Information Technology Engineering

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1393

Wireless Links, WiFi, Cellular Internet Access, and Mobility

WIRELESS AND MOBILE NETWORKS

Slides derived from those available on the Web site of the book "Computer Networking", by Kurose and Ross, PEARSON

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

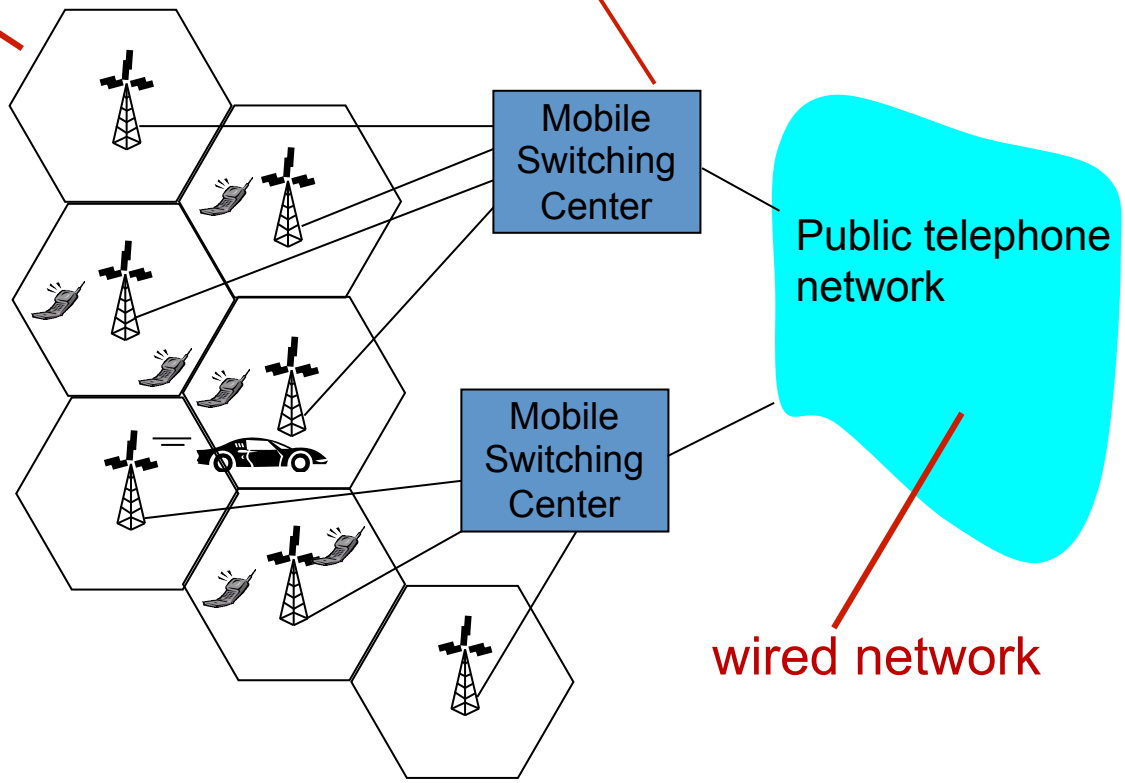
6.8 Mobility and higher-layer protocols

6.9 Summary

Components of Cellular Network Architecture

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

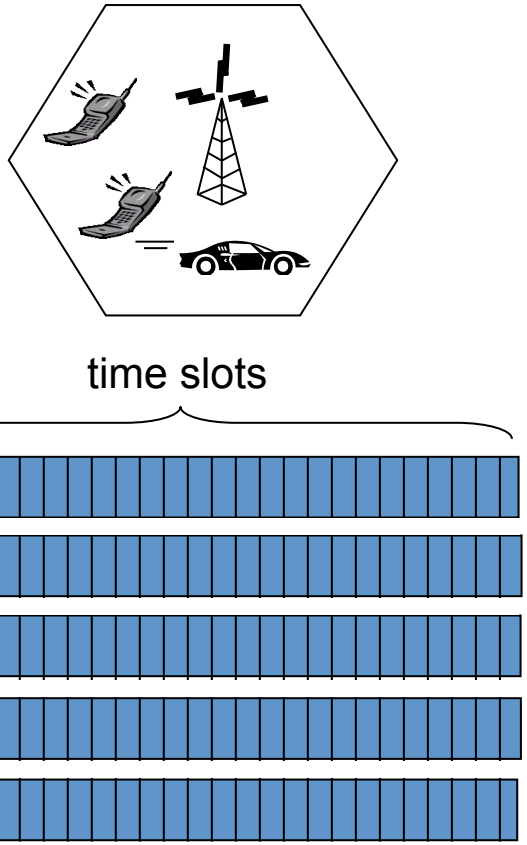
cell
- covers geographical region
- *base station* (BS) analogous to 802.11 AP
- *mobile users* attach to network through BS
- *air-interface:* physical and link layer protocol between mobile and BS



