Chapter 6 outline

6.1 Introduction

Wireless

- 6.2 Wireless links, characteristics
  - Spread spectrum
- 6.3 IEEE 802.11 wireless LANs (“wi-fi”)
- 6.4 Cellular Internet Access
  - architecture
  - standards (e.g., GSM)

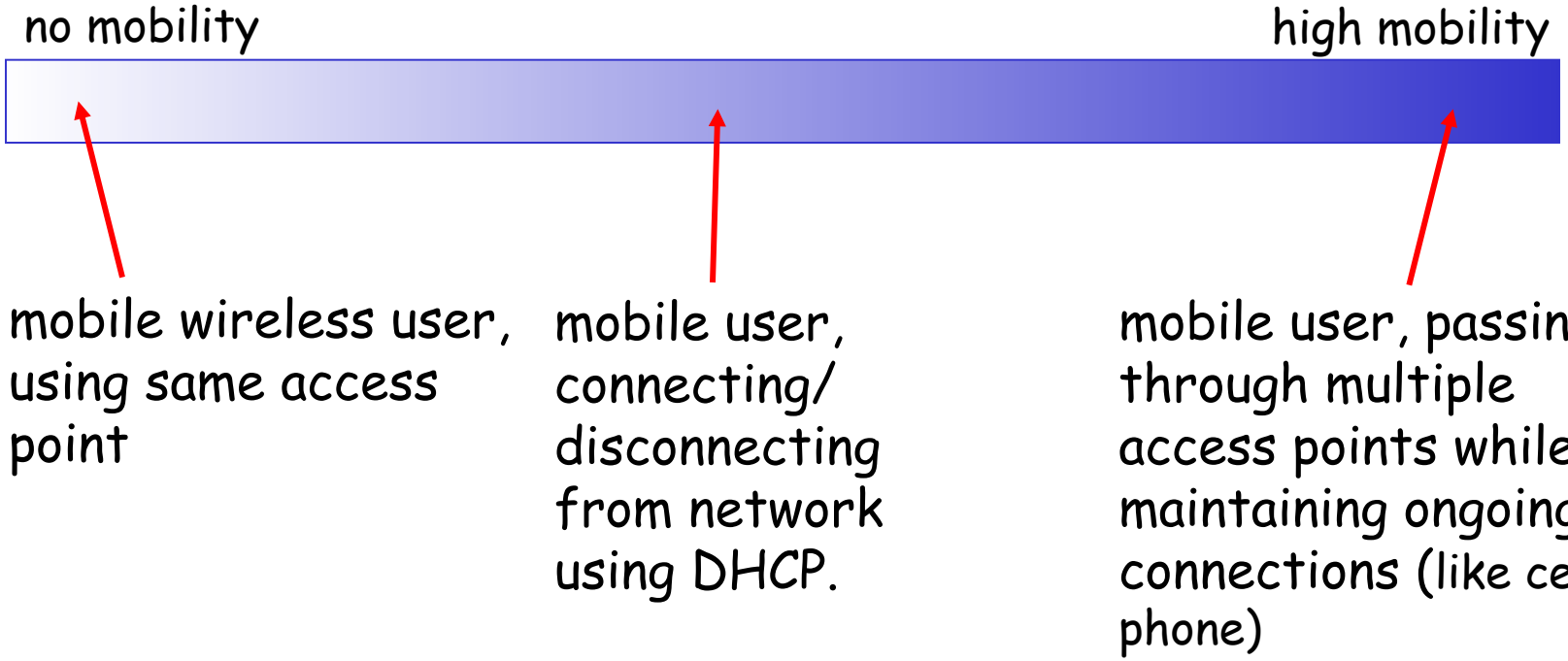
Mobility

- 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 ?

