Chapter 4.2:
Wireless and Mobile Networks

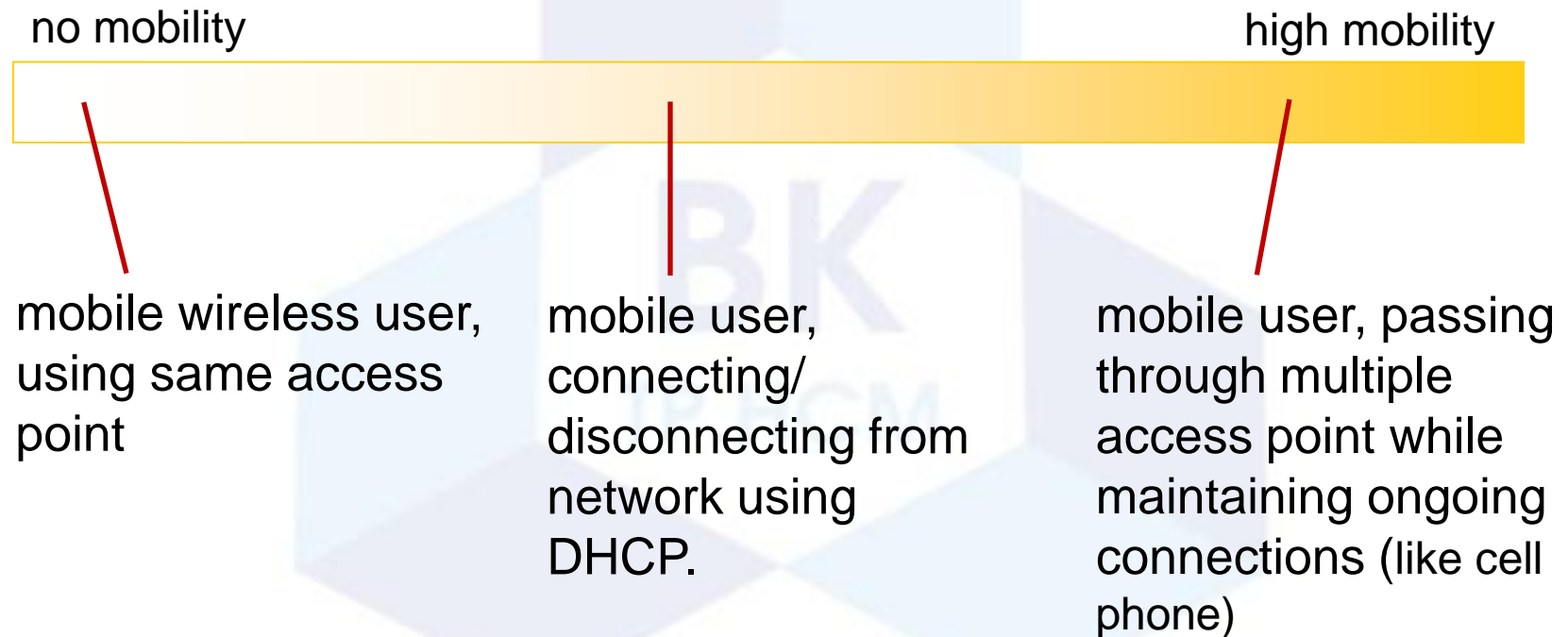NGUYỄN CAO ĐẠT
E-mail:dat@hcmut.edu.vn

Outline

- Mobility
  - Principles: addressing and routing to mobile users
  - Mobile IP
  - Handling mobility in cellular networks
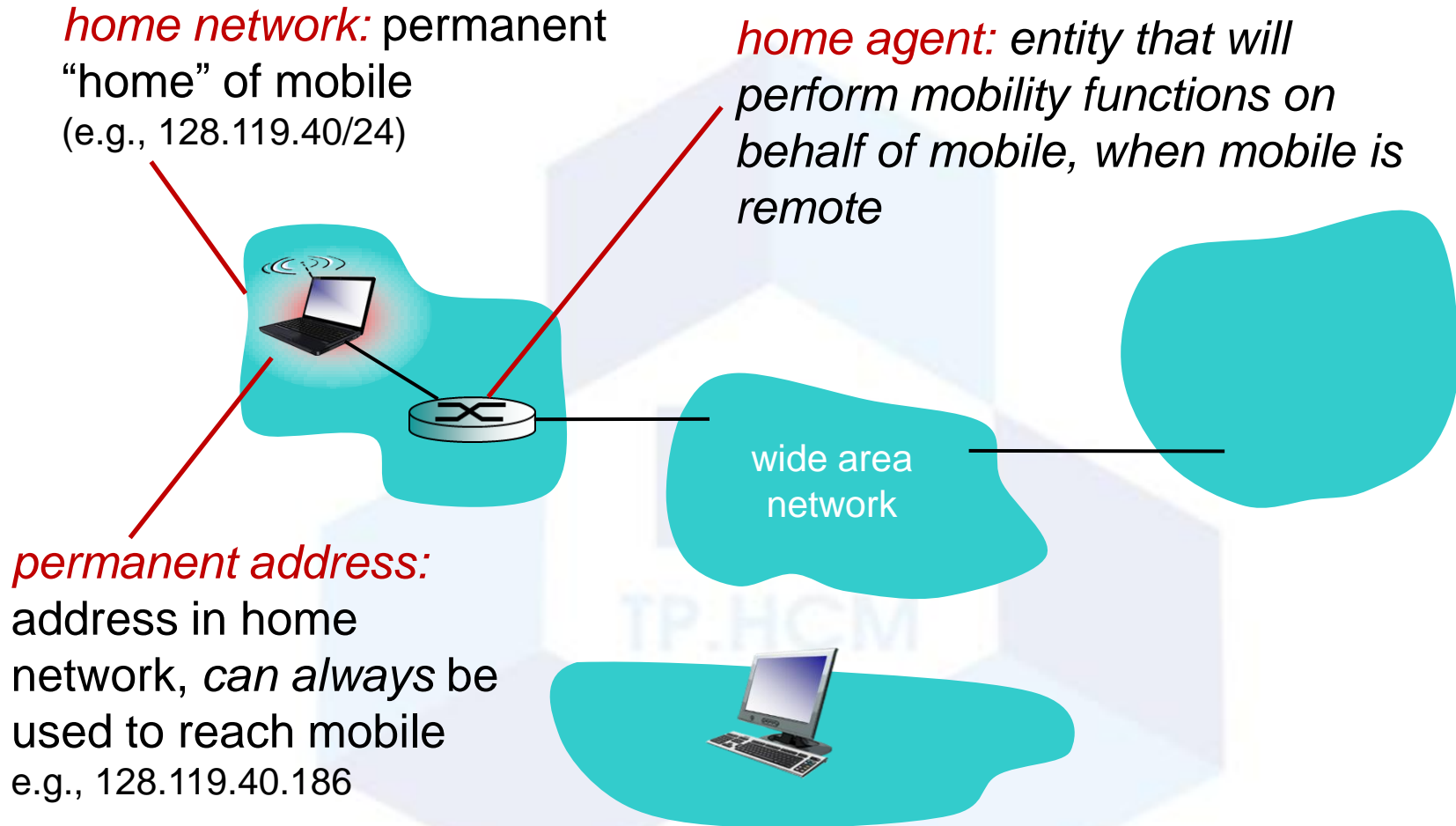 - Mobility and higher-layer protocols
- Summary

