CS 3251- Computer Networks 1:

Mobility

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11/12/13

Lecture 23

Announcements

- Project 4 has been posted
  - Due 11/26.
  - Trust me when I say that you'll want to start now...
- Homework 3 is due 11/19
  - That's one week away
- Start thinking about the final
  - Hey - it's almost Thanksgiving!

Last Time

- What is the hidden terminal problem?

- How do CDMA networks use spectrum differently than TDMA systems?
  - What is a chipping code?

- How is CSMA/CA different the CSMA/CD?

- If a manufacturer lists a range of 50m, what is the maximum range of a radio?

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)

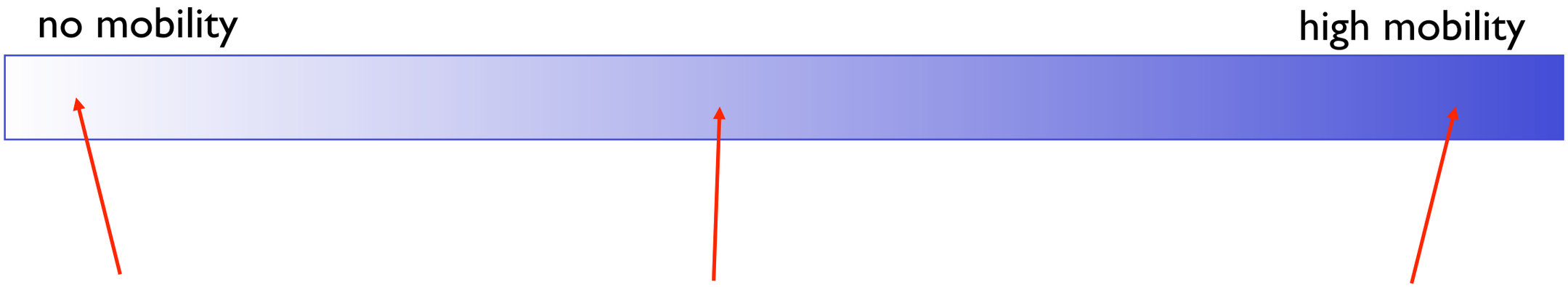
Mobility

- 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

What is mobility?

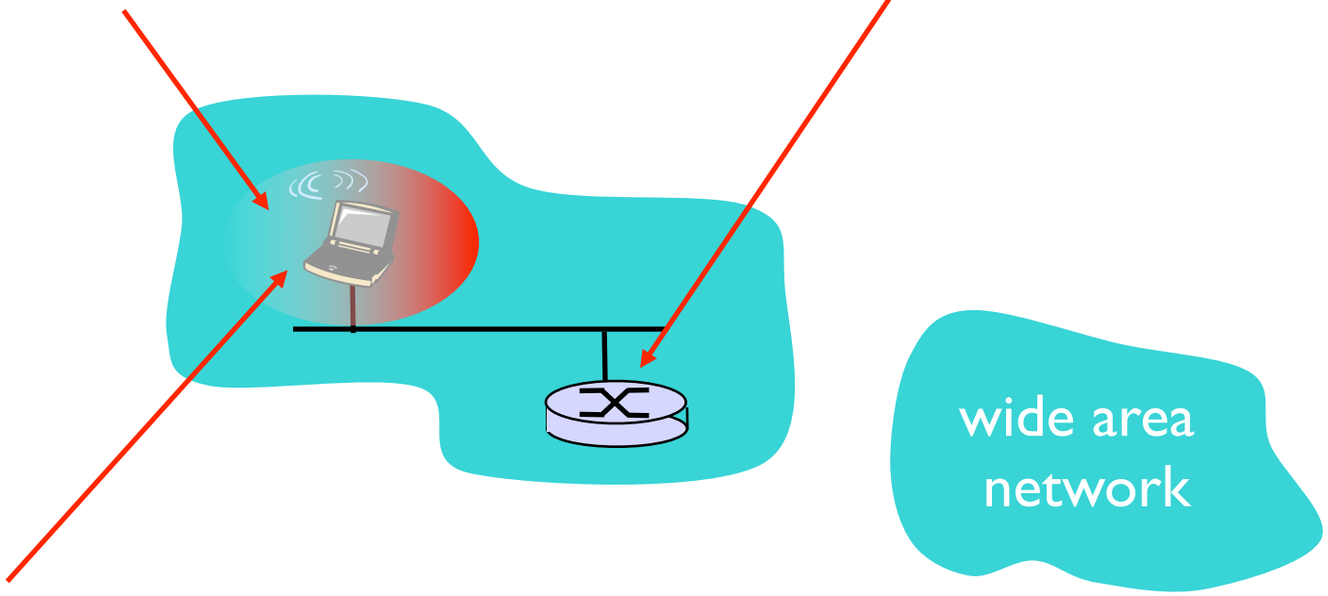
- spectrum of mobility, from the network perspective:



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



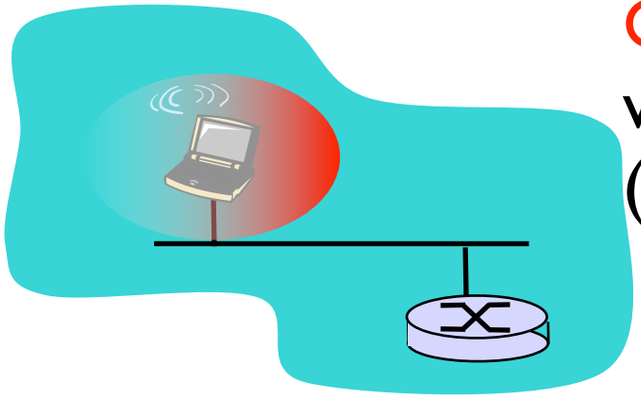
Permanent address: address in home network, can always be used to reach mobile e.g., 128.119.40.186

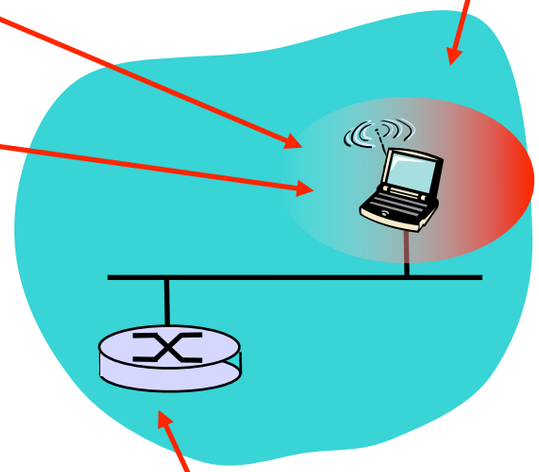
Mobility: more vocabulary

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

correspondent: wants to communicate with mobile

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

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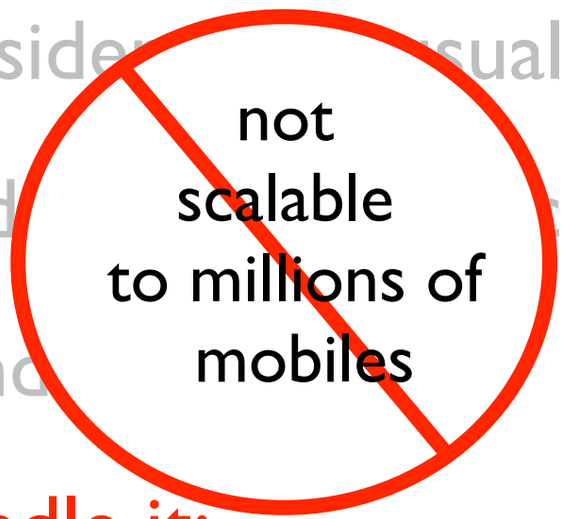