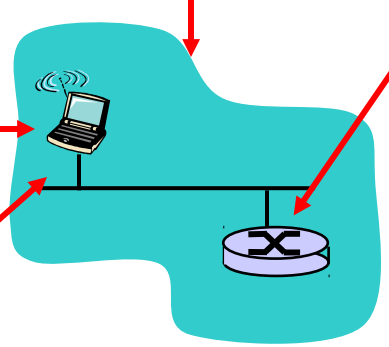
- spectrum of mobility, from the *network* perspective



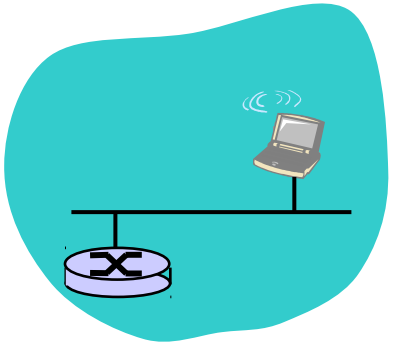
Mobility : vocabulary

Home Network permanent "home" of mobile (e.g., 128.119.40/24)

Home Agent (HA) *entity that will perform mobility functions on behalf of mobile, when mobile is remote*

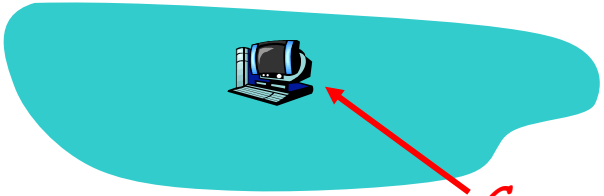


Mobile Node (MN)



wide area network

Permanent address (or Mobile Address - MA) address in home network, *can always* be used to reach mobile (e.g., 128.119.40.186)



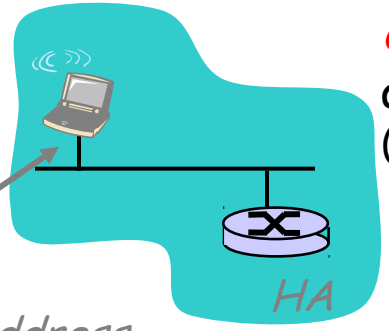
Corresponding Node (CN) *wants to communicate with mobile*

Mobility : vocabulary (more)

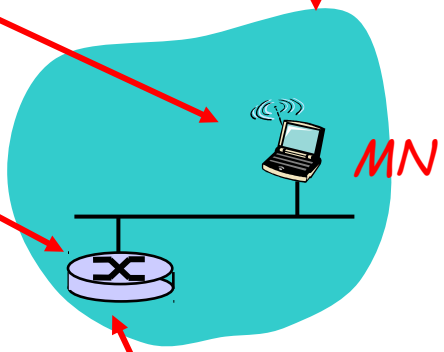
Permanent address
remains constant
(e.g., 128.119.40.186)

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

Home Network
(e.g., 128.119.40/24)

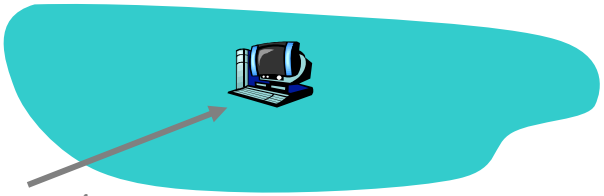


Care-of address (CoA)
address in visited network.
(e.g., 79.129.13.2)



Permanent address
(or Mobile address - MA):
128.119.40.186

Foreign agent (FA)
entity in visited network that performs mobility functions on behalf of mobile.



Corresponding node (CN)

Mobility : two main approaches

1. *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

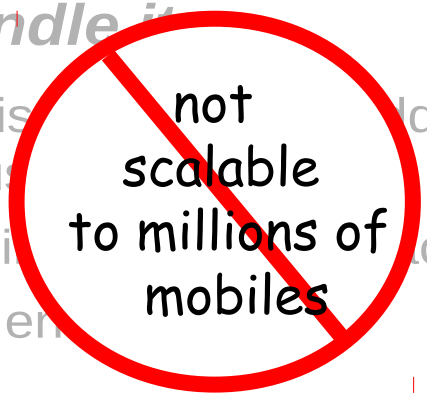
2. *Let end-systems handle it*

- *Indirect routing:* communication from correspondent to mobile goes through home agent, then forwarded to remote
- *Direct routing:* correspondent gets foreign address (CoA) of mobile, sends directly to mobile node

Mobility : two main approaches

1. Let routing handle it

- Routers advertis… ldress of mobile-nodes-in-residence via us… exchange.
- Routing tables i… ch mobile located
- No changes to en…