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

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.
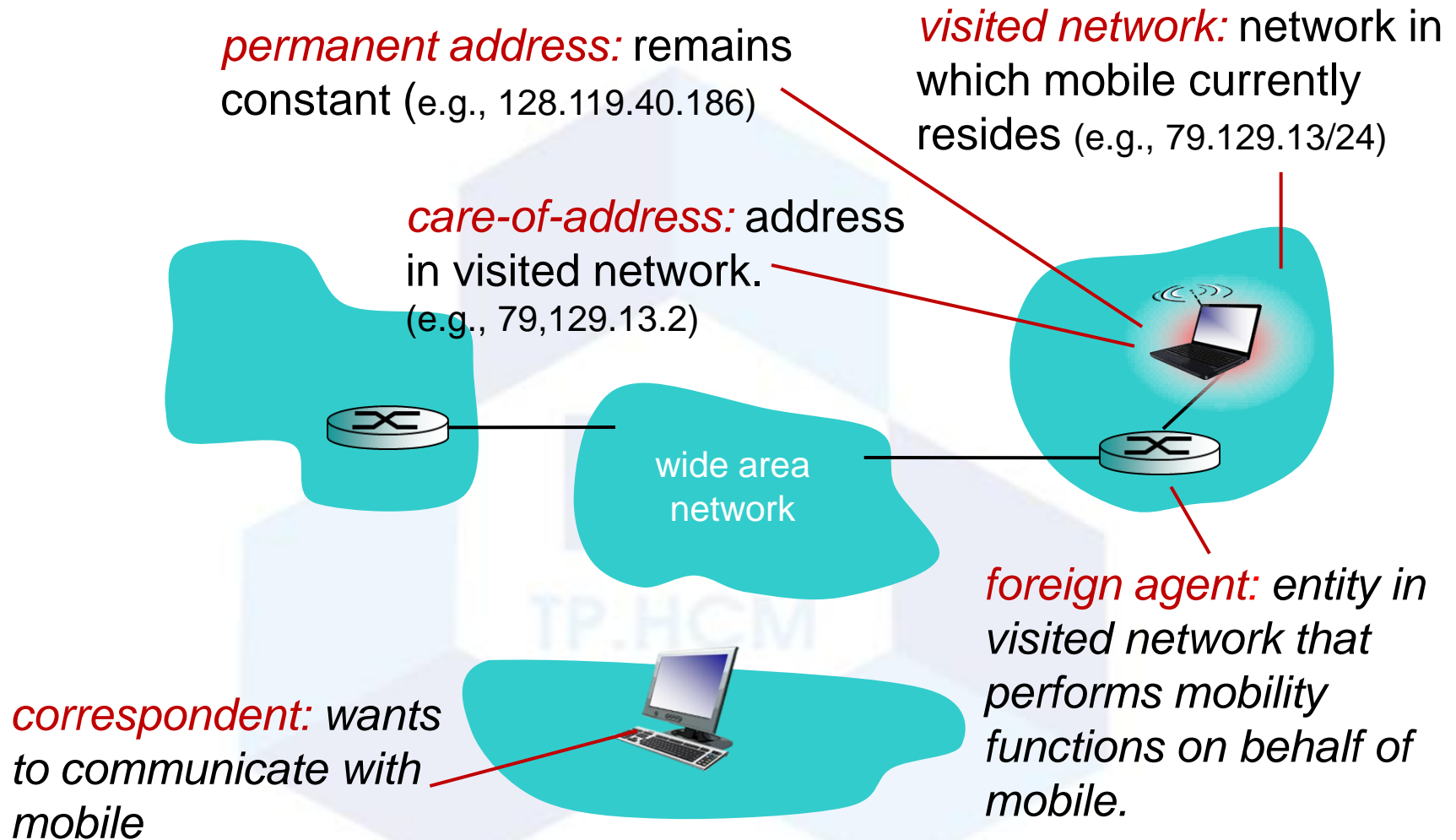
How do *you* contact a mobile friend

Consider friend frequently changing addresses, how do you find her?

- ❖ search all phone book
- ❖ call her parents?
- ❖ expect her to let you know where he/she is
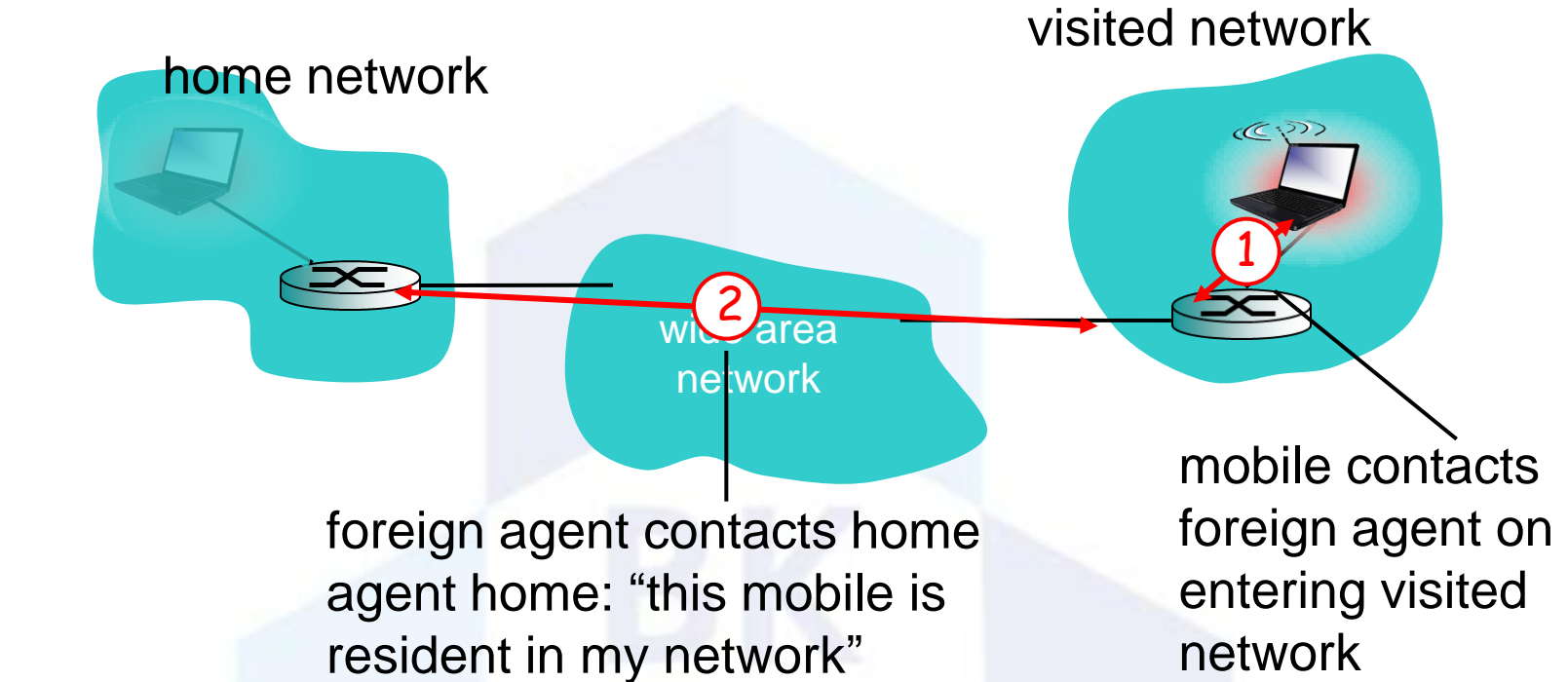
I wonder where Alice moved to?