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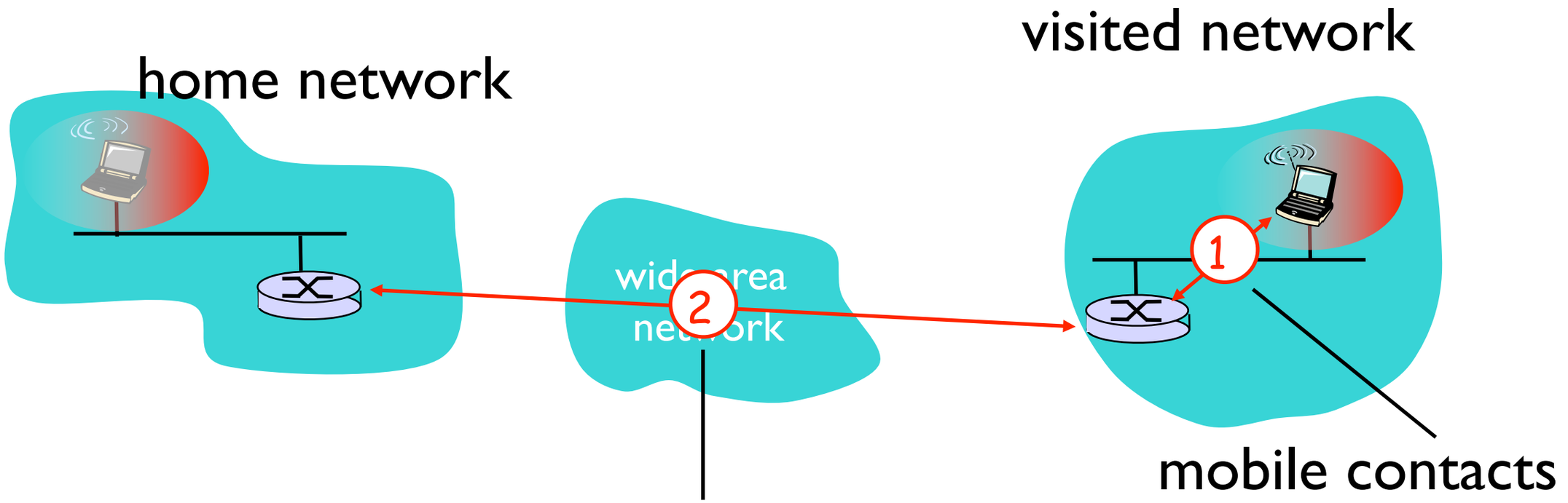
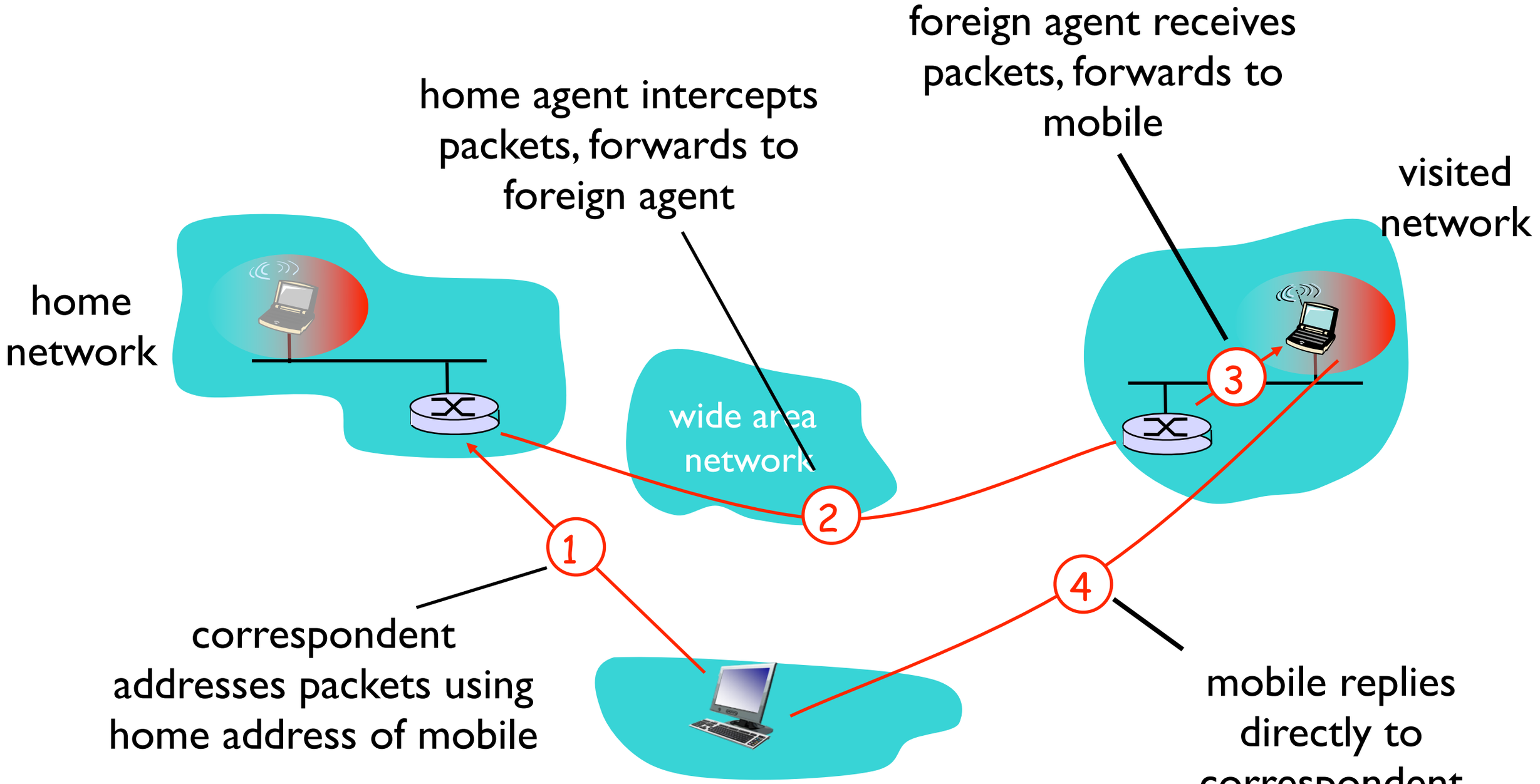
Mobility: registration