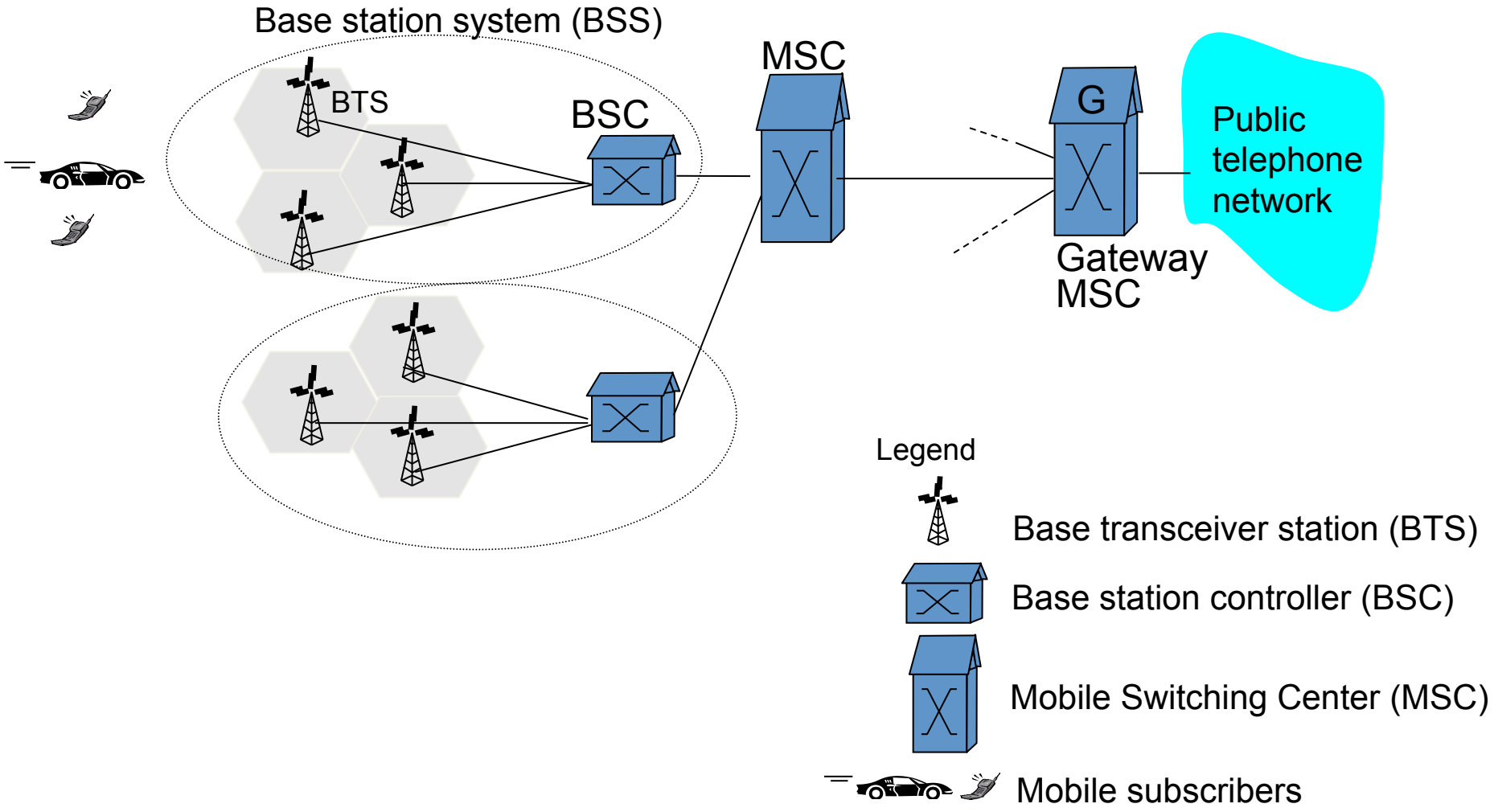
Cellular Networks: the First Hop

Two techniques for sharing mobile-to-BS radio spectrum

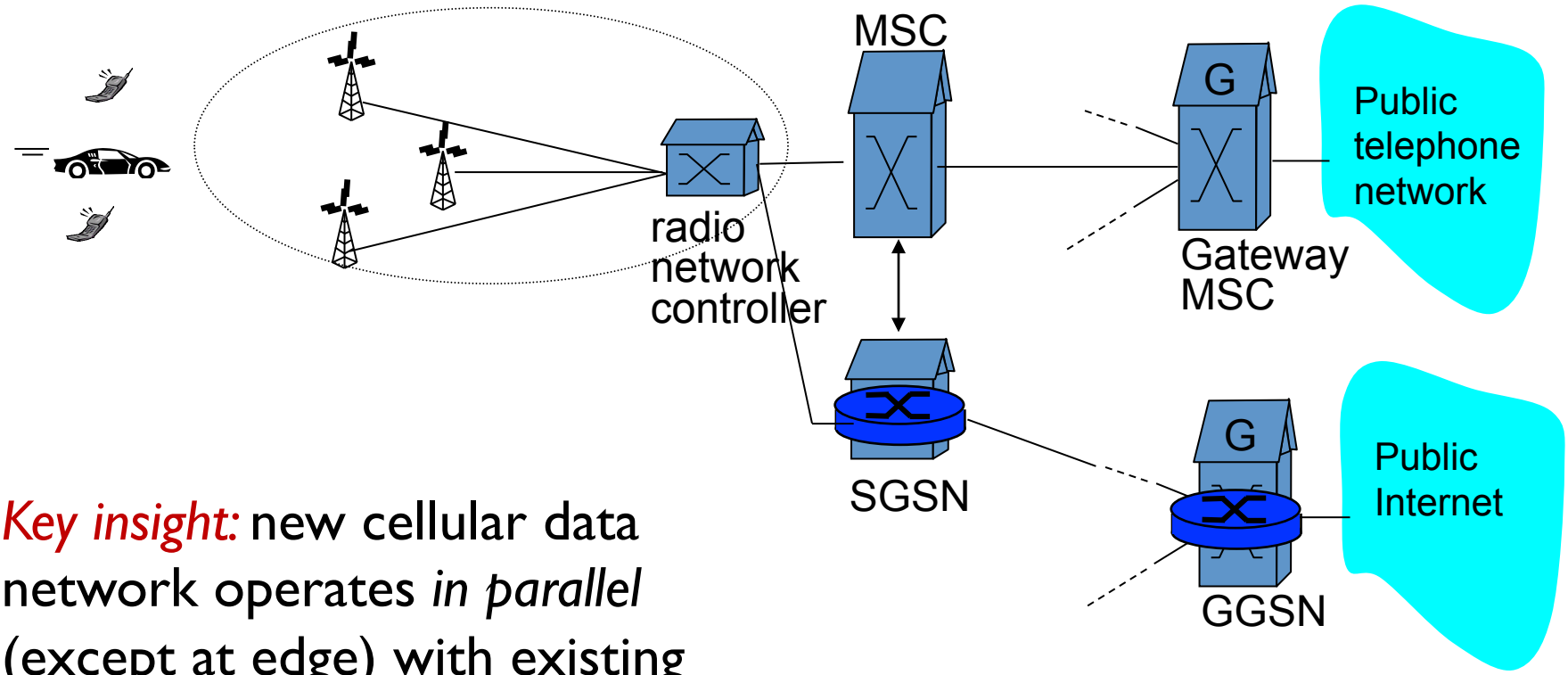
- combined FDMA/TDMA: divide spectrum in frequency channels, divide each channel into time slots
- CDMA: code division multiple access



2G (voice) Network Architecture

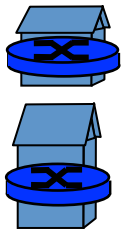


3G (voice+data) Network Architecture



Key insight: new cellular data network operates *in parallel* (except at edge) with existing cellular voice network

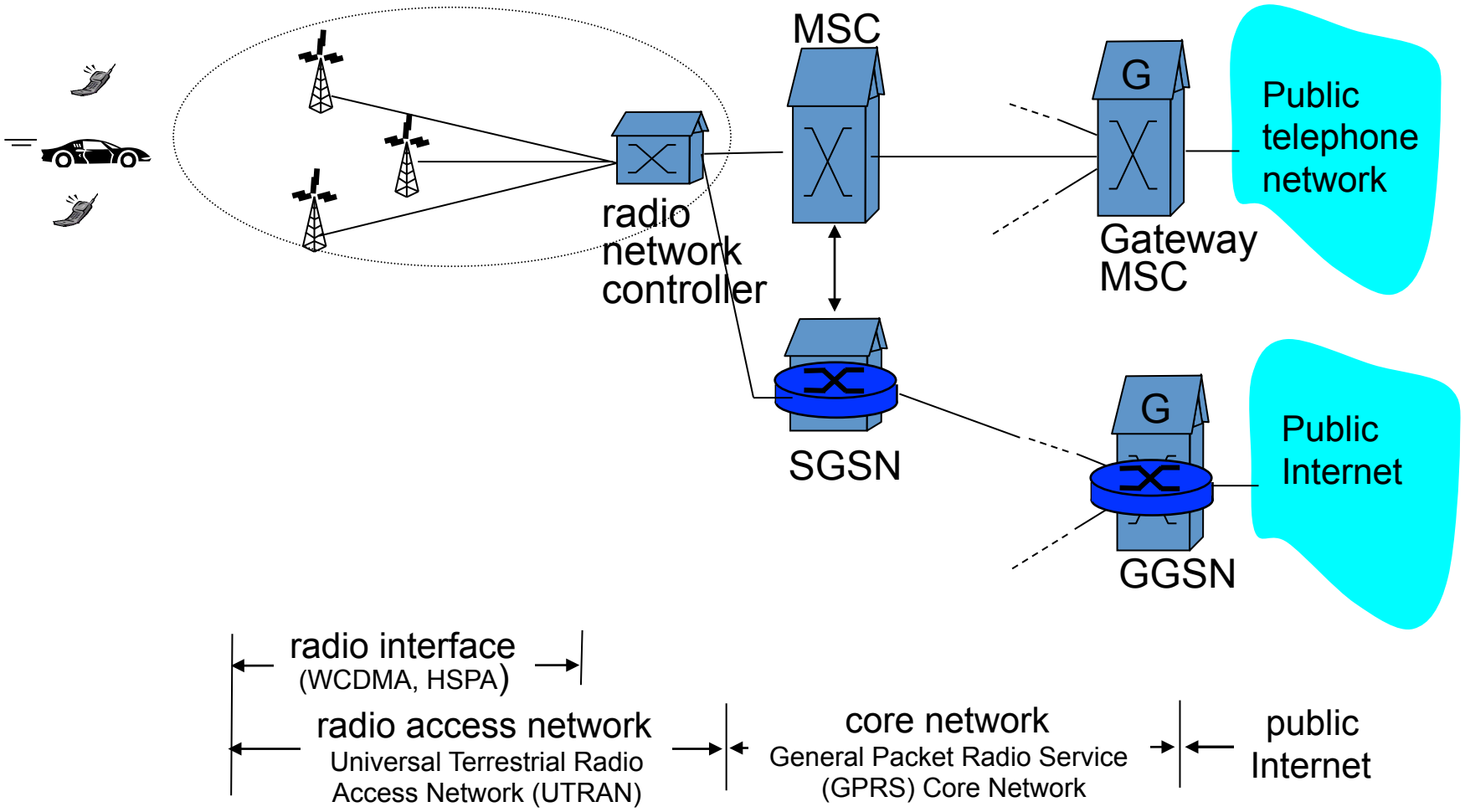
- voice network unchanged in core
- data network operates in parallel



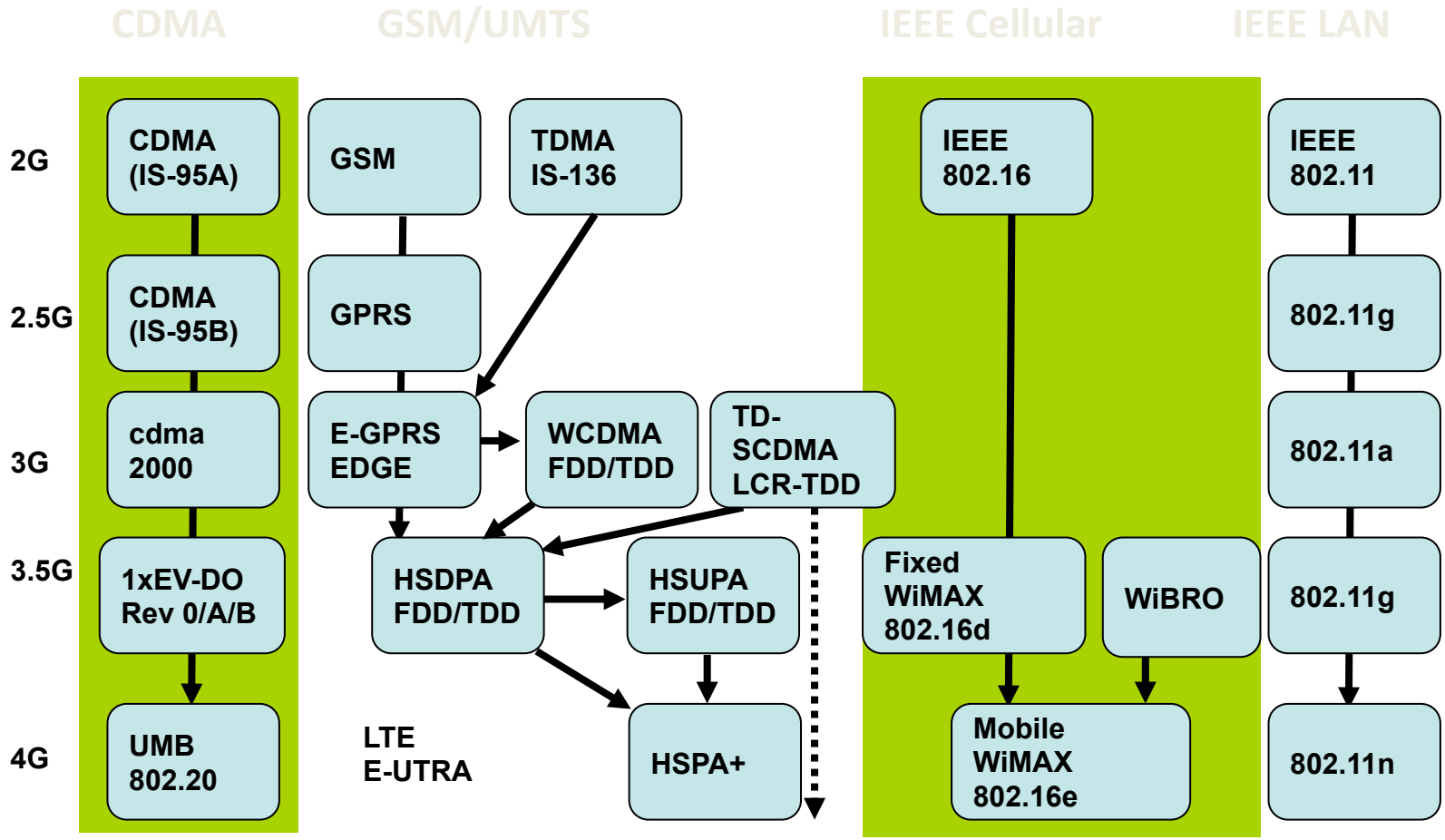
Serving GPRS (General Packet Radio Service) Support Node (SGSN)