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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not scalable to millions of mobiles
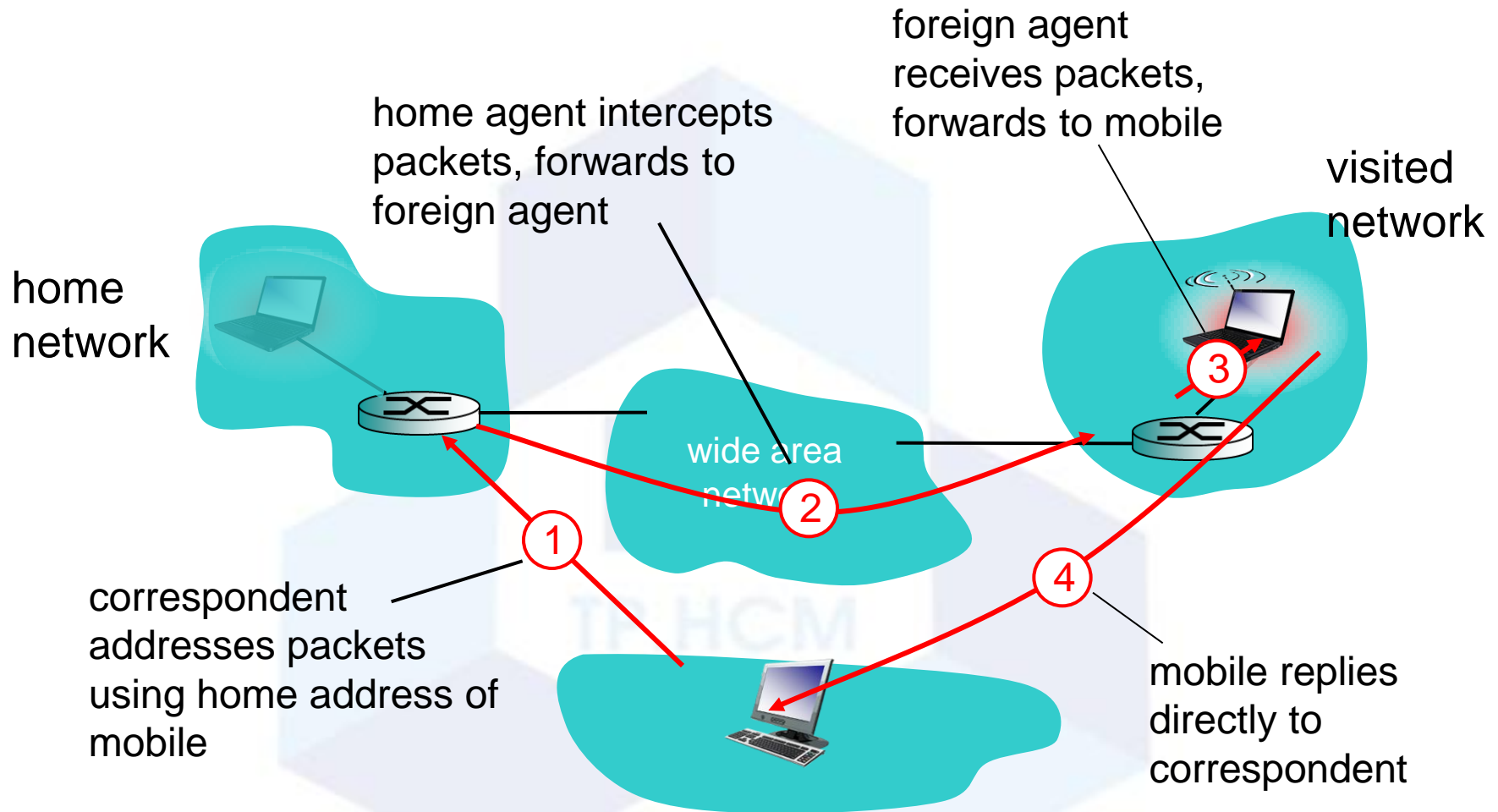
Mobility: registration

visited network

home network

wide area network

② foreign agent contacts home agent home: "this mobile is resident in my network"

① mobile contacts foreign agent on entering visited network

end result:

❖ foreign agent knows about mobile

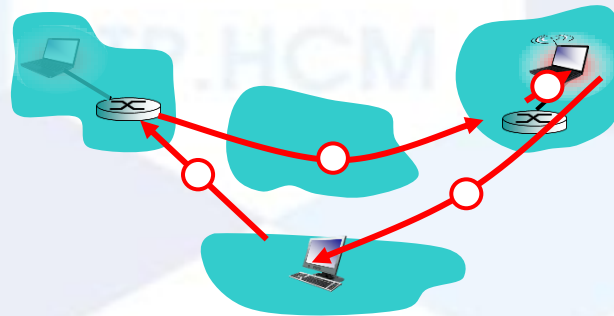❖ home agent knows location of mobile

Indirect routing

- 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!*
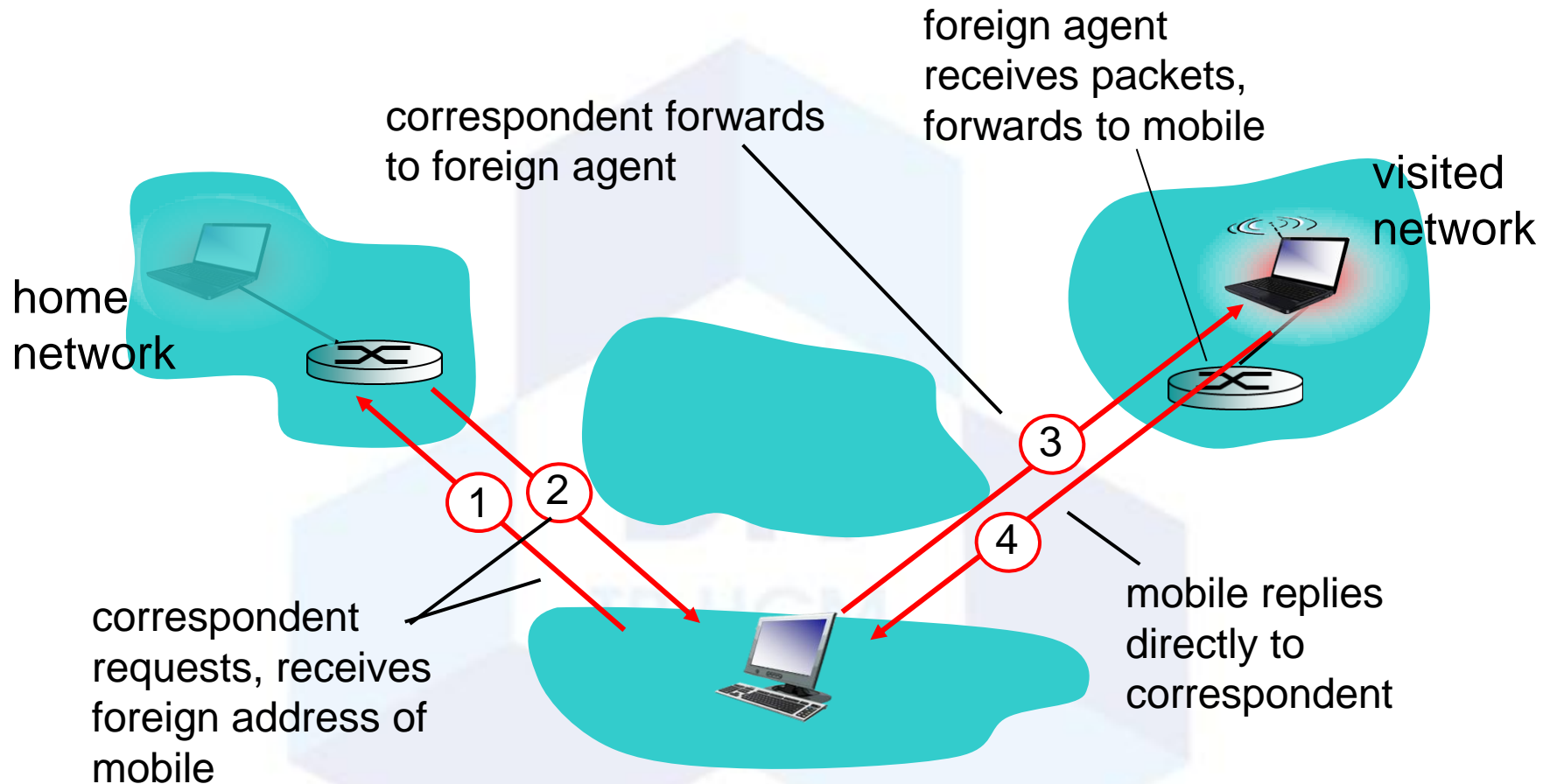
Indirect routing

home agent intercepts packets, forwards to foreign agent

foreign agent receives packets, forwards to mobile

visited network

home network

wide area network

correspondent addresses packets using home address of mobile

mobile replies directly to correspondent

1

2

3

4

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

Direct routing

correspondent forwards
to foreign agent

foreign agent
receives packets,
forwards to mobile

visited
network

home
network

3

1 **2**

4

correspondent
requests, receives
foreign address of
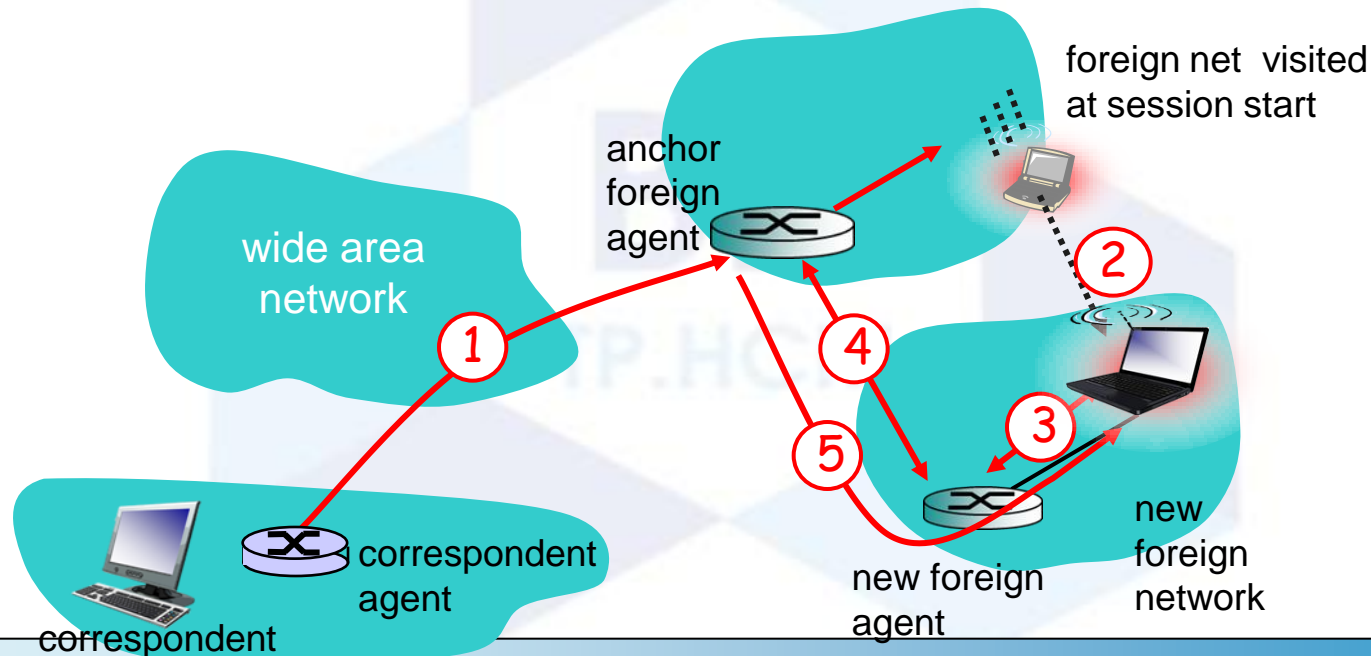mobile

mobile replies
directly to
correspondent

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?
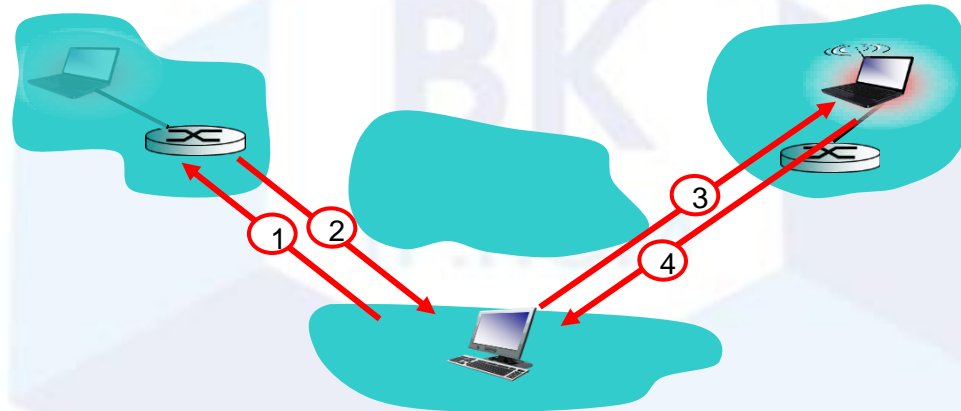
Direct routing