End result:

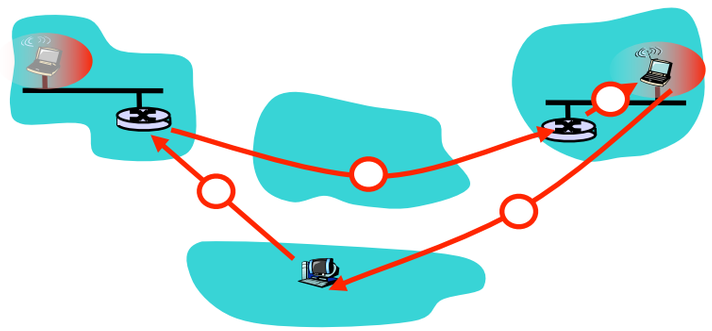
- Foreign agent knows about mobile
- Home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing: comments

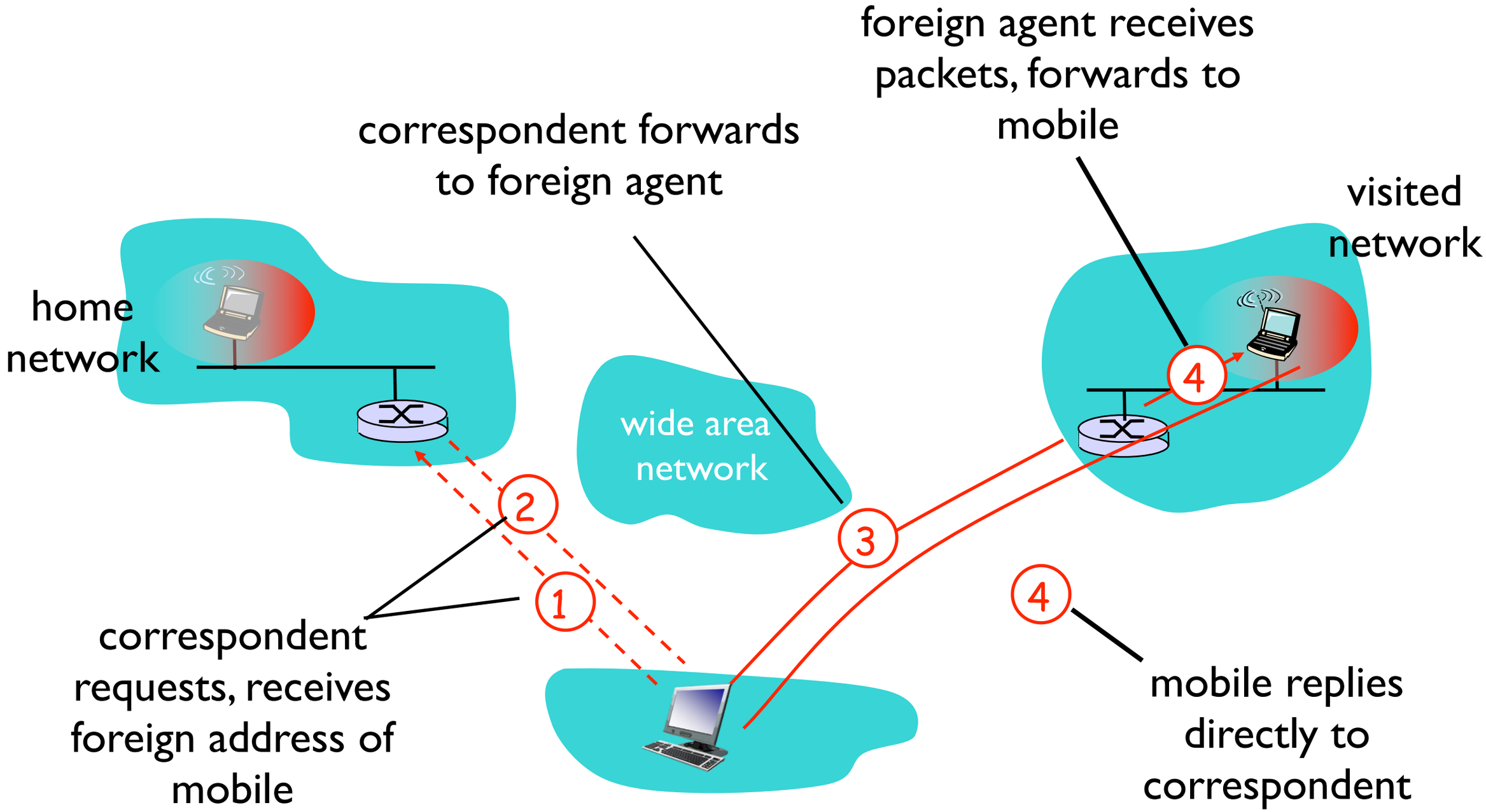
- Mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is transparent to correspondent)
  - care-of-address: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile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



Indirect Routing: moving between networks

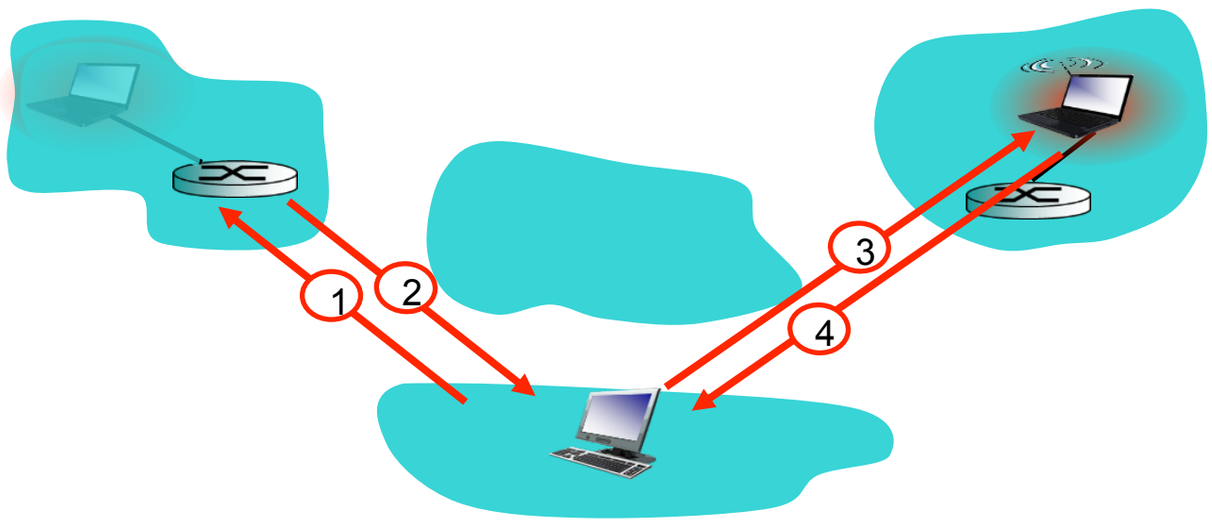
- suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
    - packets continue to be forwarded to mobile (but with new care-of-address)
- mobility, changing foreign networks transparent: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