Gateway GPRS Support Node (GGSN)

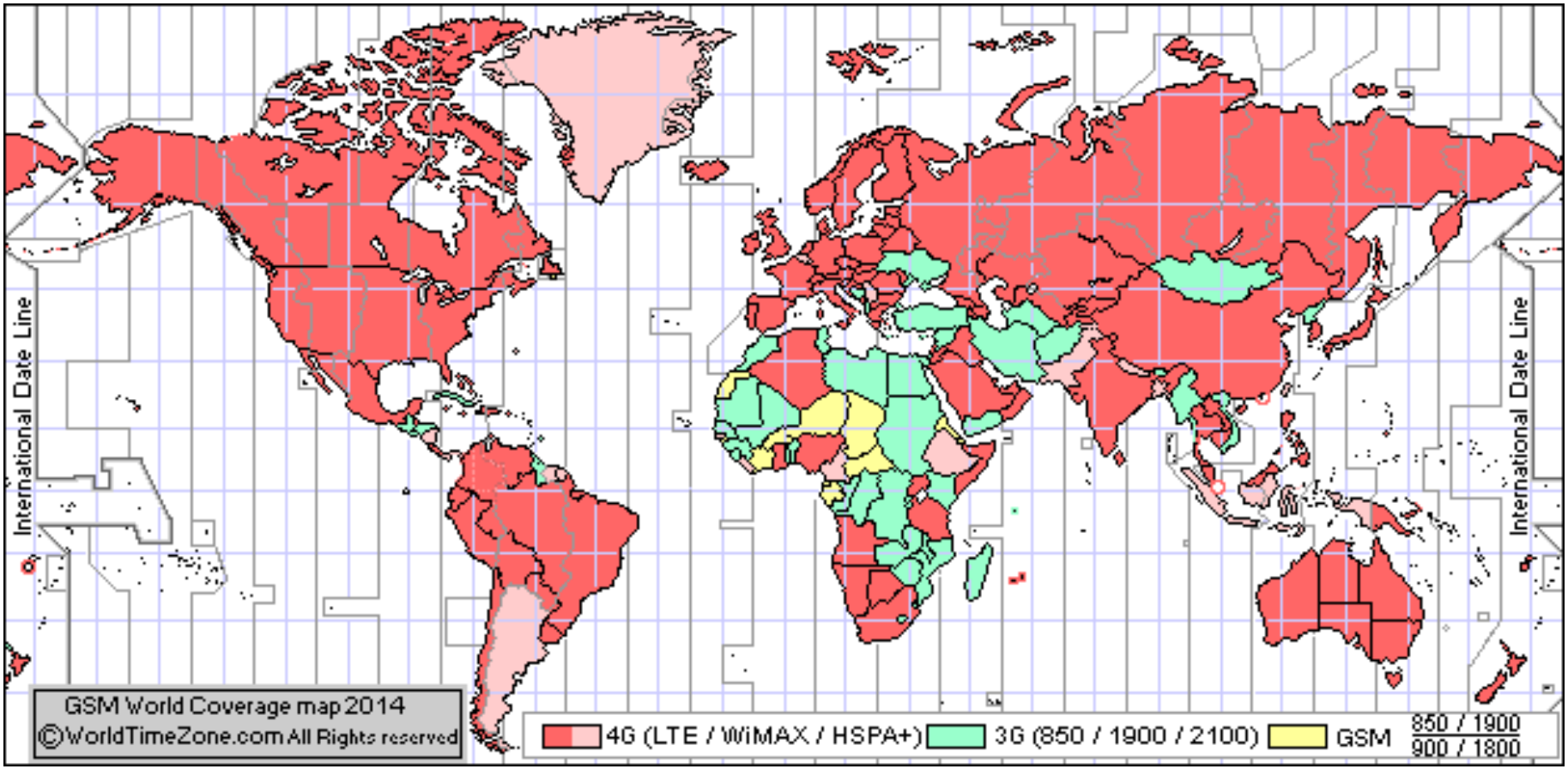
3G (voice+data) Network Architecture



Wireless Technology Evolution to 4G



LTE (Long Term Evolution) Coverage



LTE Penetration and Speed

Data speeds of LTE Advanced

	LTE Advanced
Peak download	1 Gbit/s
Peak upload	500 Mbit/s

Data speeds of LTE

	LTE
Peak download	100 Mbit/s
Peak upload	50 Mbit/s

Data speeds of WiMAX

	WiMAX
Peak download	128 Mbit/s
Peak upload	56 Mbit/s

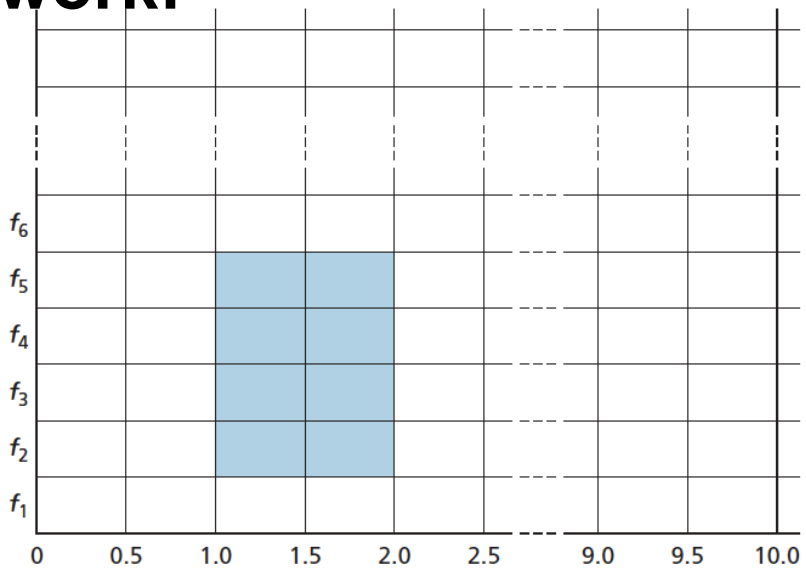
Rank	Country/Territory	Penetration
1	South Korea	62.0%
2	Japan	21.3%
3	Australia	21.1%
4	United States	19.0%
5	Sweden	14.0%
6	Canada	8.0%
7	United Kingdom	5.0%
8	Germany	3.0%
9	Russia	2.0%
10	Philippines	1.0%

In February 2007, the Japanese company NTT DoCoMo tested a 4G communication system prototype with 4×4 MIMO called VSF-OFCDM at 100 Mbit/s while moving, and 1 Gbit/s while stationary.

NTT DoCoMo completed a trial in which they reached a maximum packet transmission rate of approximately 5 Gbit/s in the downlink with 12×12.

4G: LTE

- **All-IP core network**
- Need to provide QoS for VoIP:
  - **Evolved Packet Core:**
    - Manage network resources to provide high quality of service
    - Separation between the network control (Mobility) and user data planes
    - Allows multiple types of radio access networks (2G and 3G) to attach
  - **LTE Radio Access Network:**
    - OFDM
    - MIMO



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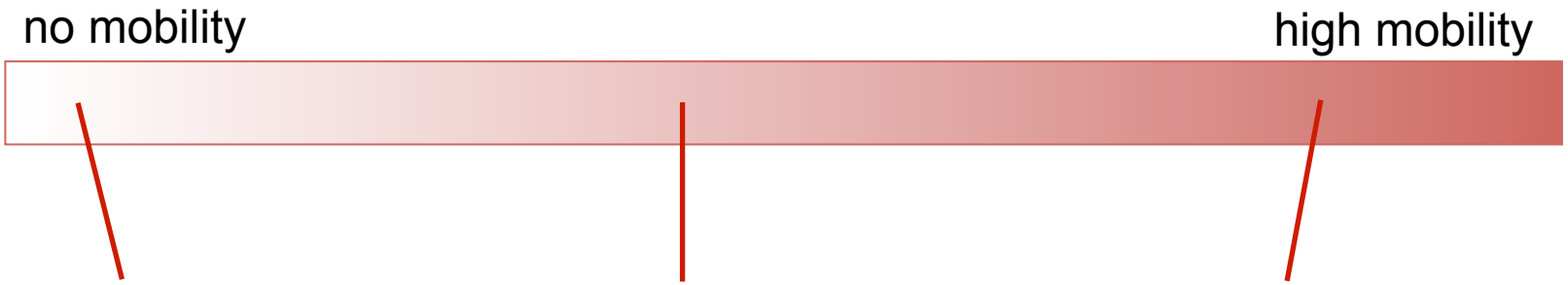
What is Mobility?