❖ 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)

foreign net visited at session start

anchor foreign agent

wide area network

① ② ③ ④ ⑤

new foreign agent

new foreign network

correspondent agent

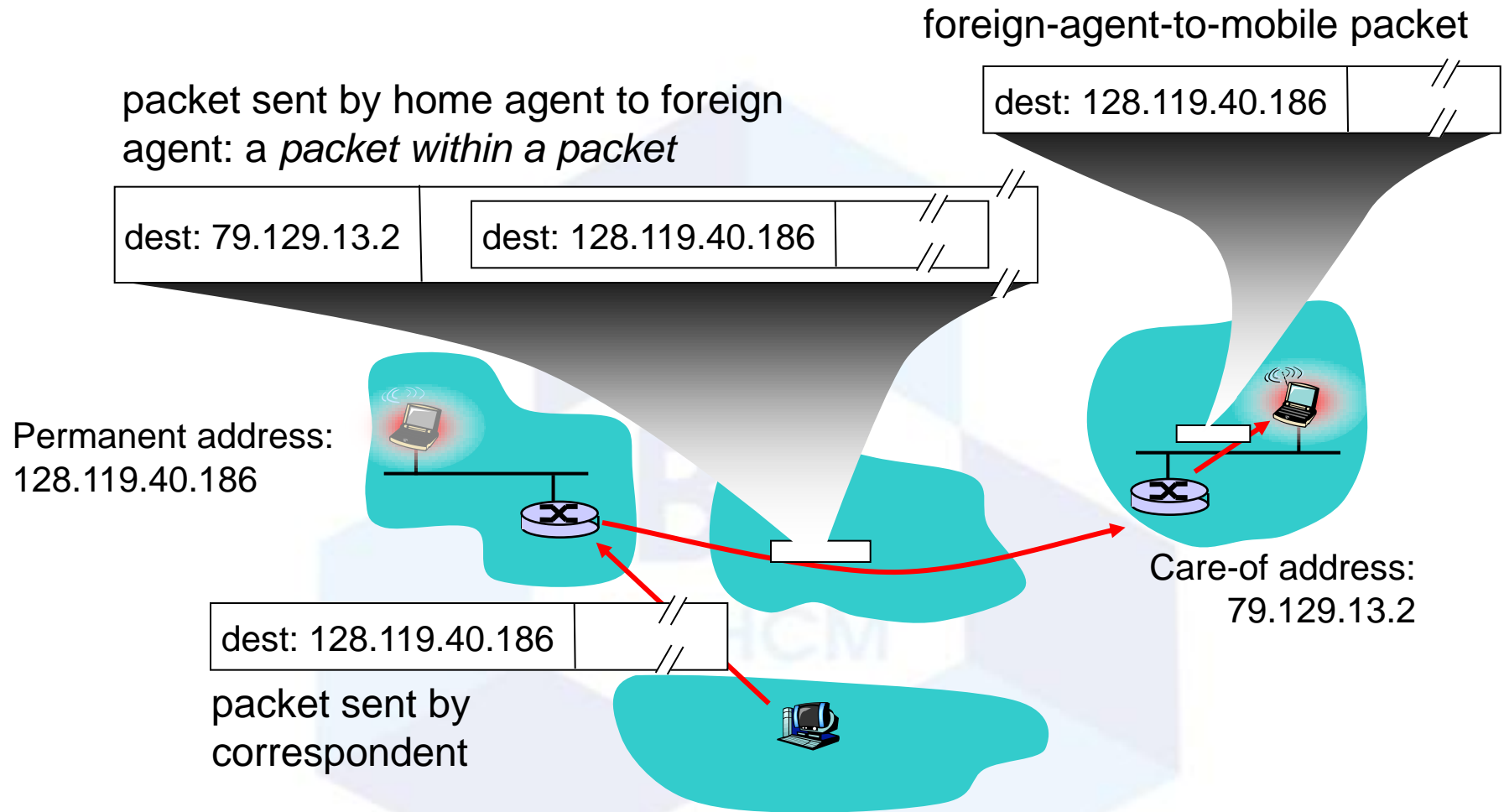correspondent

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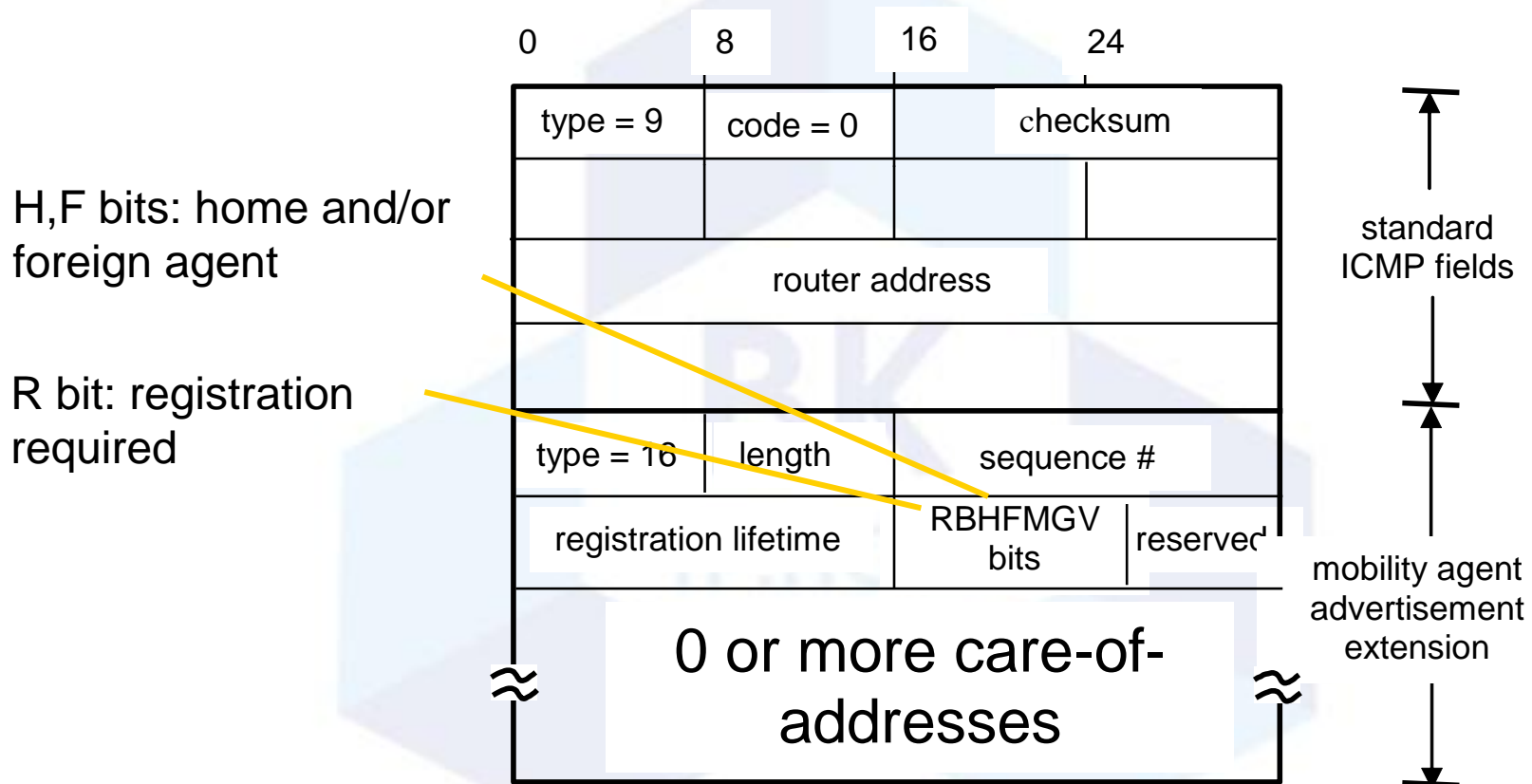 - Mobility and higher-layer protocols
- Summary