Mobility via Direct Routing



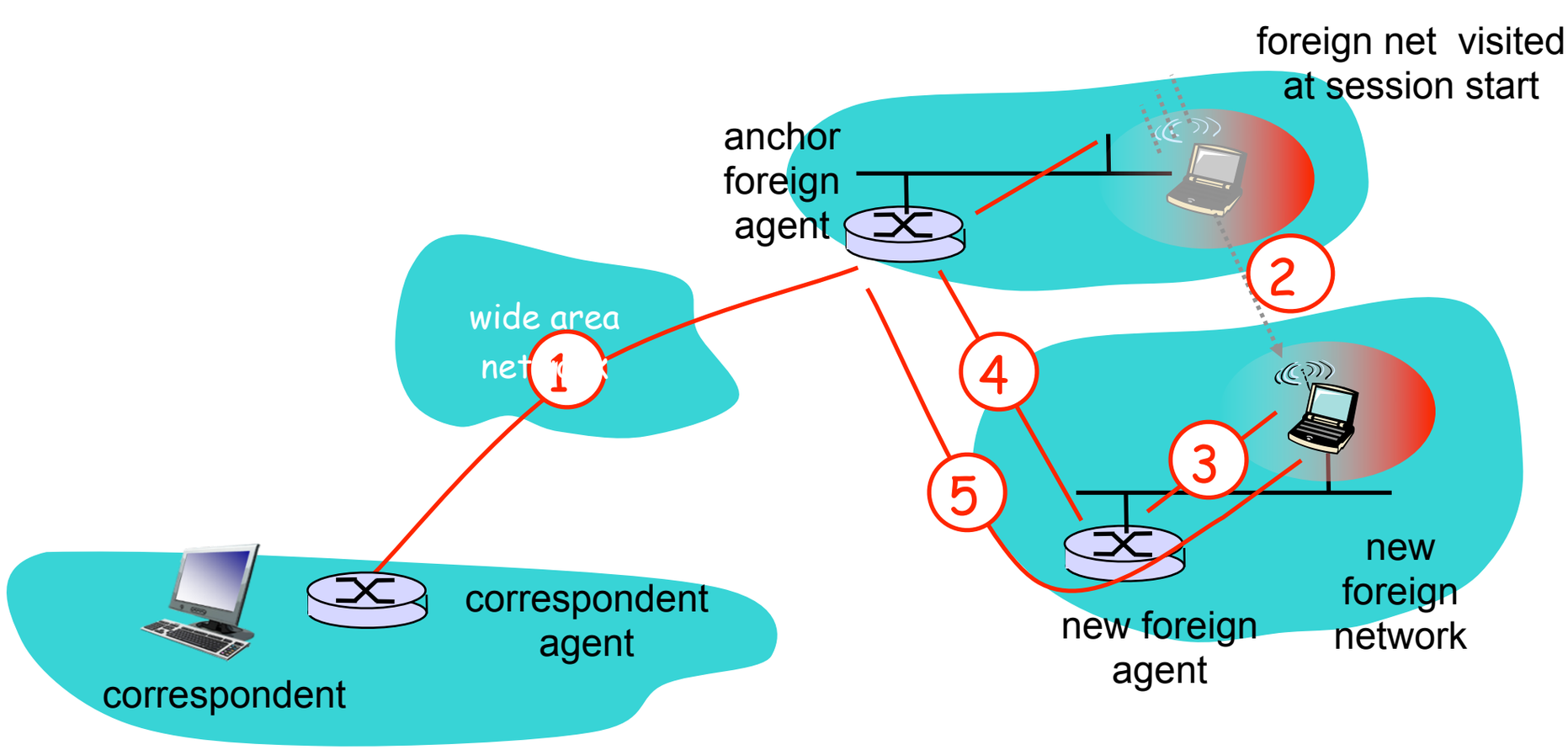
Mobility via Direct Routing: comments

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



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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  - architecture
  - standards (e.g., GSM)

Mobility

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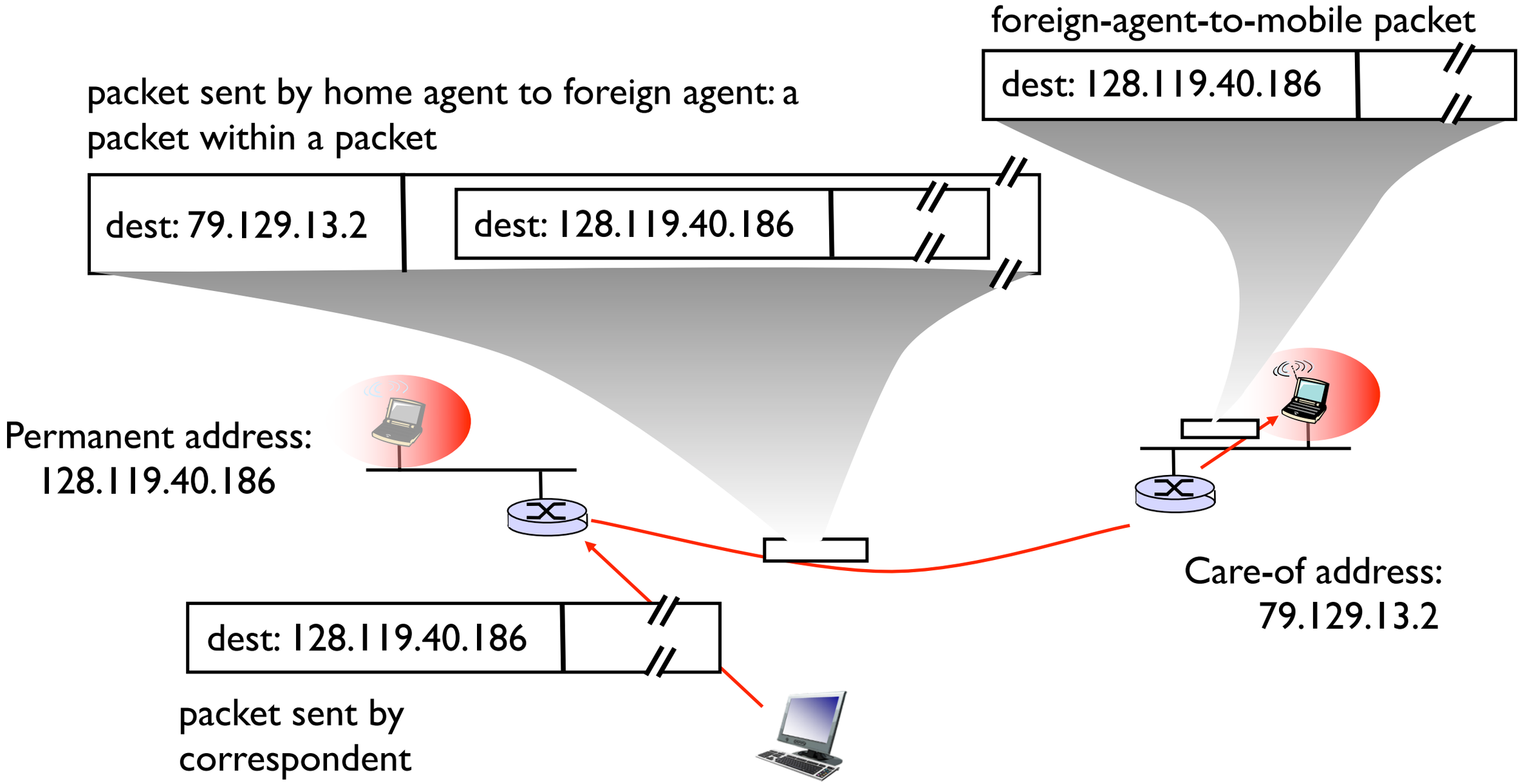
6.9 Summary