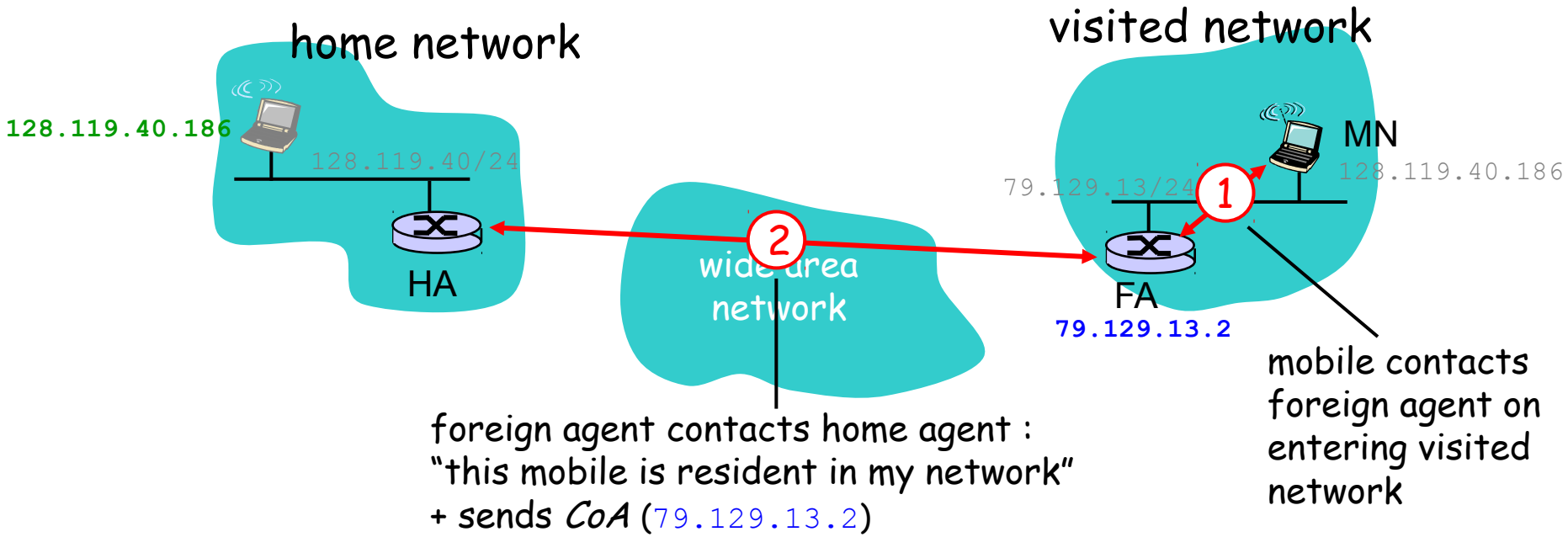
2. Let end-systems handle it

- *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

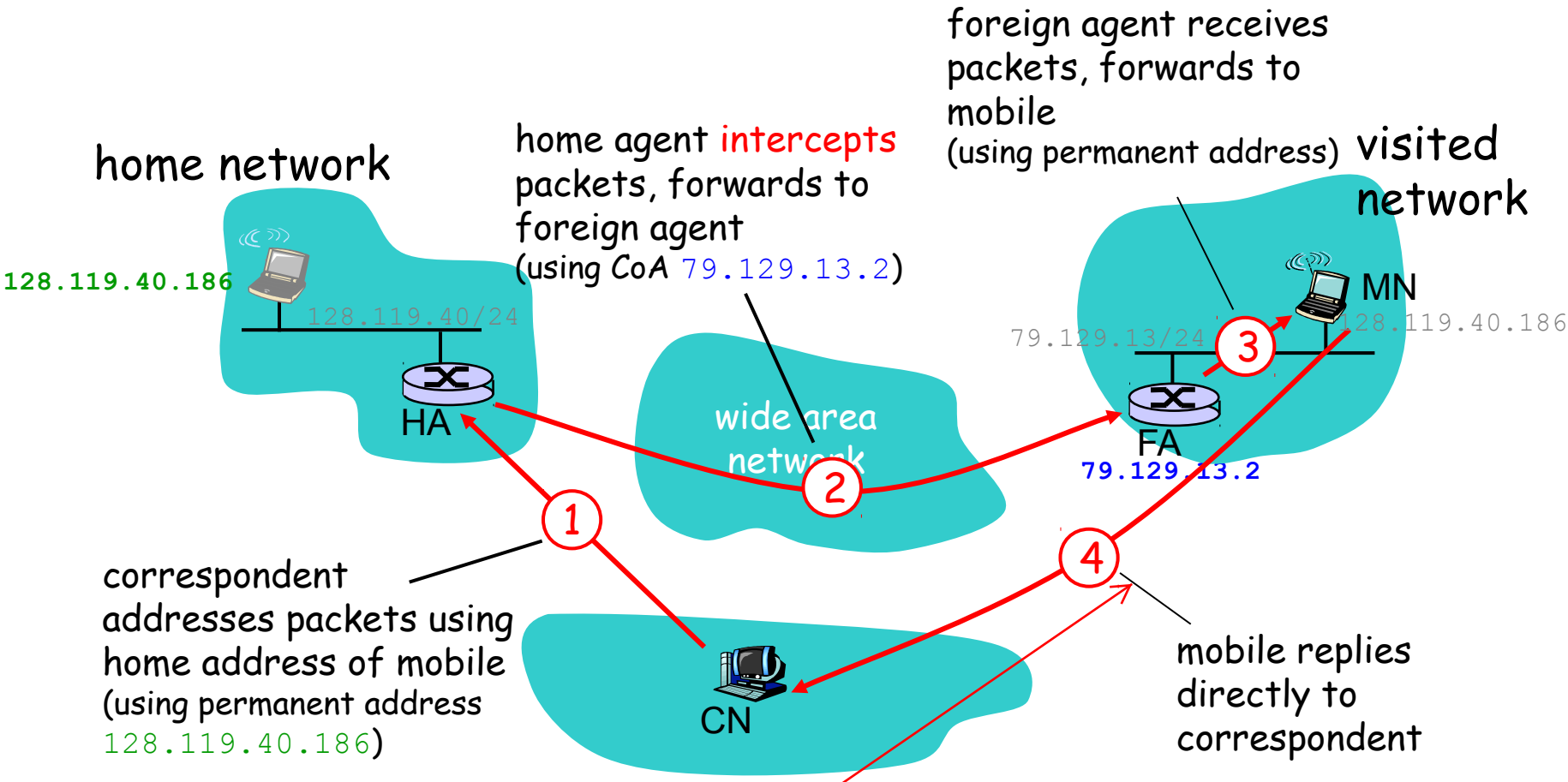
Mobility : registration

Objectives

- Foreign agent must learn existence of visiting node
- Home agent must learn location of mobile



1. Indirect Routing



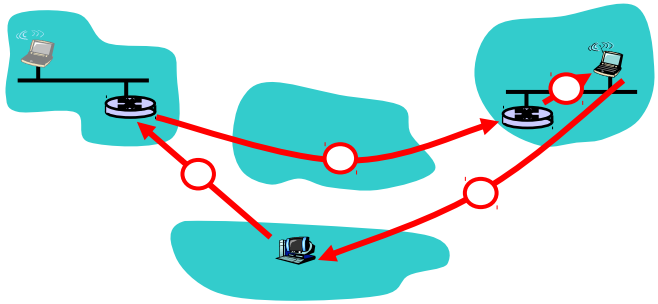
/!\ peut être considéré comme spofing car IP source différente de l'IP sur réseau

1. Indirect Routing - discussion

Observation : Mobile uses 2 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
- Note : foreign agent functions may be done by mobile itself

- **Drawback** : triangle routing
  - CN → home → network → MN
  - inefficient when correspondent and mobile are in same network