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

foreign-agent-to-mobile packet

dest: 128.119.40.186	

packet sent by home agent to foreign agent: a *packet within a packet*

dest: 79.129.13.2	dest: 128.119.40.186	

Permanent address:
128.119.40.186

Care-of address:
79.129.13.2

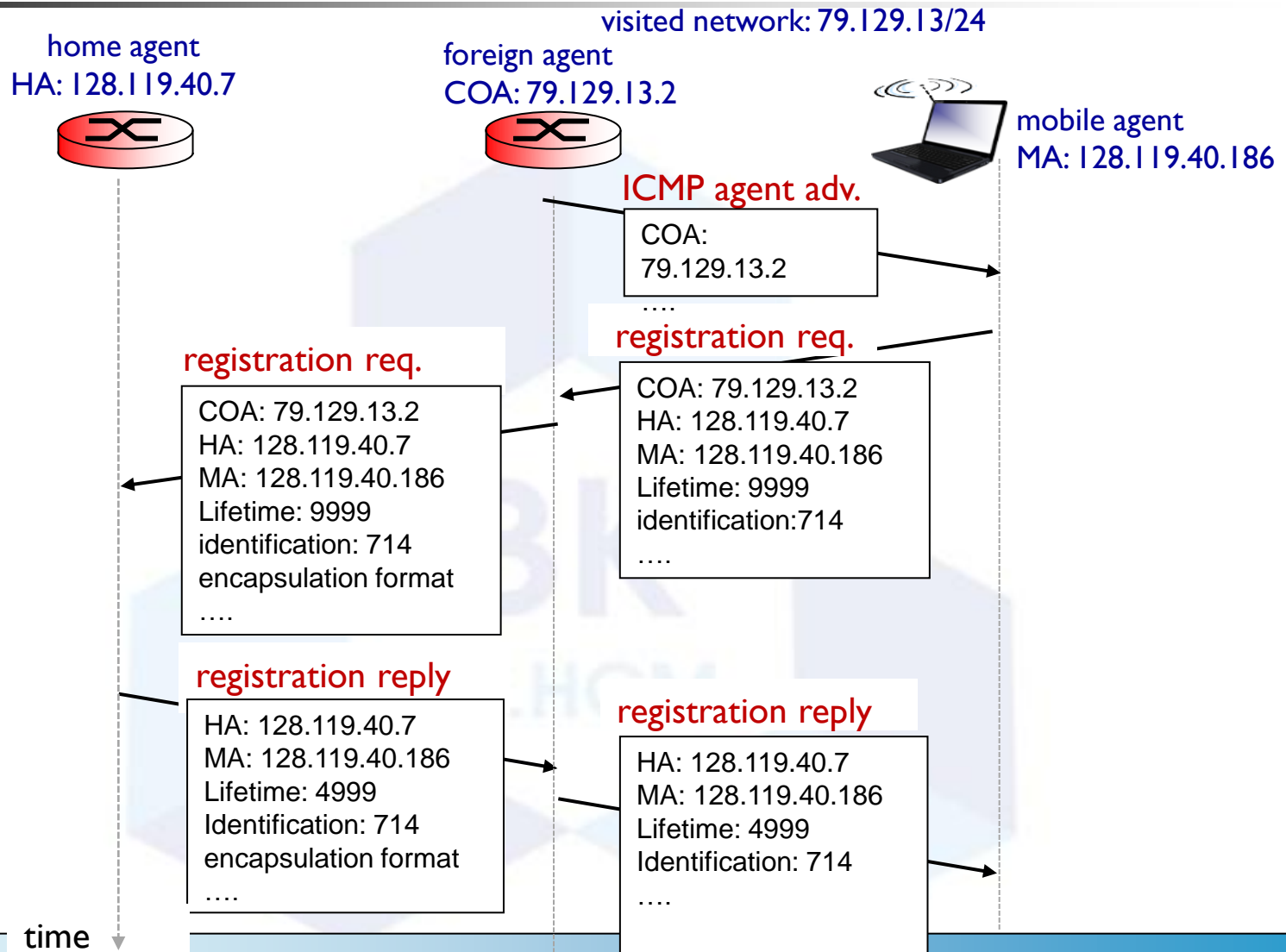| dest: 128.119.40.186	

packet sent by
correspondent

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
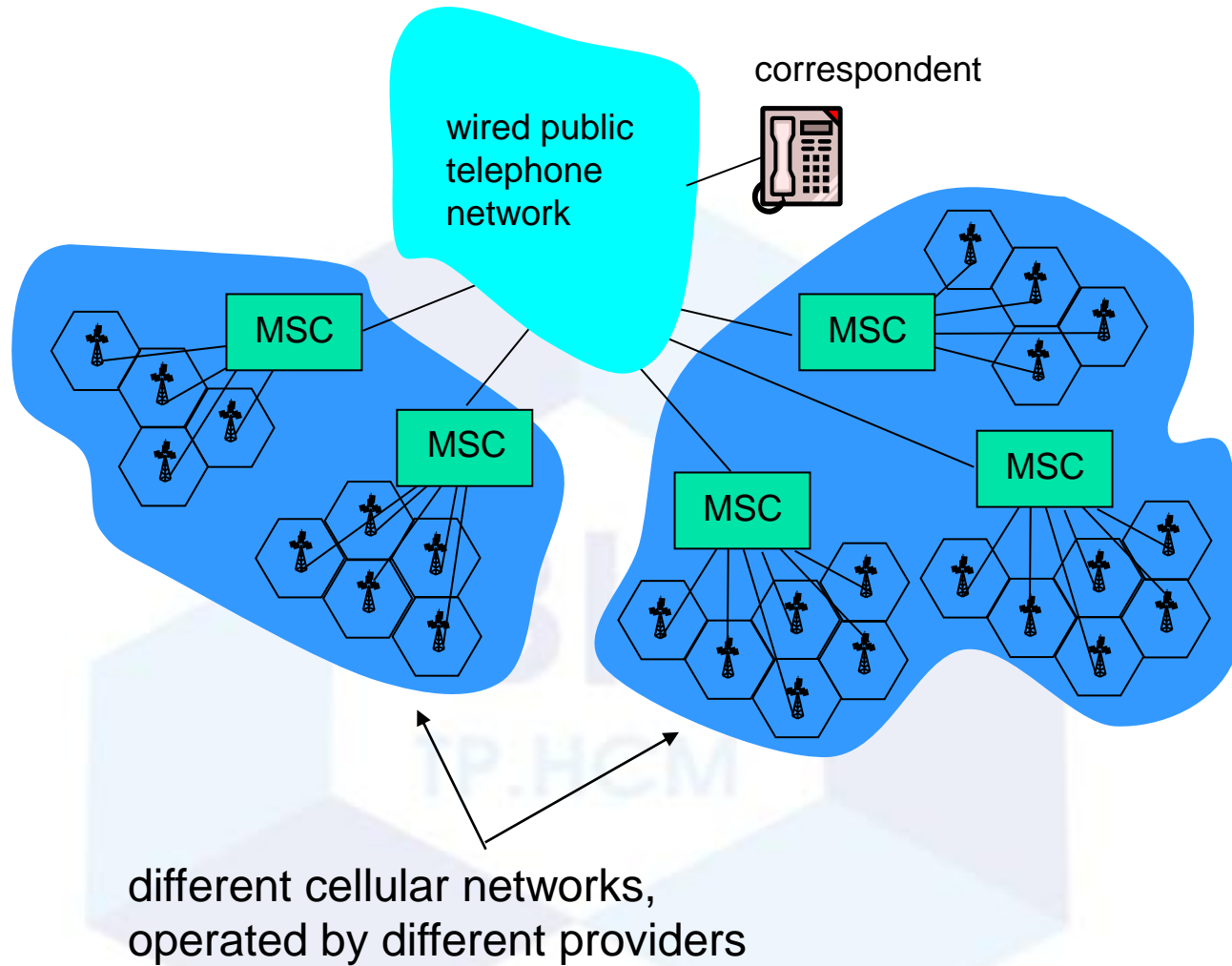
R bit: registration required