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



mobile wireless user, using same access point

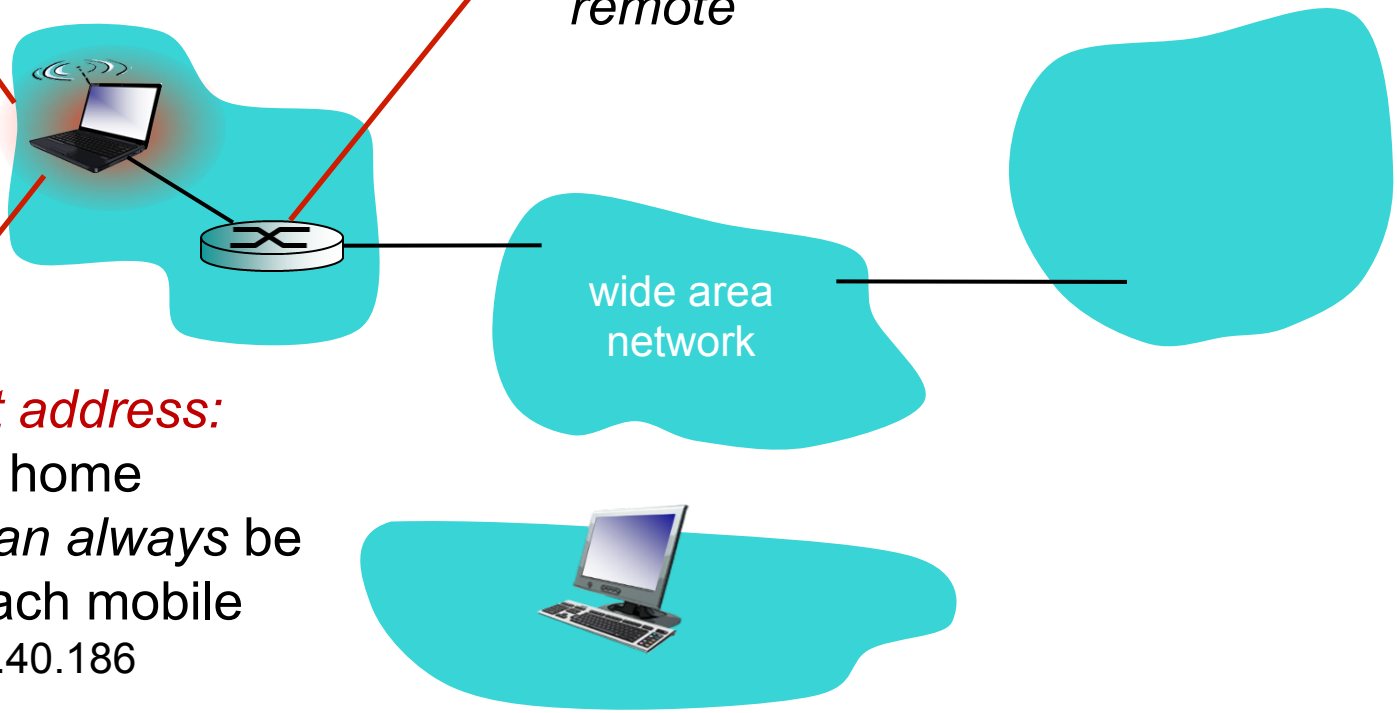
mobile user, connecting/ disconnecting from network using DHCP.

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*



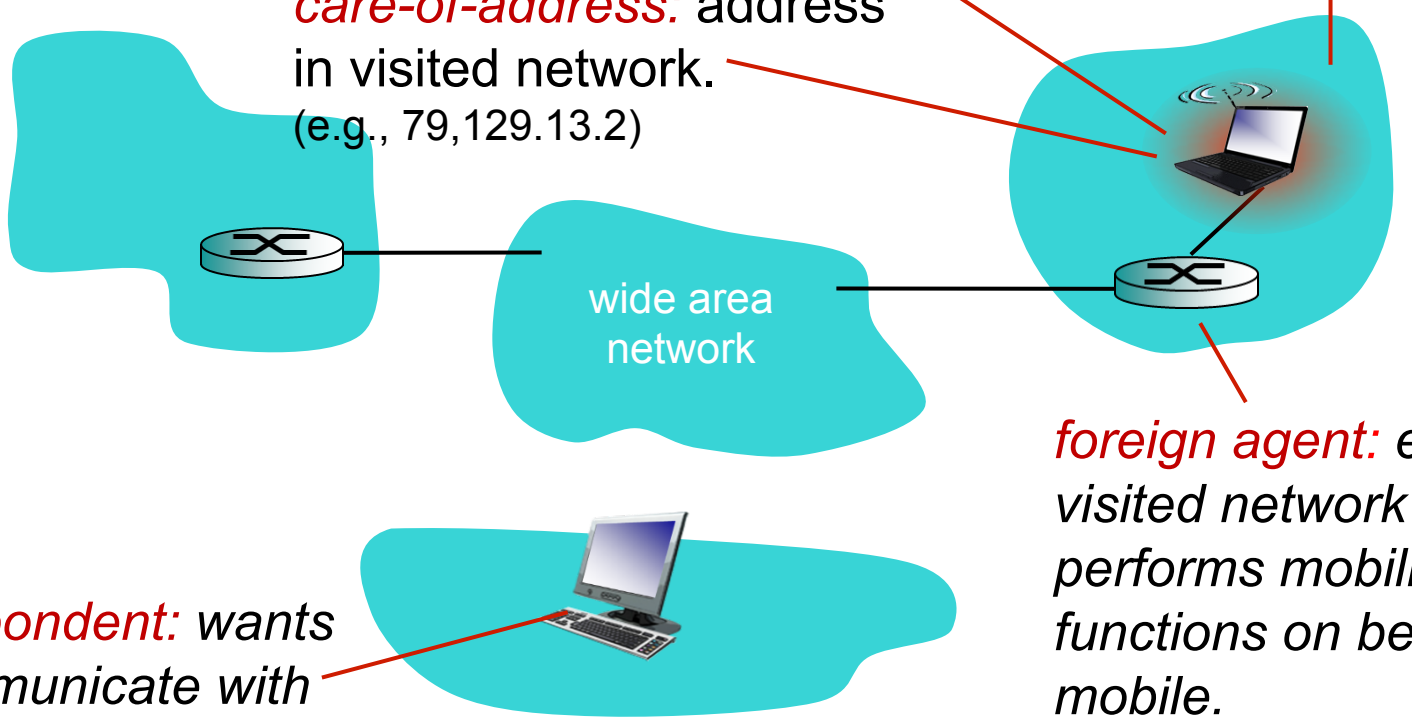
permanent address: address in home network, *can always* be used to reach mobile
e.g., 128.119.40.186

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)



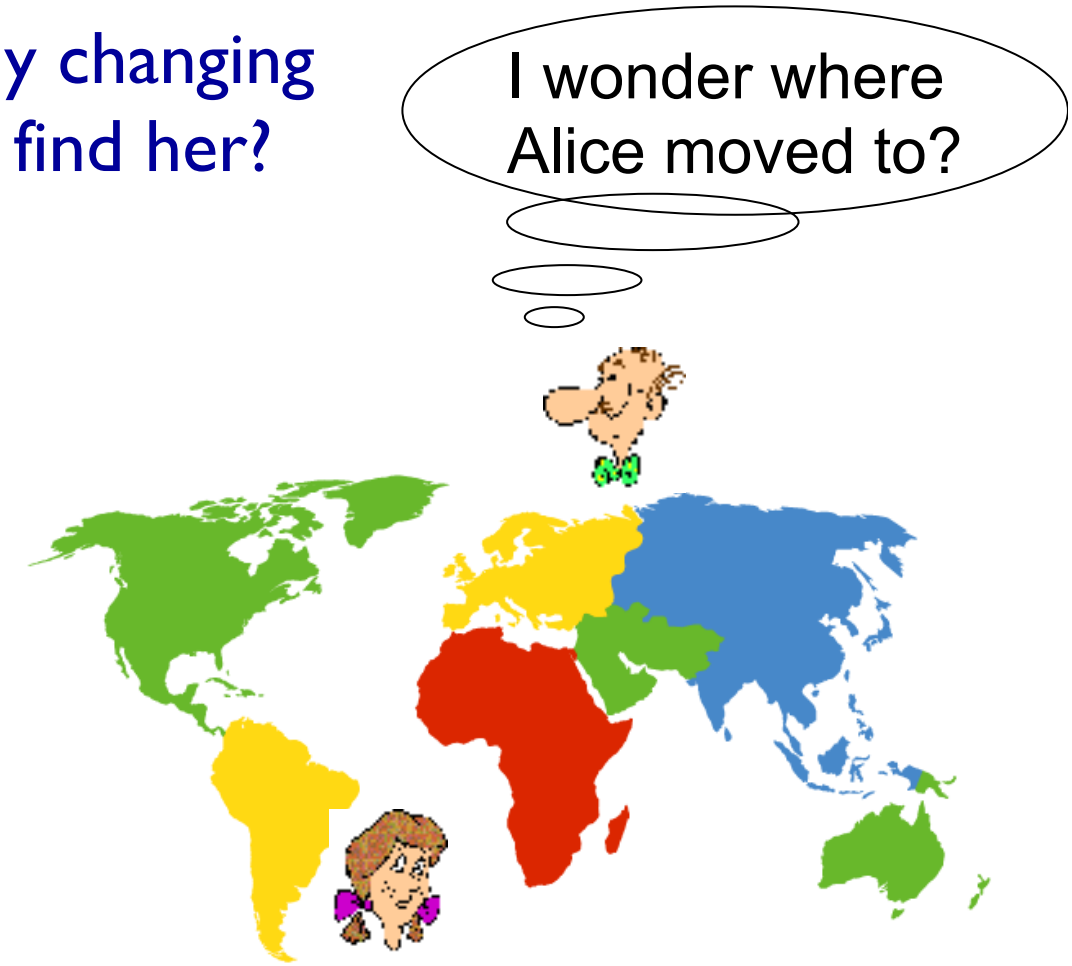
foreign agent: *entity in visited network that performs mobility functions on behalf of mobile.*