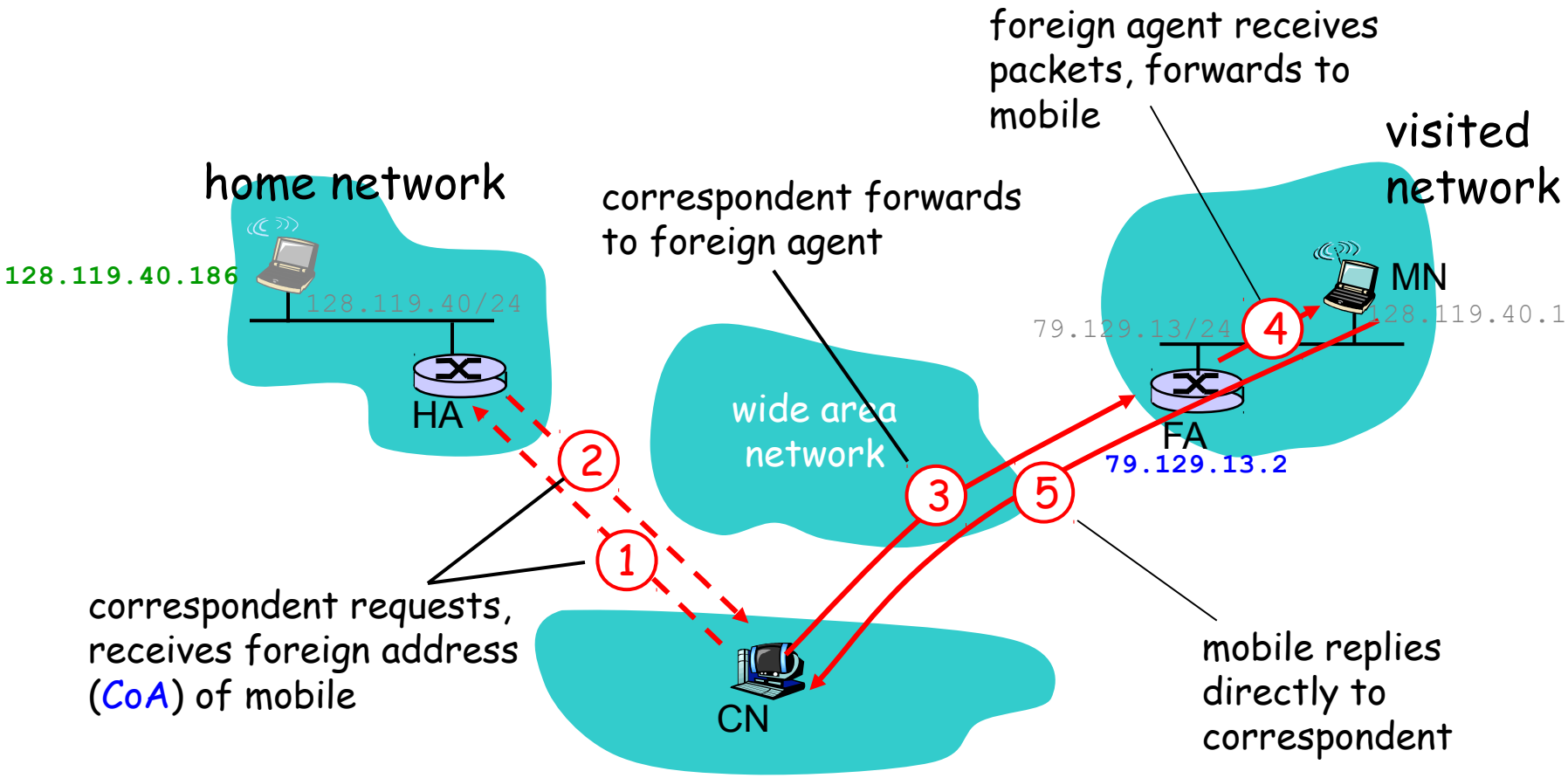
1. Indirect Routing - discussion

Suppose mobile node moves to another network

1. Registers with new foreign agent
2. New foreign agent registers with home agent
3. Home agent updates *Care-of Address* for mobile
4. Packets continue to be forwarded to mobile (but with new *Care-of Address*)

Benefit : Mobility (changing foreign networks) is transparent : *on-going connections can be maintained !*