Mobile IP

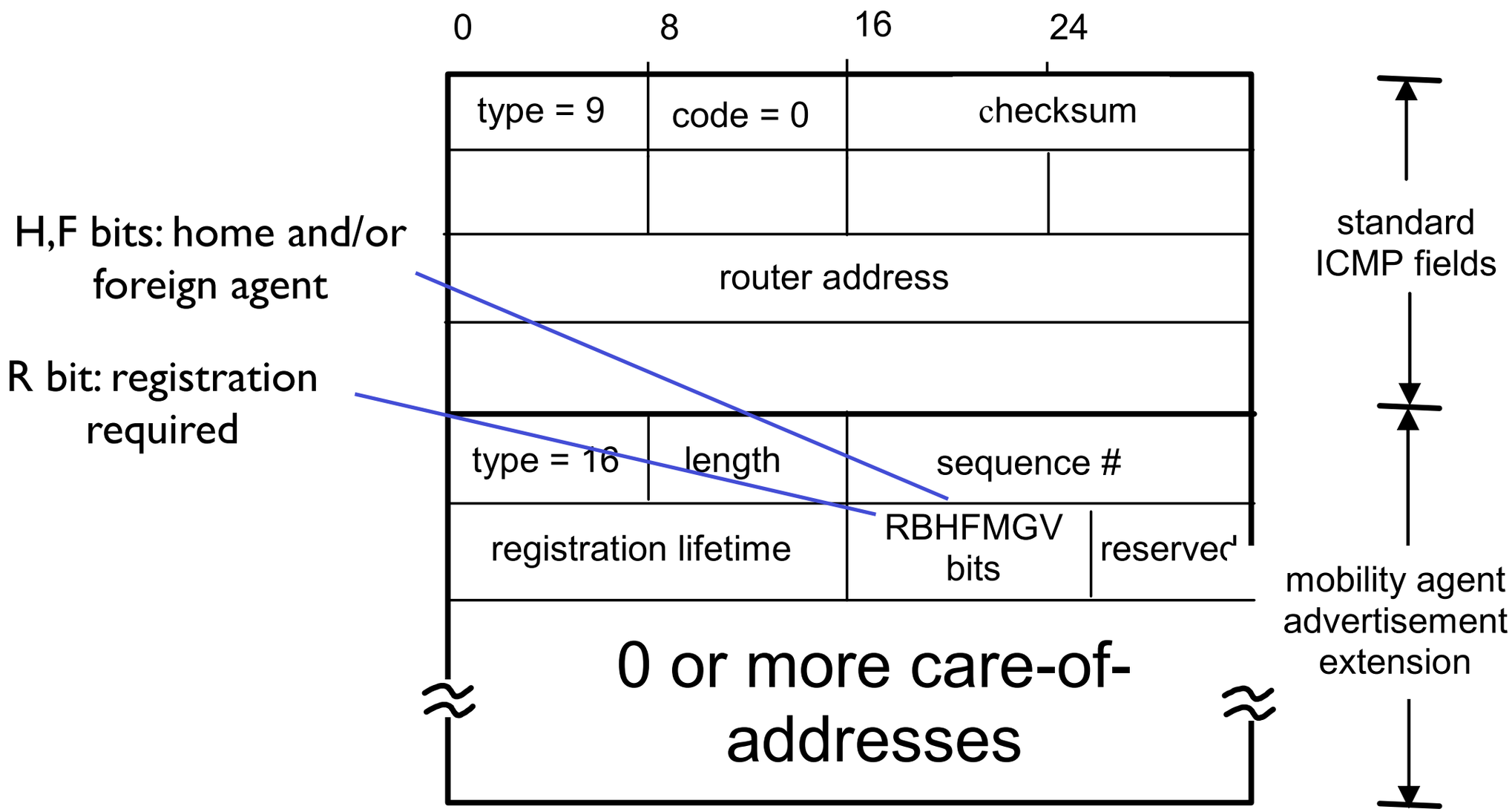
- RFC 3344
- has many features we've seen:
  - home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)
- three components to standard:
  - indirect routing of datagrams
  - agent discovery
  - registration with home agent