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:* n… advertise permanent address of mobile-nodes-in-… usual routing table exchange.
  - routing tab… here each mobile located
  - no changes … ems
- *Let end-systems handle it:*
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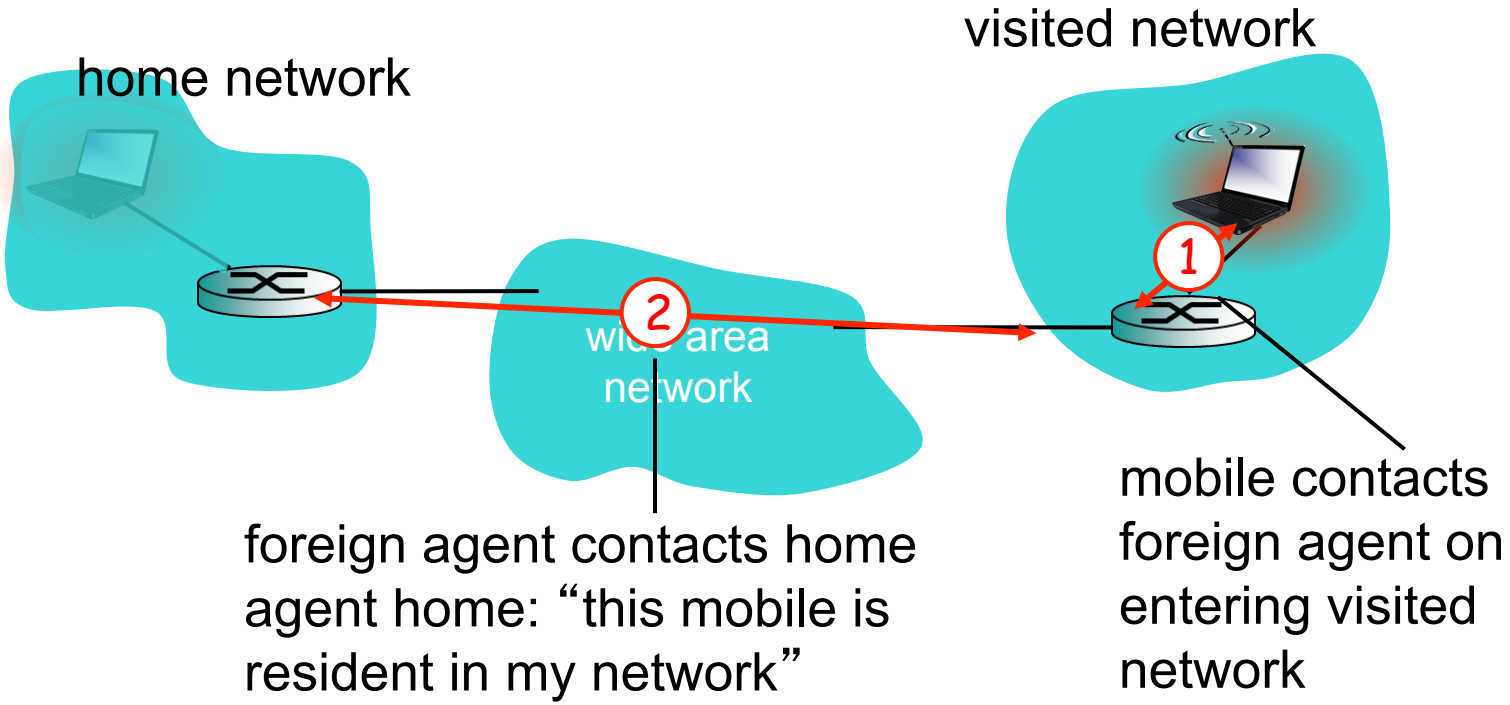
not scalable to millions of mobiles

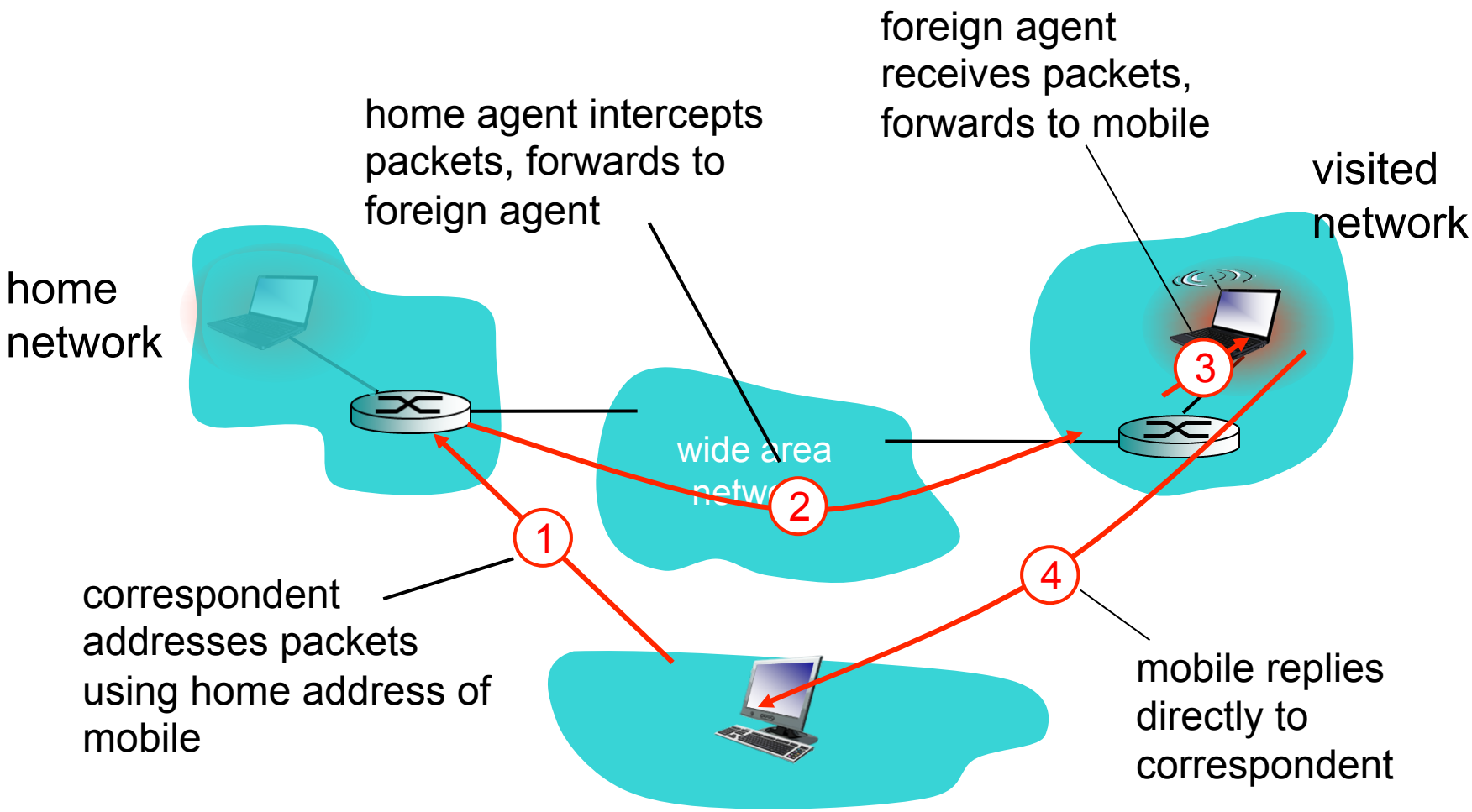
Mobility: Registration



end result:

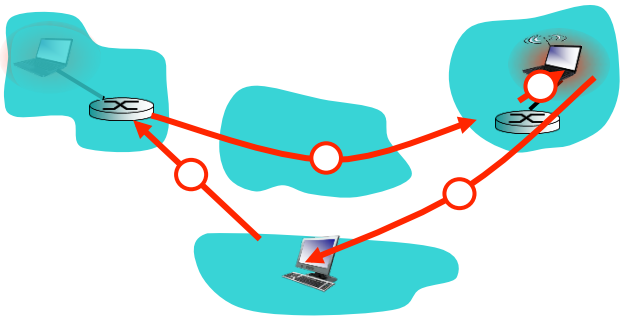
- foreign agent knows about mobile
- home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing: Comments

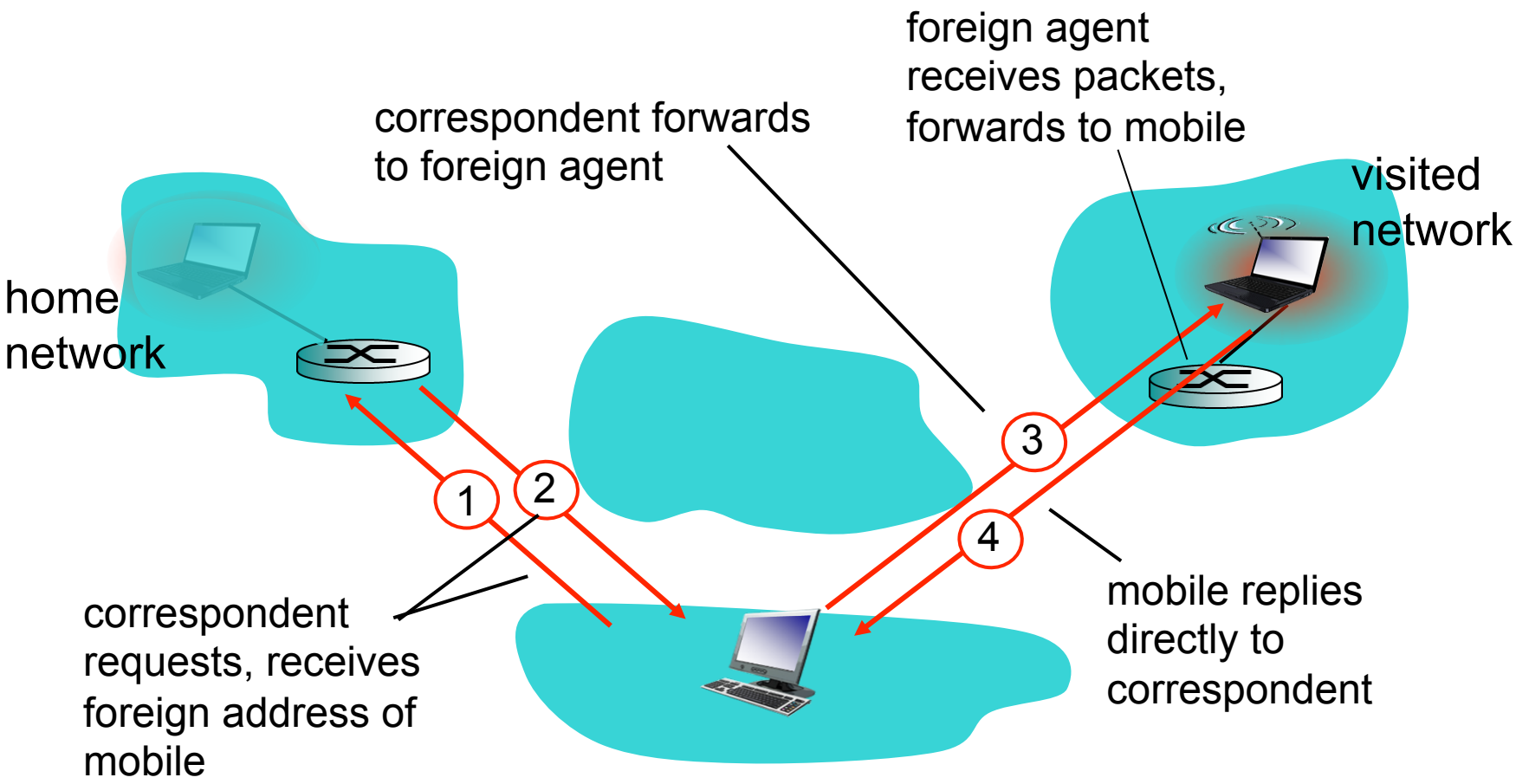
- Mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
  - care-of-address: used by home agent to forward datagrams to mobile
- Foreign agent functions may be done by mobile itself
- Triangle routing: correspondent-home-network-mobile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