0	8	16	24
type = 9	code = 0	checksum	
router address			
type = 16	length	sequence #	
registration lifetime		RBHFMGV bits	reserved
0 or more care-of-addresses			

standard ICMP fields

mobility agent advertisement extension

Mobile IP: registration example

visited network: 79.129.13/24

home agent
HA: 128.119.40.7

foreign agent
COA: 79.129.13.2

mobile agent
MA: 128.119.40.186

ICMP agent adv.

COA:
79.129.13.2
….

registration req.

registration req.

COA: 79.129.13.2
HA: 128.119.40.7
MA: 128.119.40.186
Lifetime: 9999
identification: 714
encapsulation format
….

COA: 79.129.13.2
HA: 128.119.40.7
MA: 128.119.40.186
Lifetime: 9999
identification:714
….

registration reply

registration reply

HA: 128.119.40.7
MA: 128.119.40.186
Lifetime: 4999
Identification: 714
encapsulation format
….

HA: 128.119.40.7
MA: 128.119.40.186
Lifetime: 4999
Identification: 714
….

time

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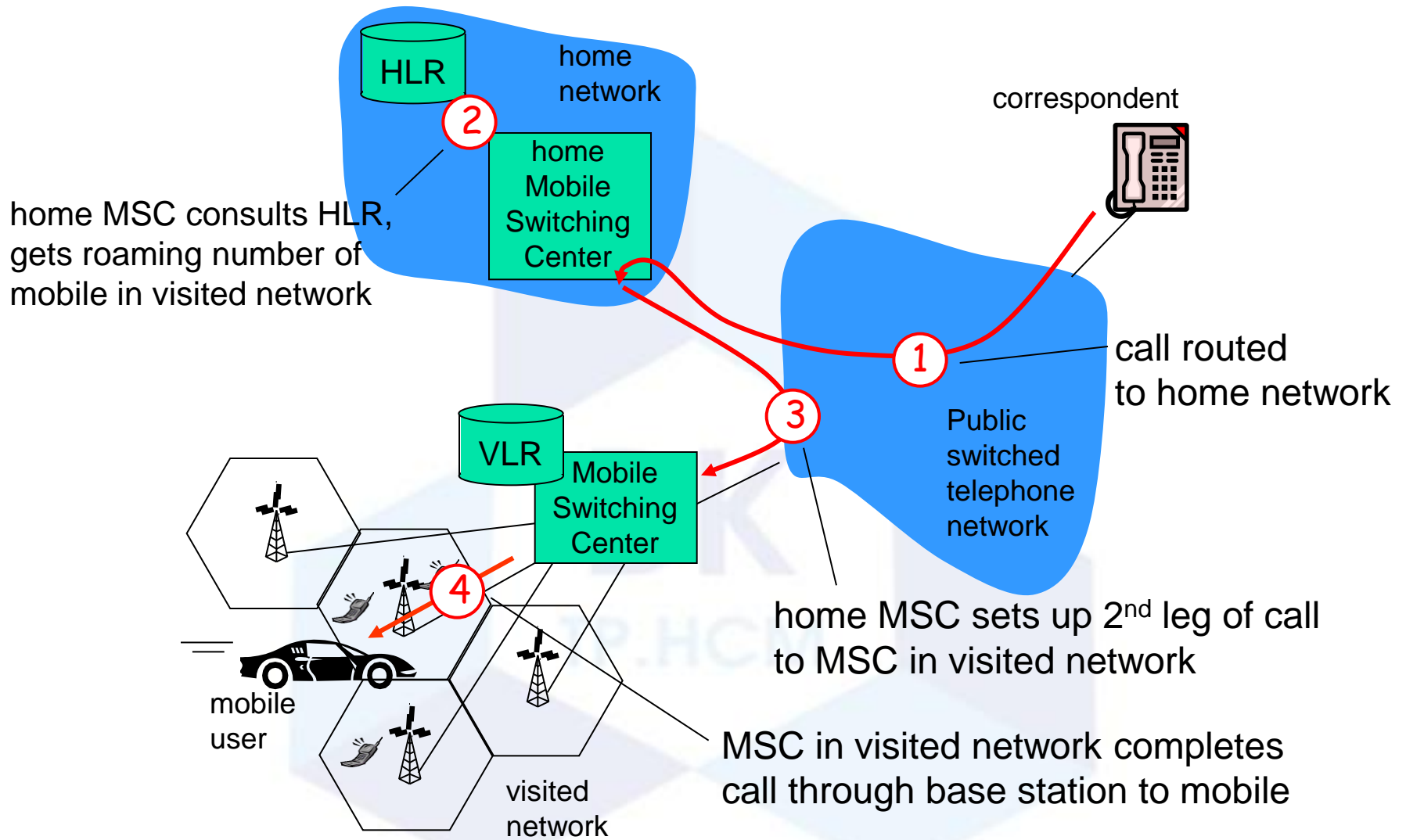 - Mobility and higher-layer protocols
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Components of cellular network architecture

correspondent

wired public telephone network

MSC
MSC
MSC
MSC
MSC

different cellular networks, operated by different providers

Handling mobility in cellular networks

❖ *home network*: network of cellular provider you subscribe to

▪ *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

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

HLR

home network

home Mobile Switching Center

correspondent

call routed to home network

Public switched telephone network

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

VLR

Mobile Switching Center

mobile user

visited network

MSC in visited network completes call through base station 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 doesnt mandate why to perform handoff (policy), only how (mechanism)

