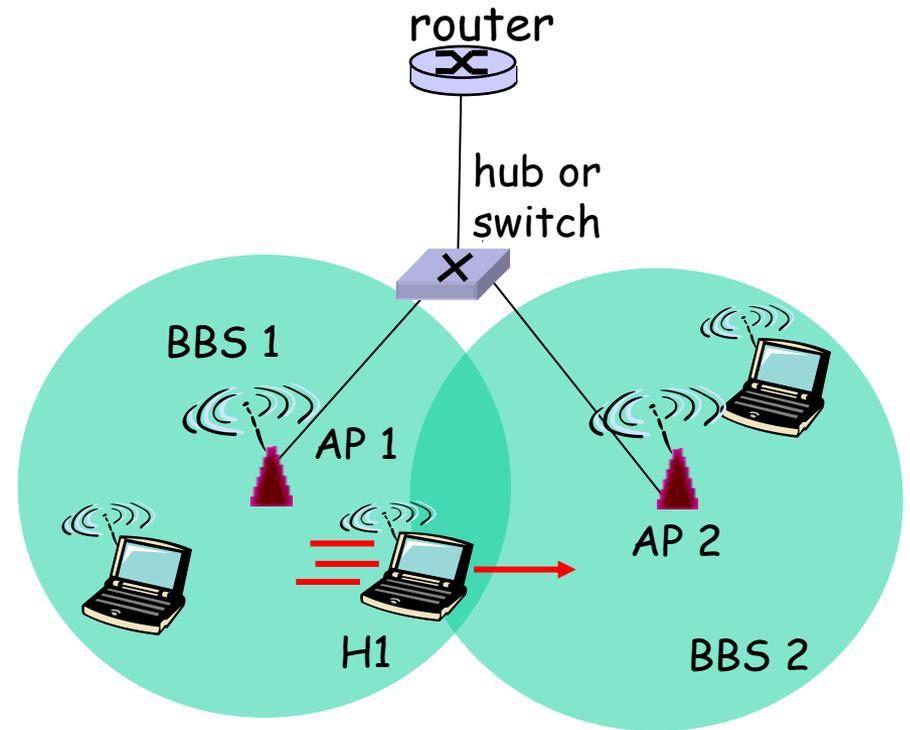- IS-41 allows optional path minimization step to shorten multi-MSC chain

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

router

hub or switch

BBS 1

AP 1

AP 2

H1

BBS 2

GSM: Mobility summary

GSM element	Comment on GSM element
Home system	Network to which mobile user's permanent phone number belongs
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
Visited System	Network other than home system where mobile user is currently residing
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
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.