Indirect Routing: Moving Between Networks

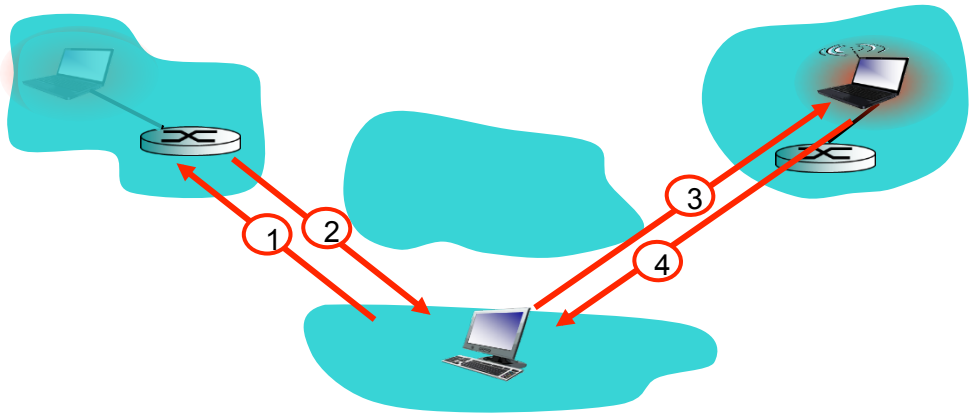
- Suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)
- Mobility, changing foreign networks transparent: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

Mobility via Direct Routing



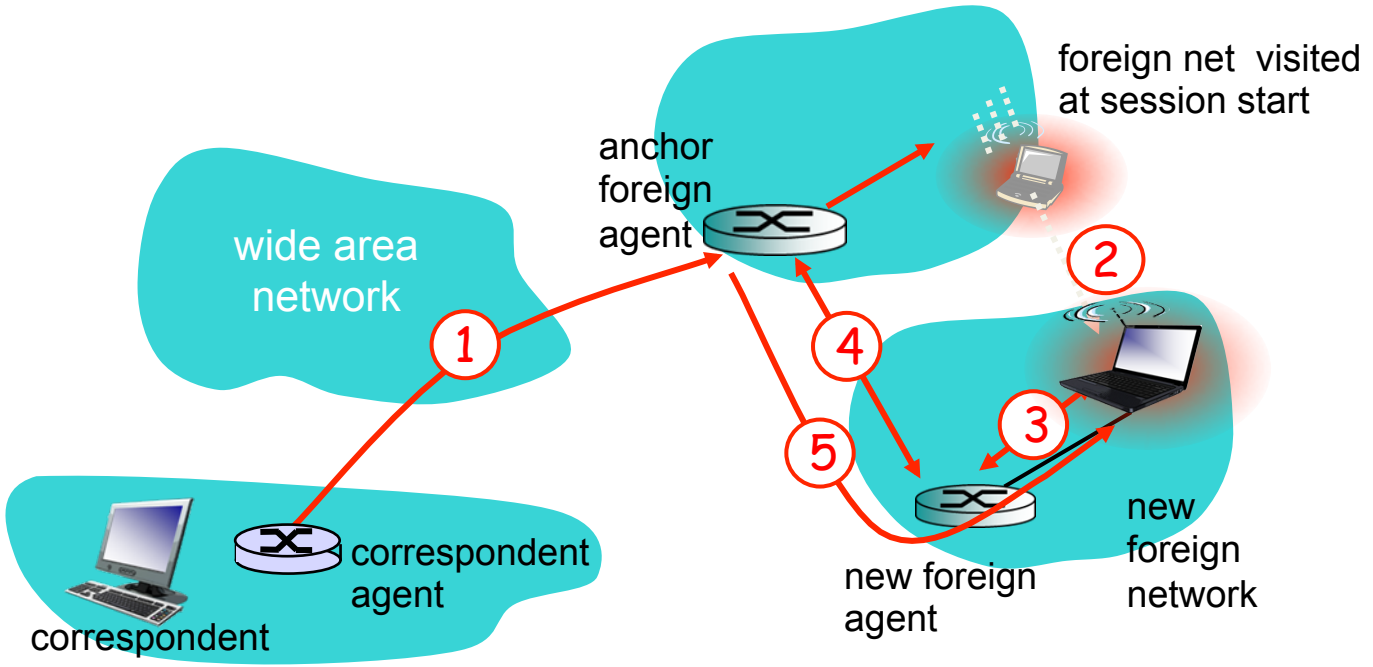
Mobility via Direct Routing: Comments

- 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)



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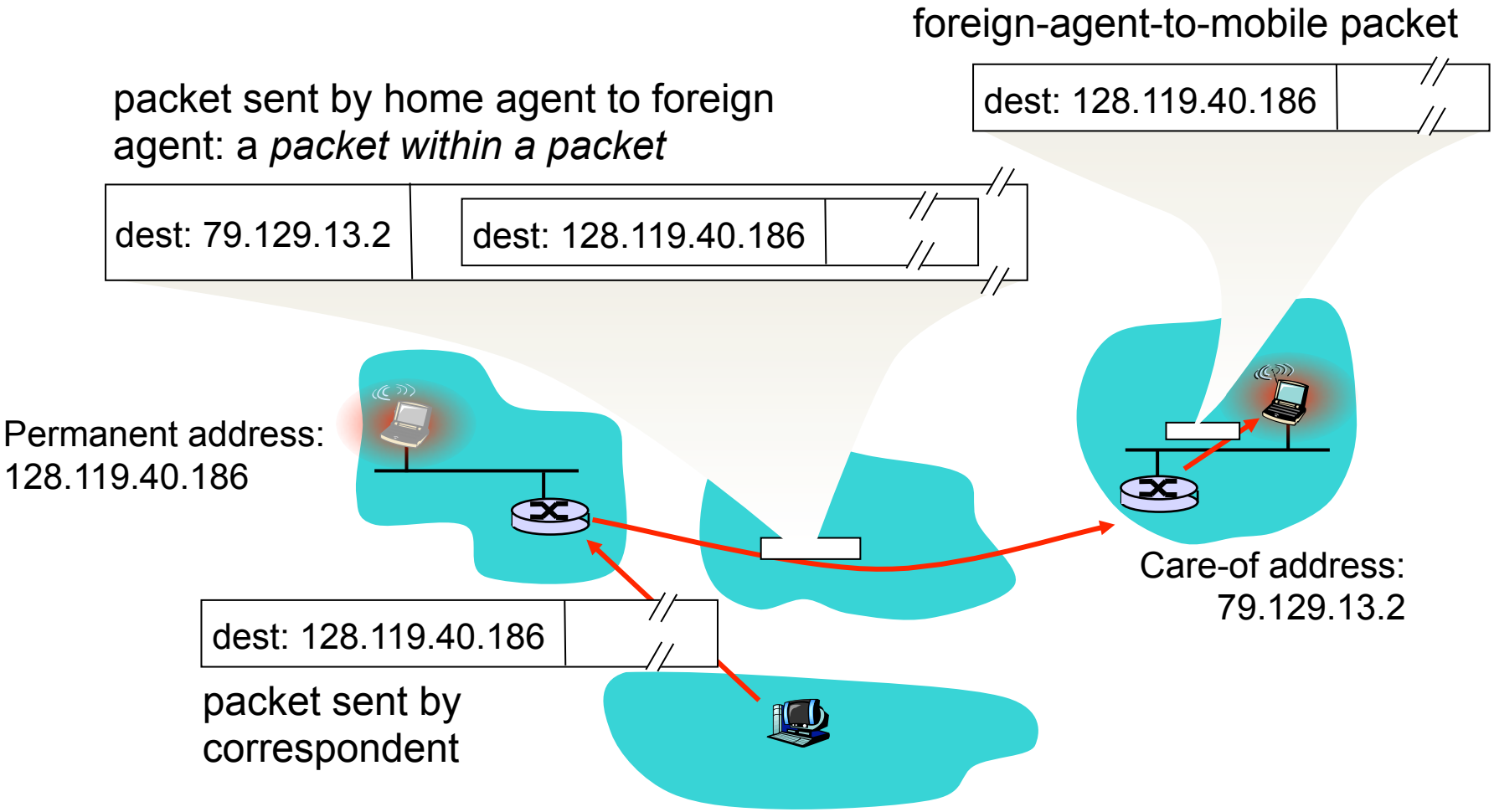
Mobile IP

- RFC 3344 and 5944 for IPv4
- 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