Mobile IP: indirect routing

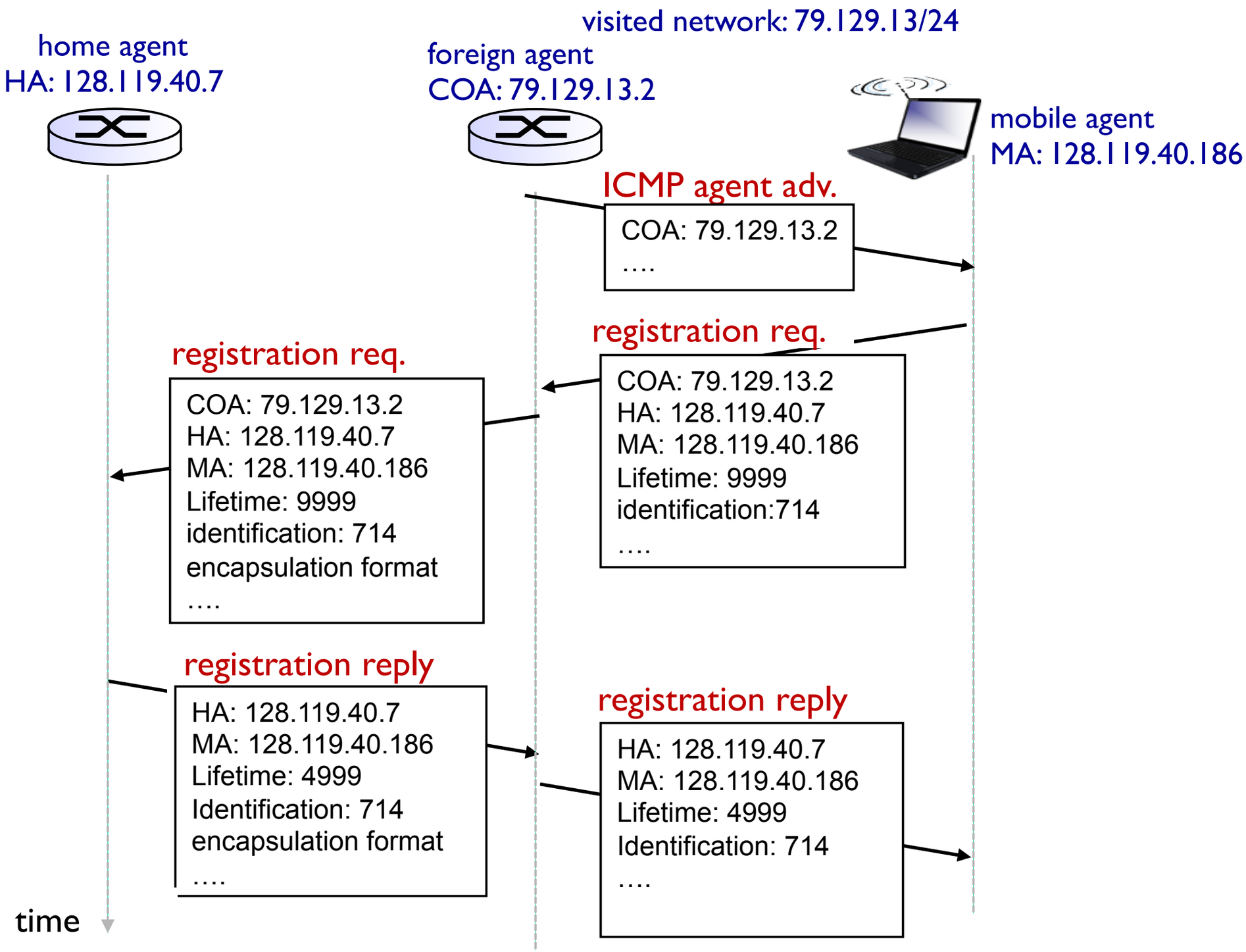


Mobile IP: agent discovery

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

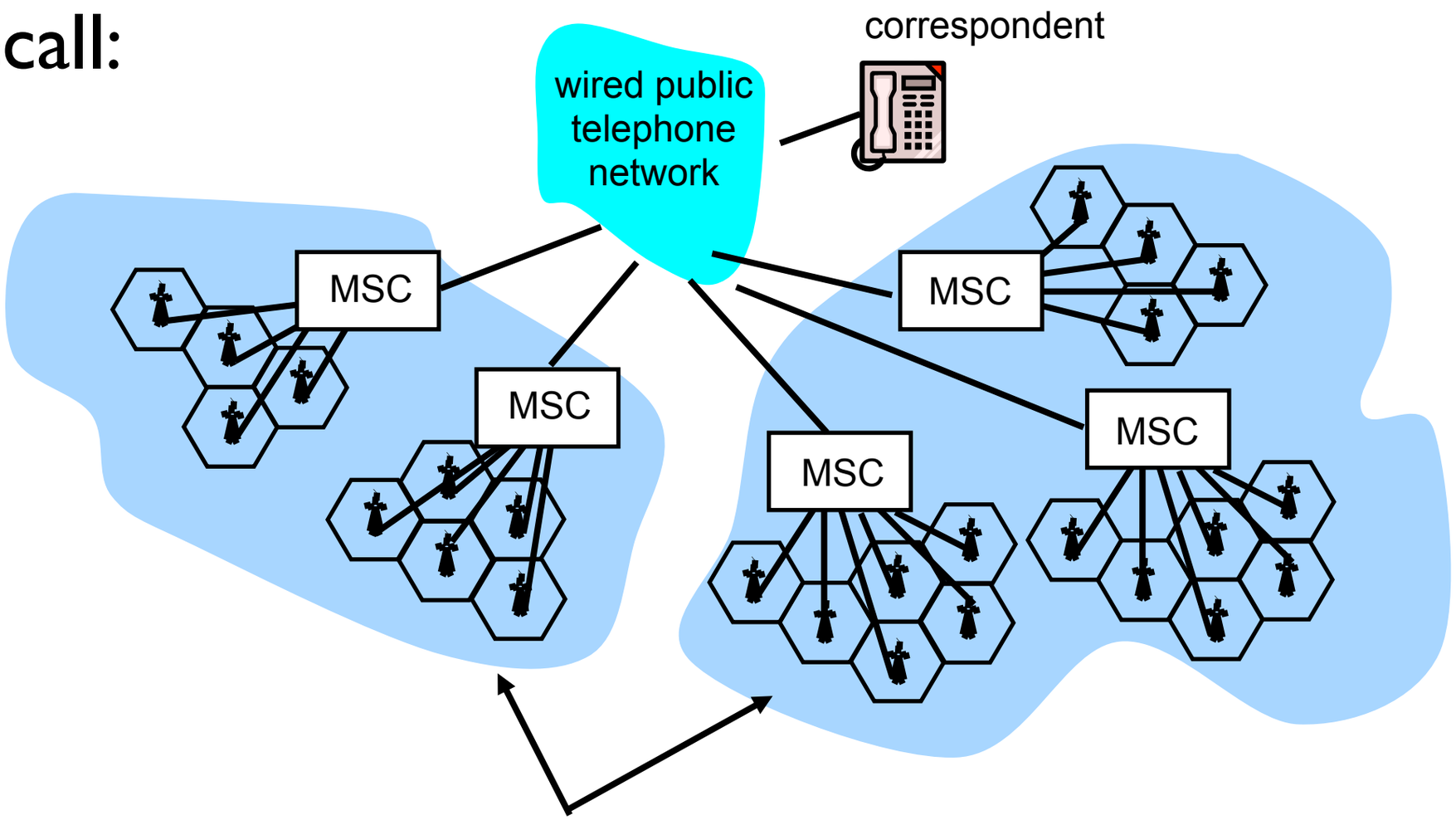


Mobile IP: registration example



Cellular Network Components

recall:



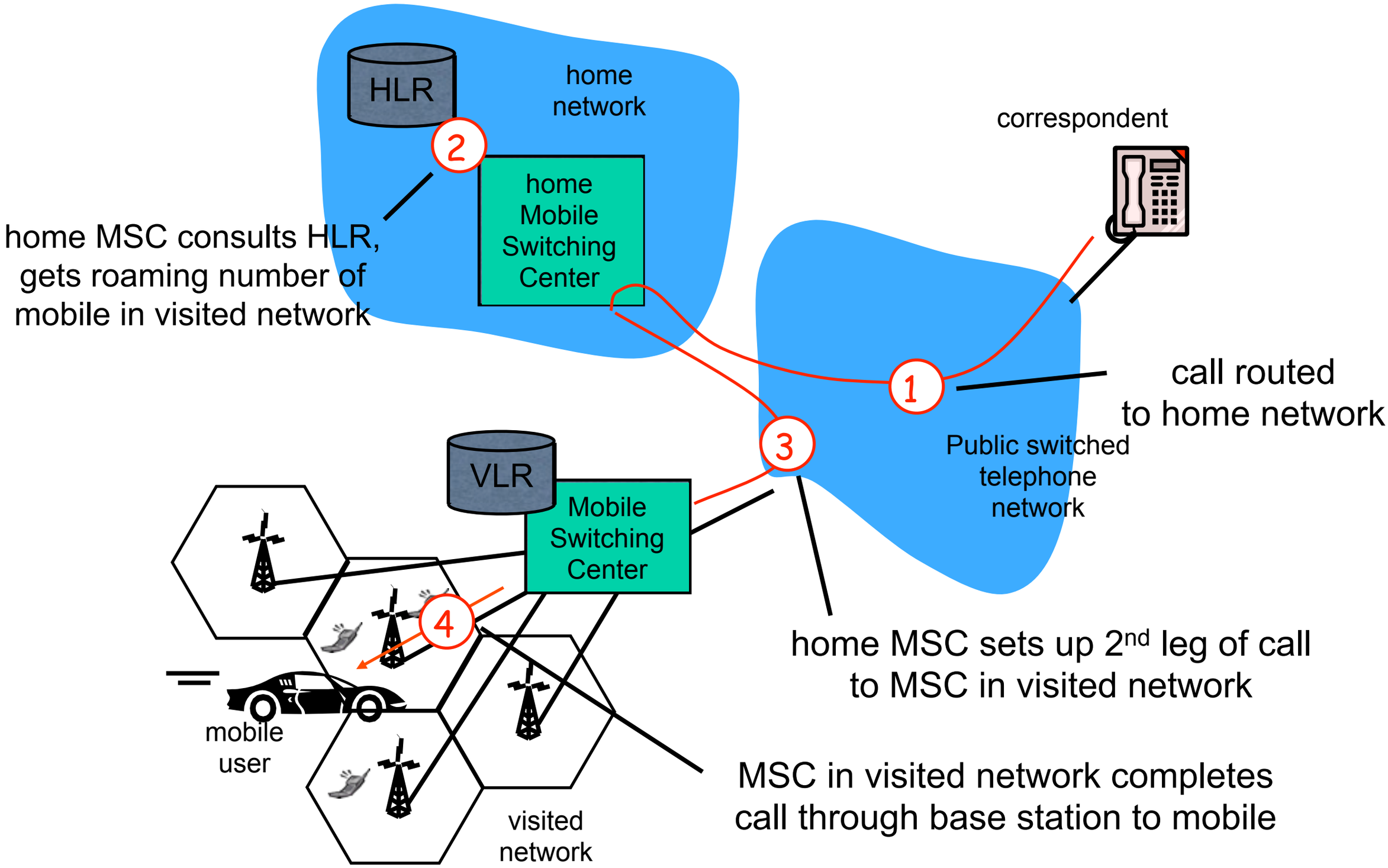
different cellular networks,
operated by different providers

Handling mobility in cellular networks

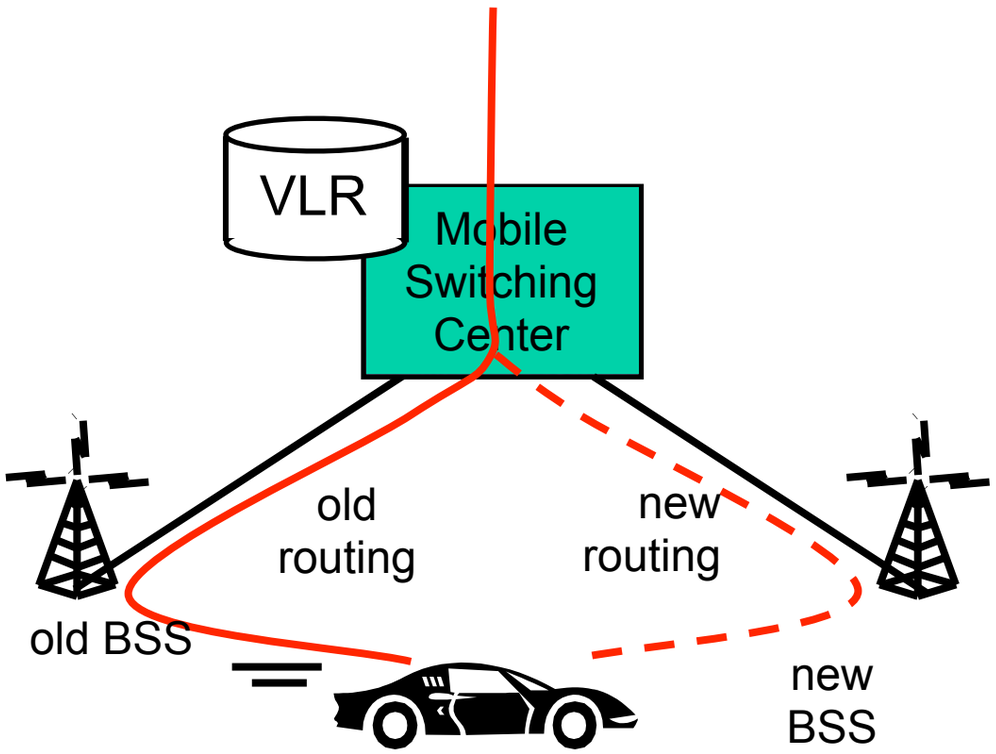
- home network: network of cellular provider you subscribe to (e.g., AT&T, Verizon)
  - home location register (HLR): database in home network containing permanent cell phone #, profile information (services, preferences, billing), information about current location (could be in another network)