2. Direct Routing



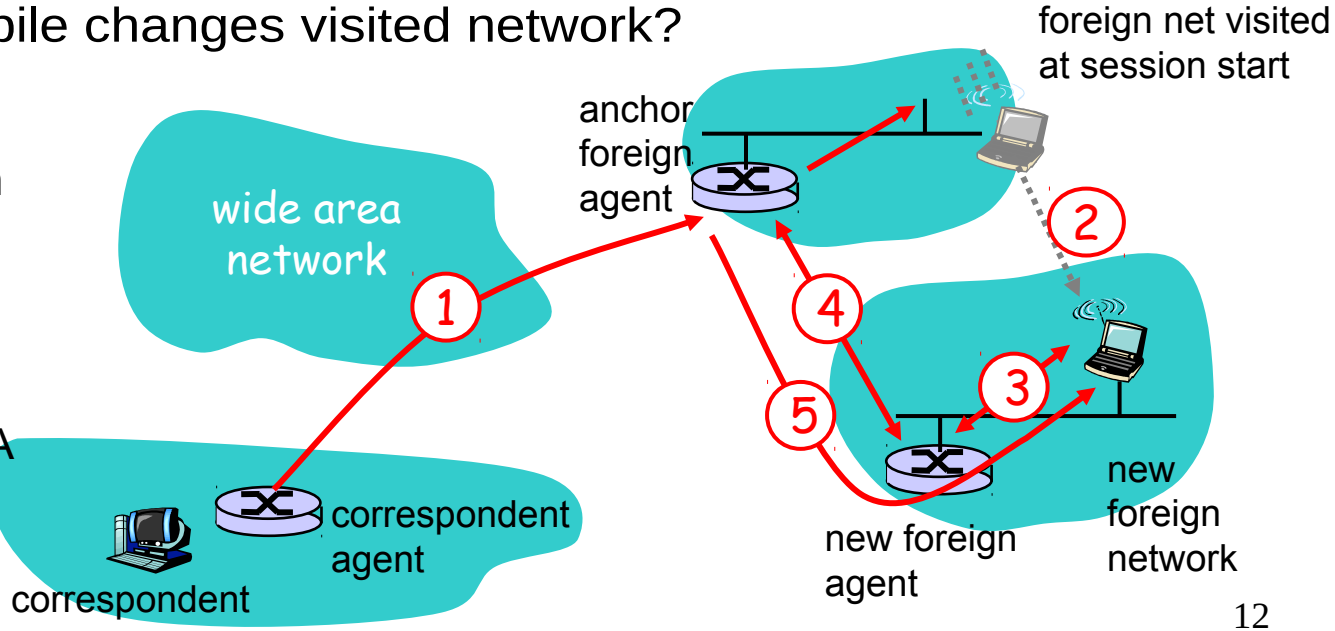
2. Direct Routing - discussion

- **Benefit**
  - Overcome triangle routing problem
- **Drawback**
  - Not transparent to correspondent : correspondent must get *Care-of Address* from home agent
  - what if mobile changes visited network?