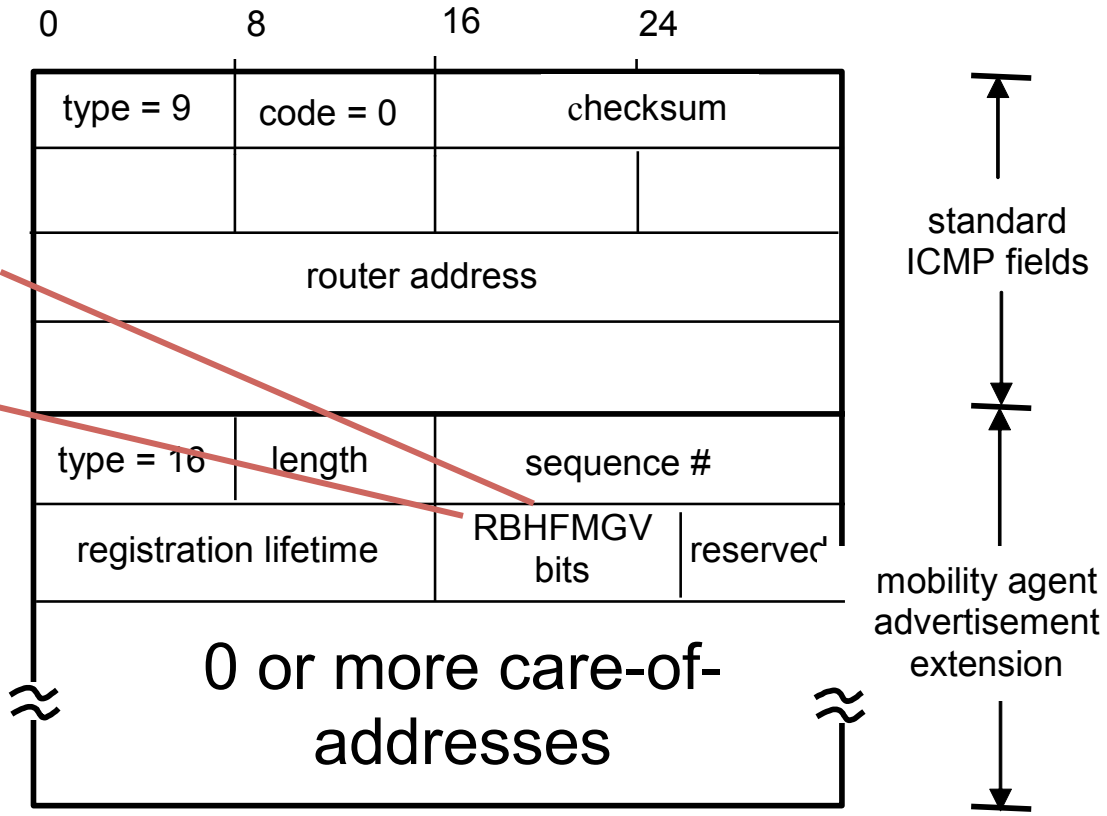


Mobile IP: Agent Discovery

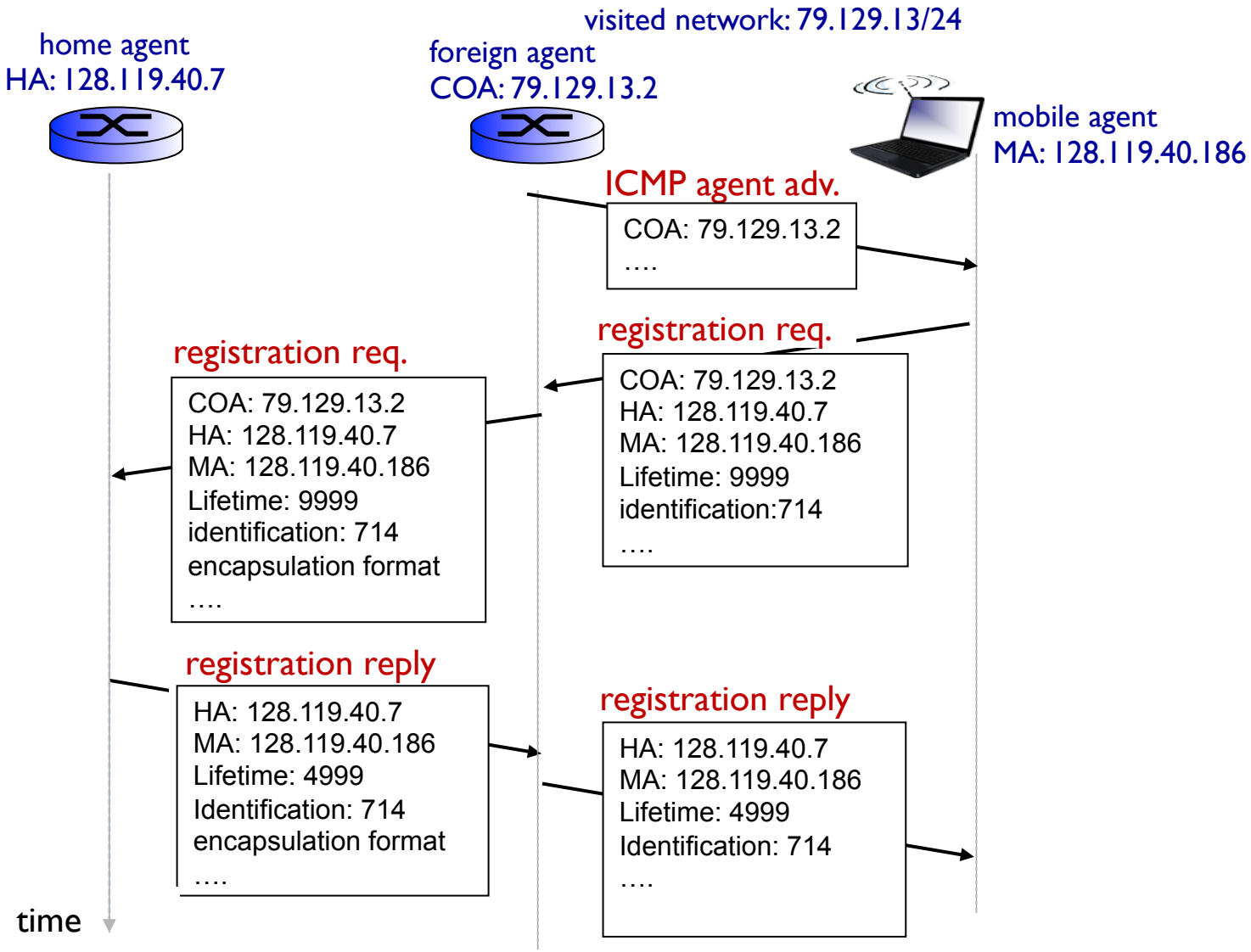
- *Agent advertisement:* foreign/home agents advertise service by broadcasting ICMP messages (typefield = 9)