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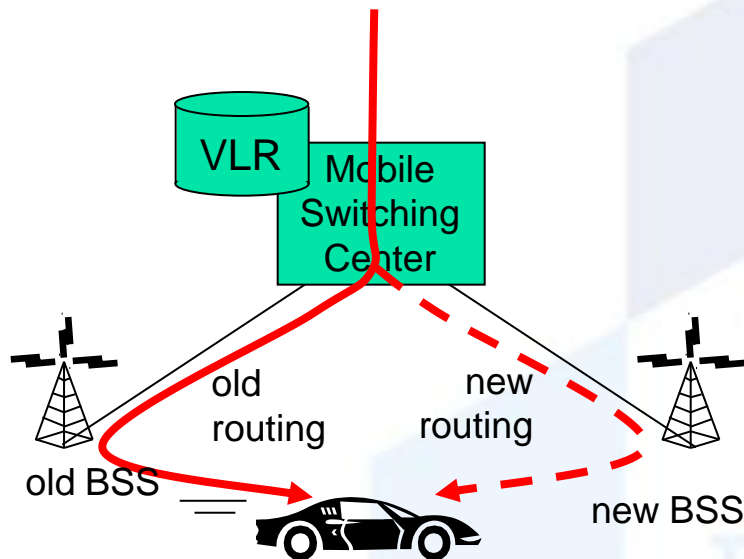
GSM: handoff with common MSC
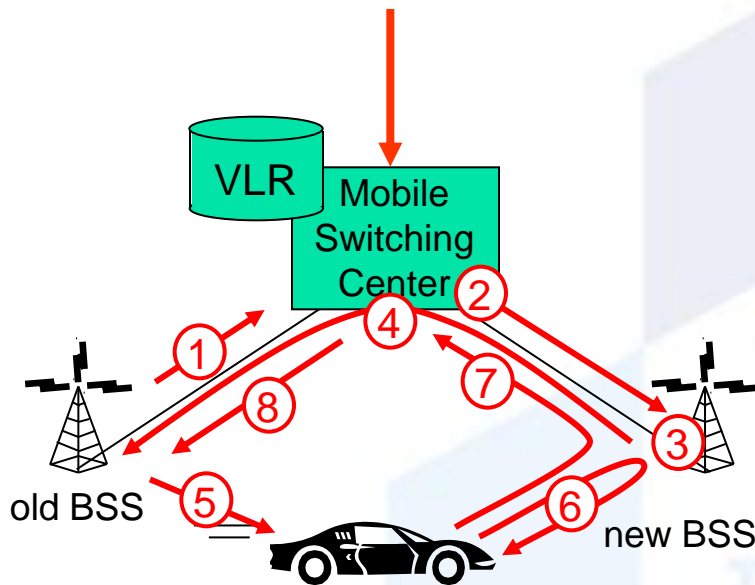
1. old BSS informs MSC of impending handoff, provides list of 1+ new BSSs

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
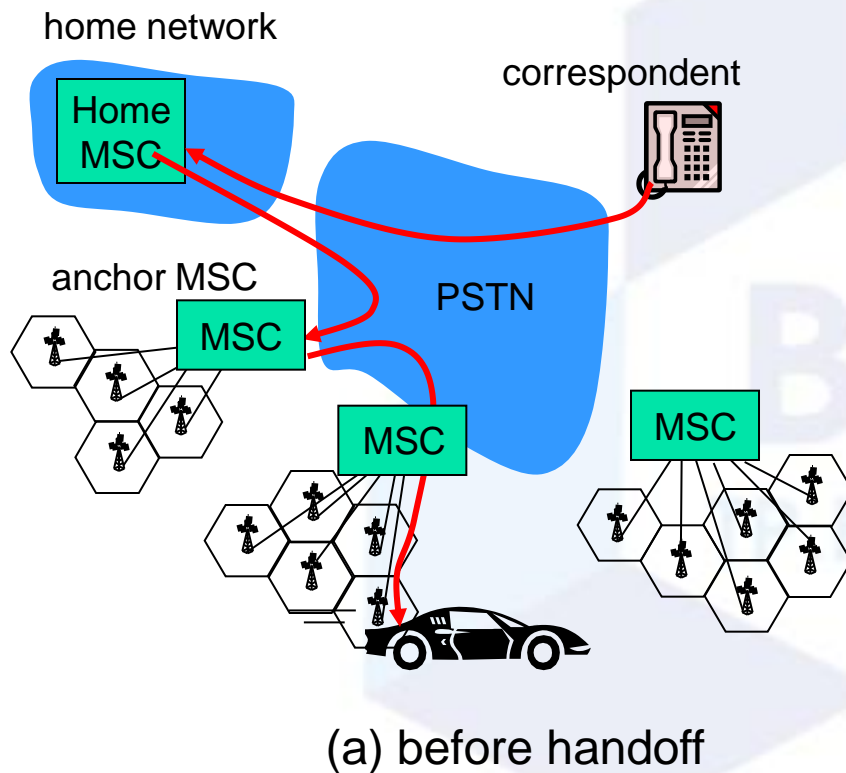
home network

correspondent

anchor MSC

Home MSC

PSTN

MSC

MSC

MSC

(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
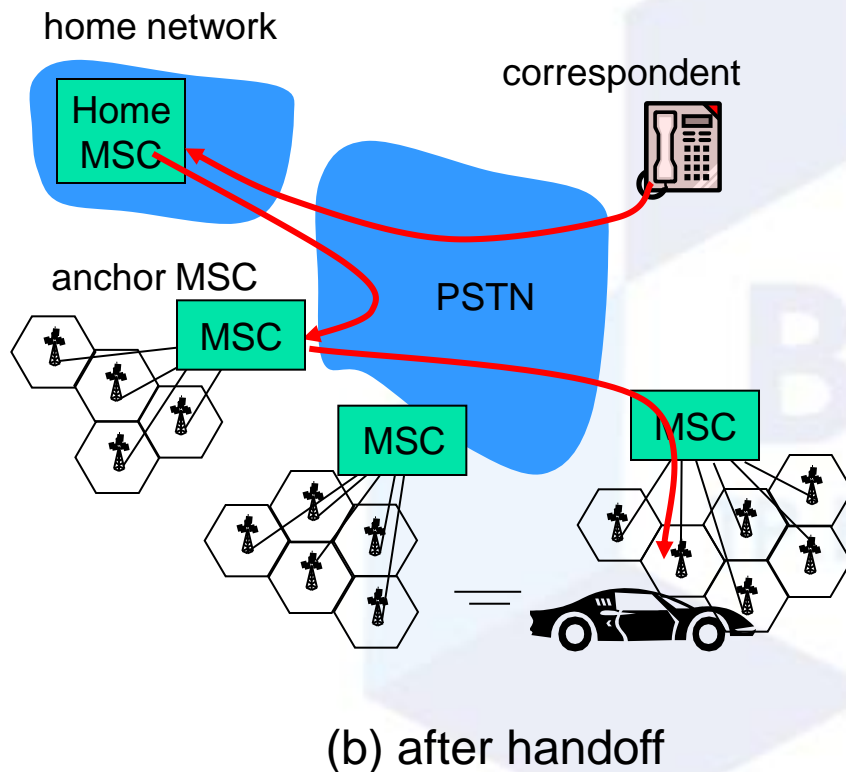
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❖ new MSCs add on to end of MSC chain as mobile moves to new MSC
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home network

correspondent

anchor MSC

Home MSC

PSTN

MSC

MSC

MSC

(b) after handoff

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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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

Summary

Wireless

- wireless links:
  - capacity, distance
  - channel impairments
- IEEE 802.11 ("Wi-Fi")
  - CSMA/CA reflects wireless channel characteristics
- cellular access
  - architecture
  - standards (e.g., GSM, 3G, 4G)
  - CDMA

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