- 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

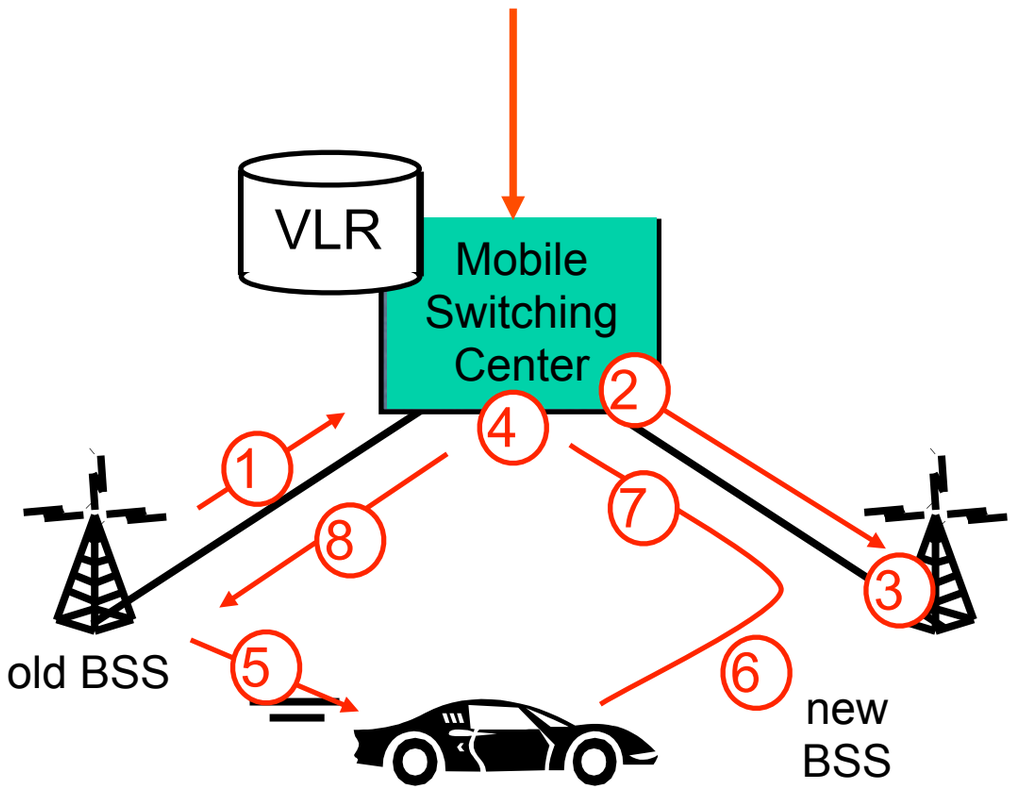


GSM: Handoff with Common MSC



- 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

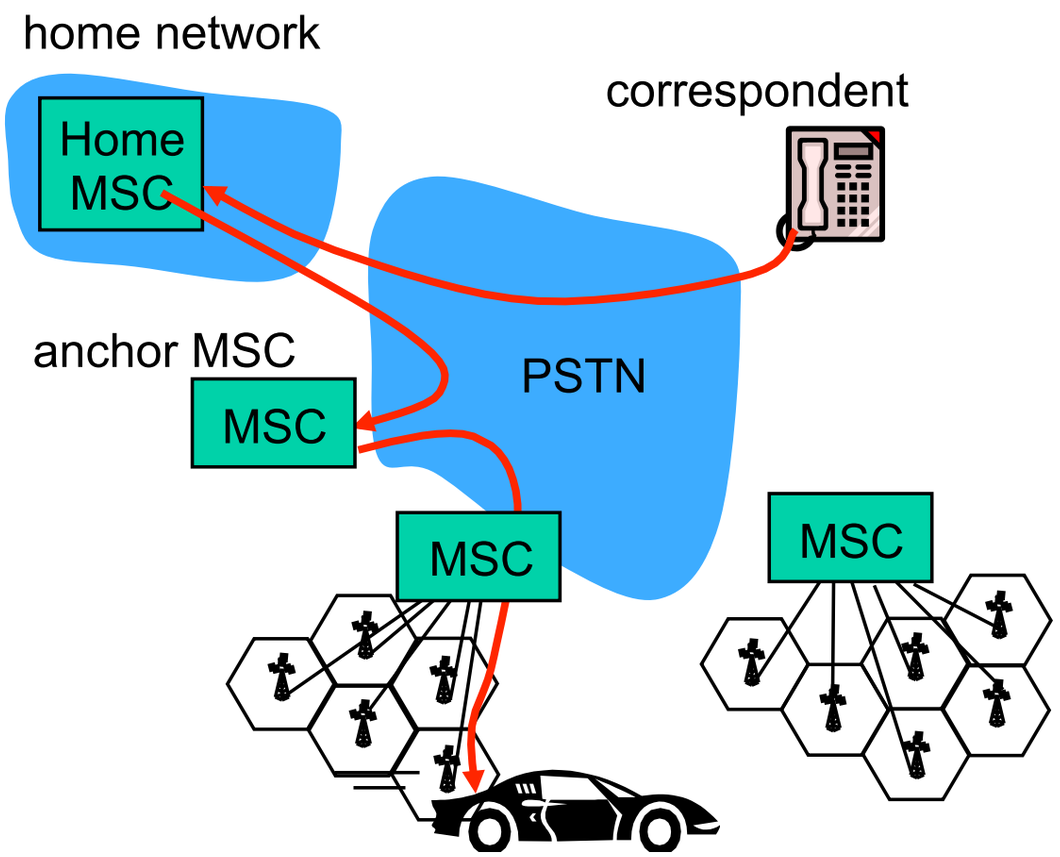
GSM: Handoff with Common MSC



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

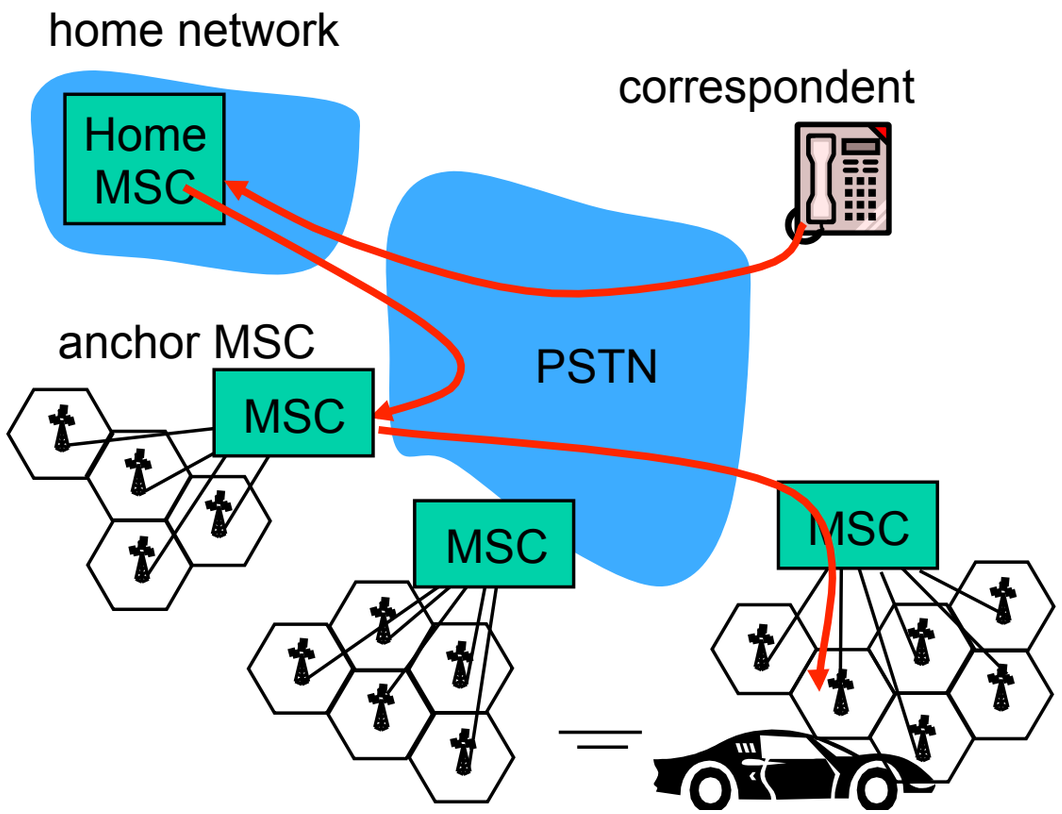
GSM: Handoff Between MSCs



(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
- IS-41 allows optional path minimization step to shorten multi-MSC chain

GSM: Handoff Between MSCs



(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

Mobility: GSM versus Mobile IP

GSM element	Comment on GSM element	Mobile IP element
Provider Network	Network to which the 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

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, CDMA-2000, UMTS)

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

Next Time

- Read Sections 8.1-8.2
  - Security!

- Get started on Homework 3 and Project 4!

- Start getting prepared for the final...