H,F bits: home and/or foreign agent

R bit: registration required

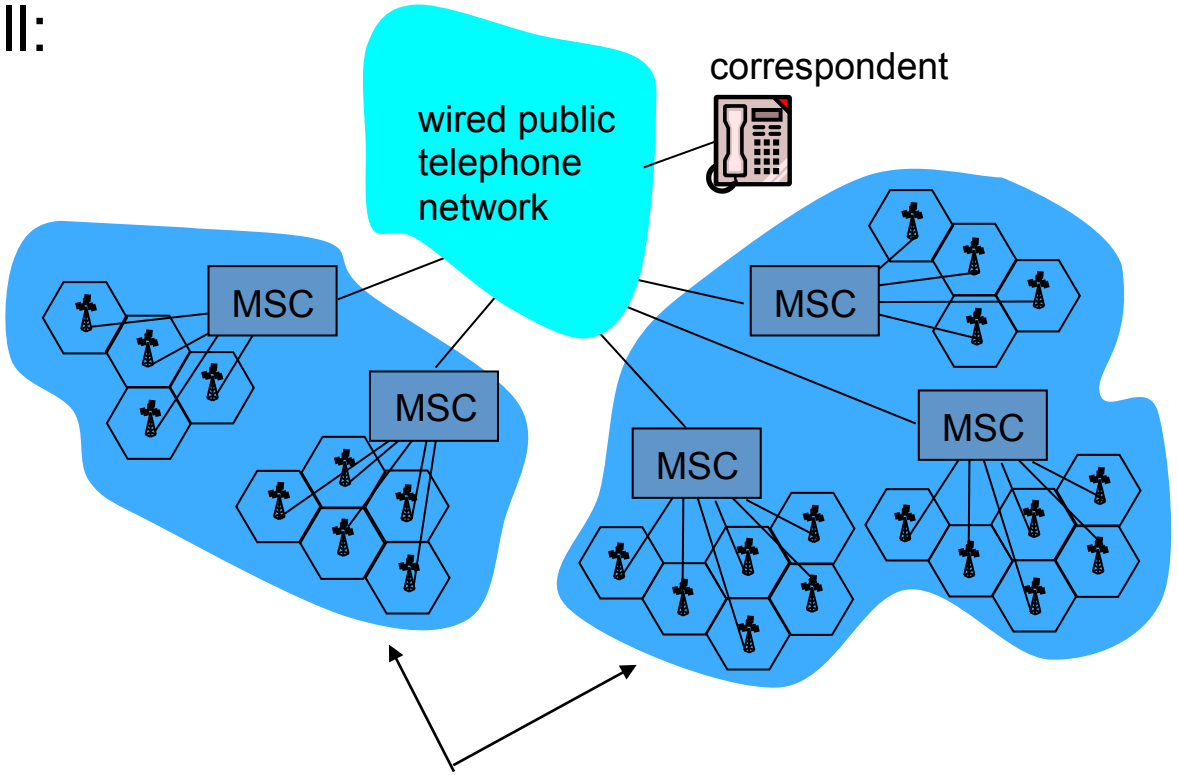


Mobile IP: Registration Example



Components of Cellular Network Architecture

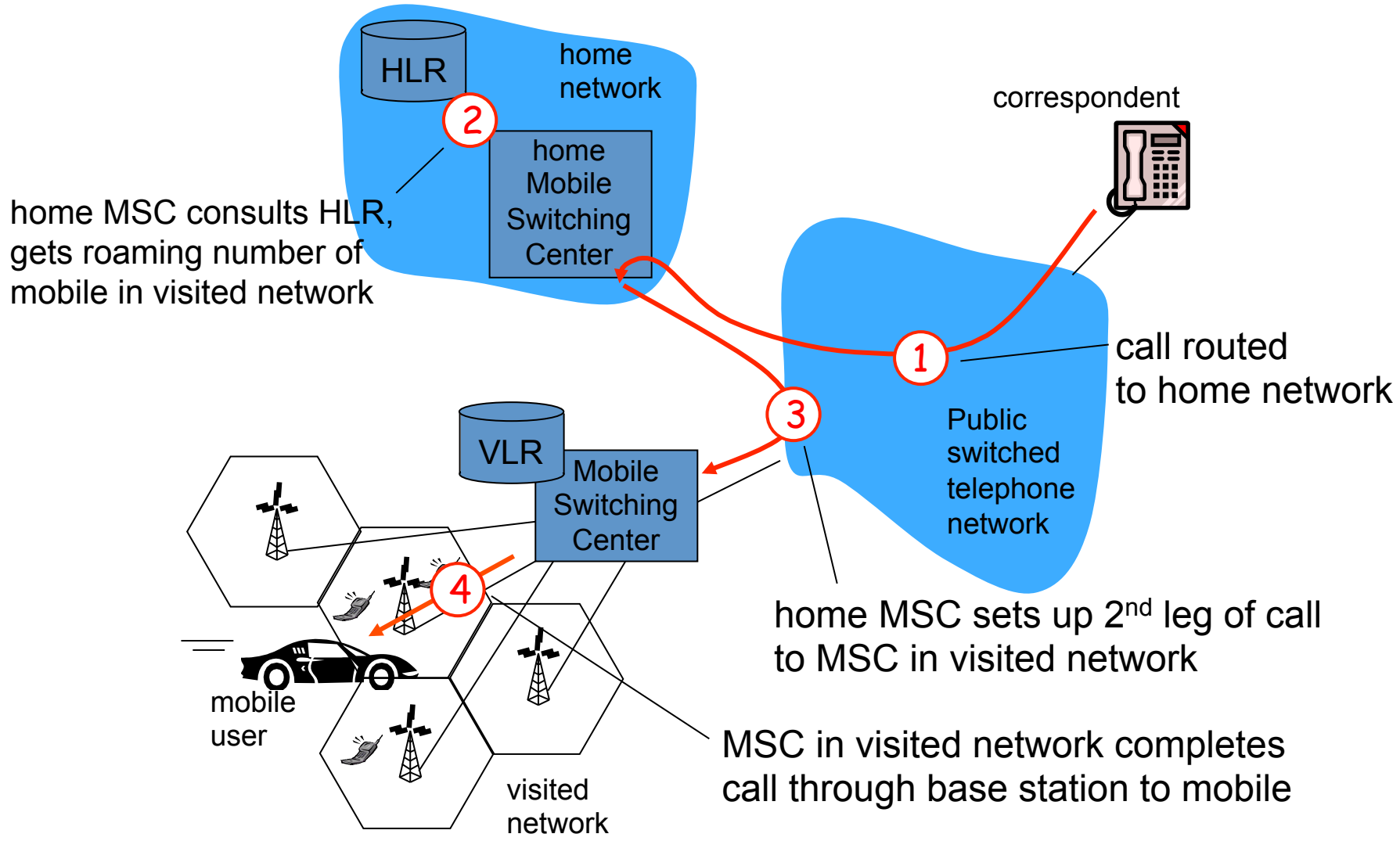
recall:



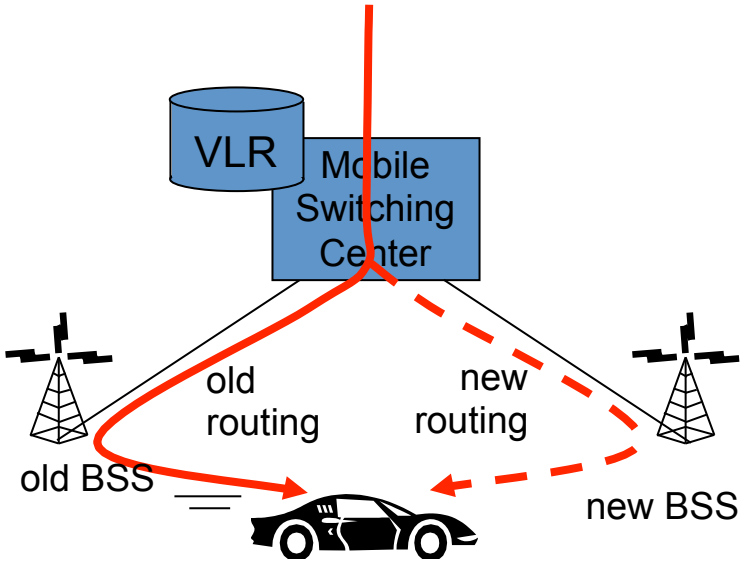
Handling mobility in cellular networks

- *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

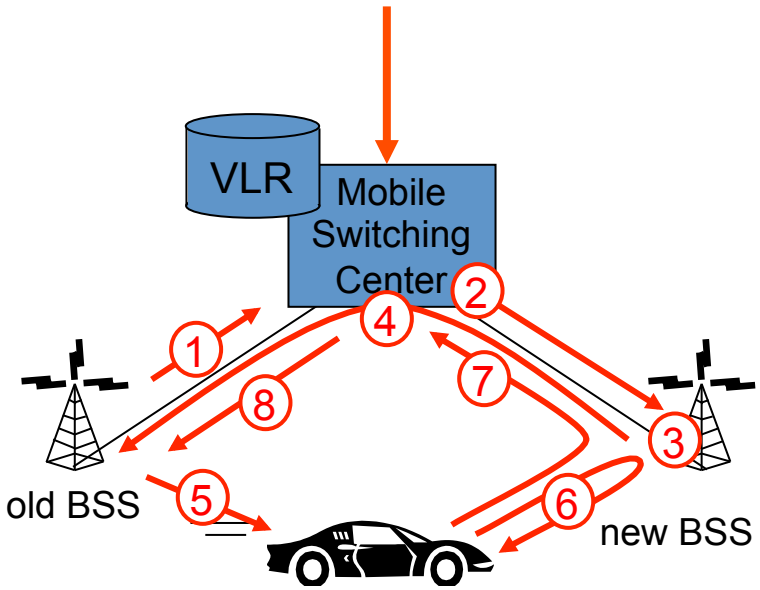


GSM: Handoff with Common MSC



- *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

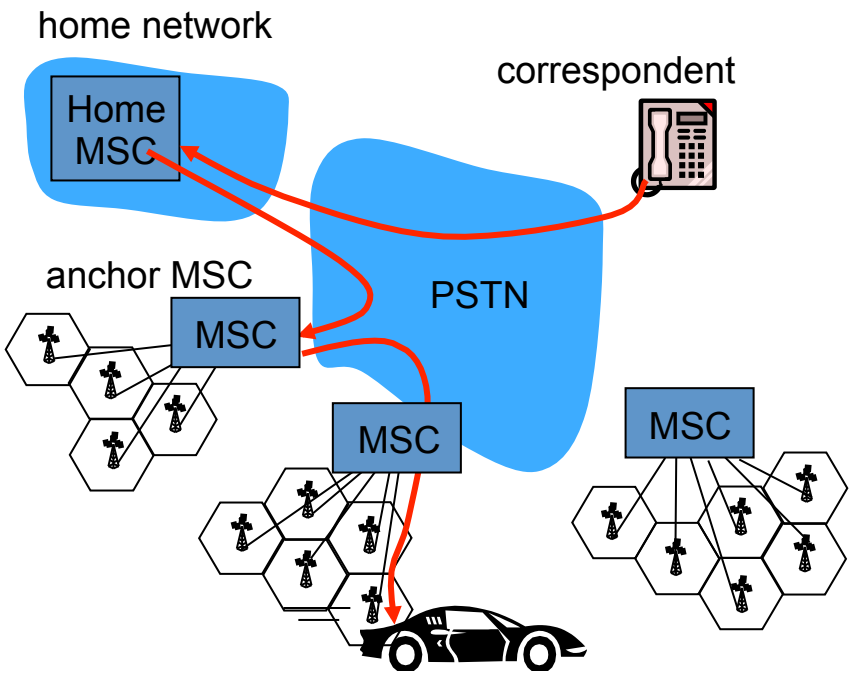
GSM: Handoff with Common MSC



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, 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

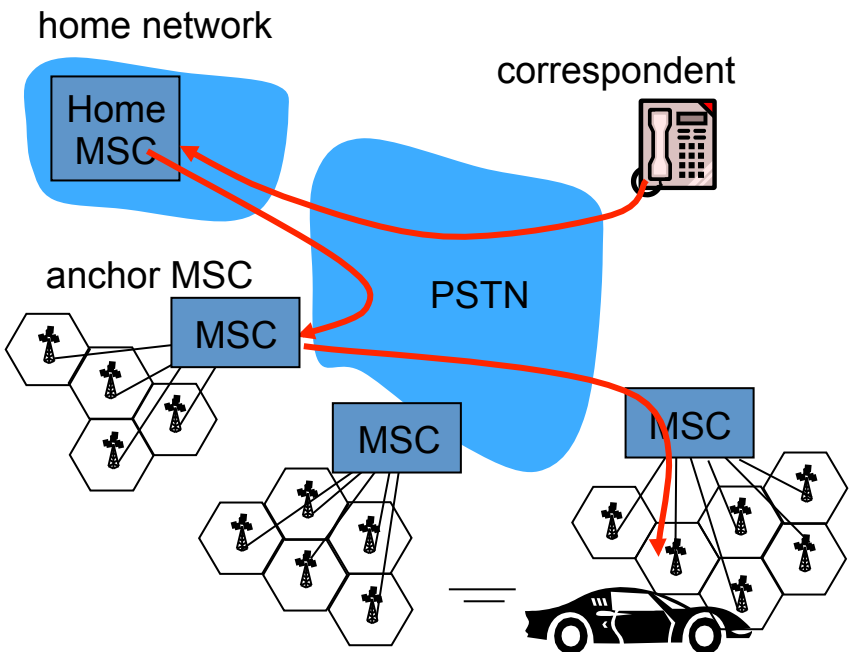
GSM: Handoff between MSCs



(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

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**

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