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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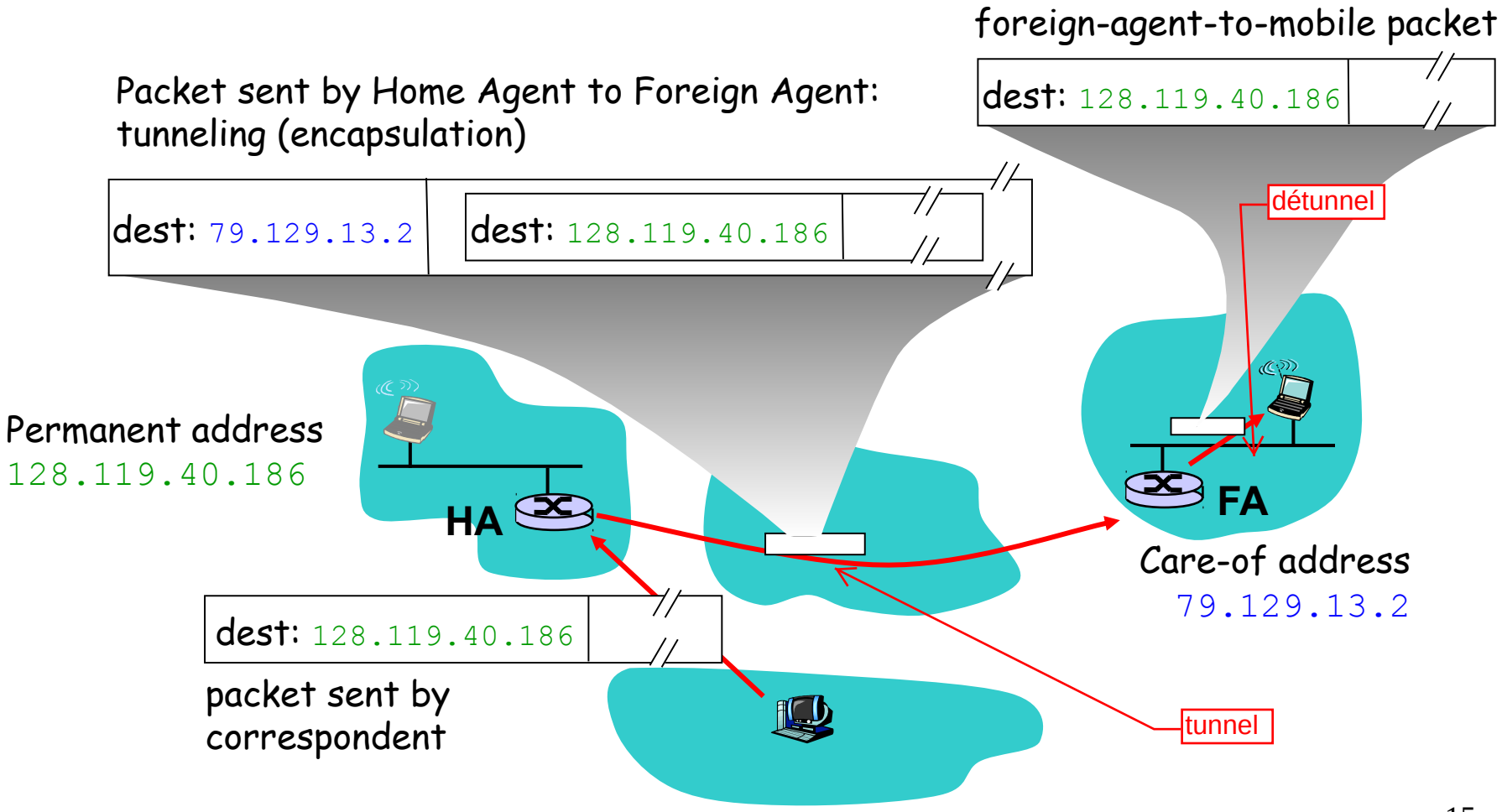
6.9 Summary

Mobile IP

- **“Mobile IP”** paper
  - C. Perkins, IEEE Communications Magazine, 1997
- “***IP Mobility Support for IPv4***”
  - RFC 3344, Aug. 2002
  - Has many features we’ve seen : Home Agents, Foreign Agents, Discovery, Registration, Care-of Addresses, ...

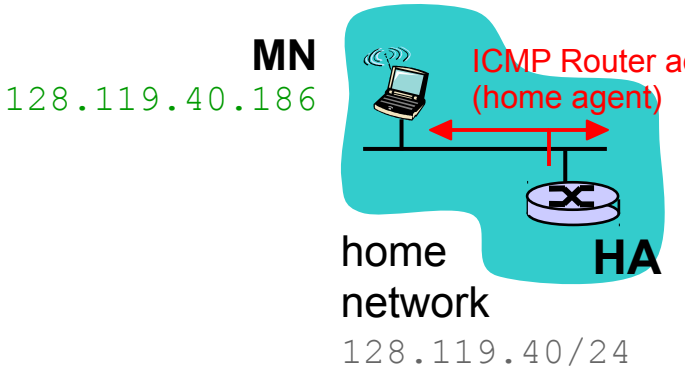
- Three components standardized
  1. Indirect routing of datagrams
  2. Agent discovery
  3. Registration with home agent

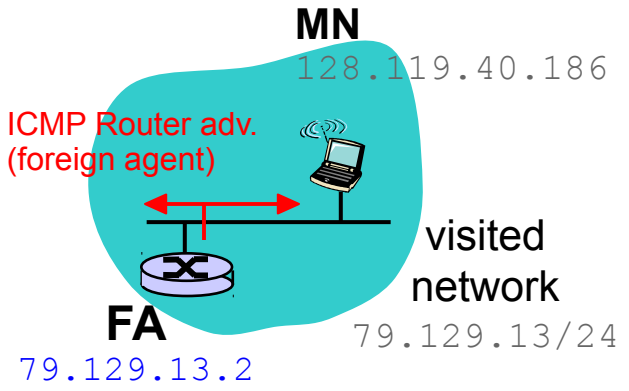
Mobile IP - 1. Indirect routing



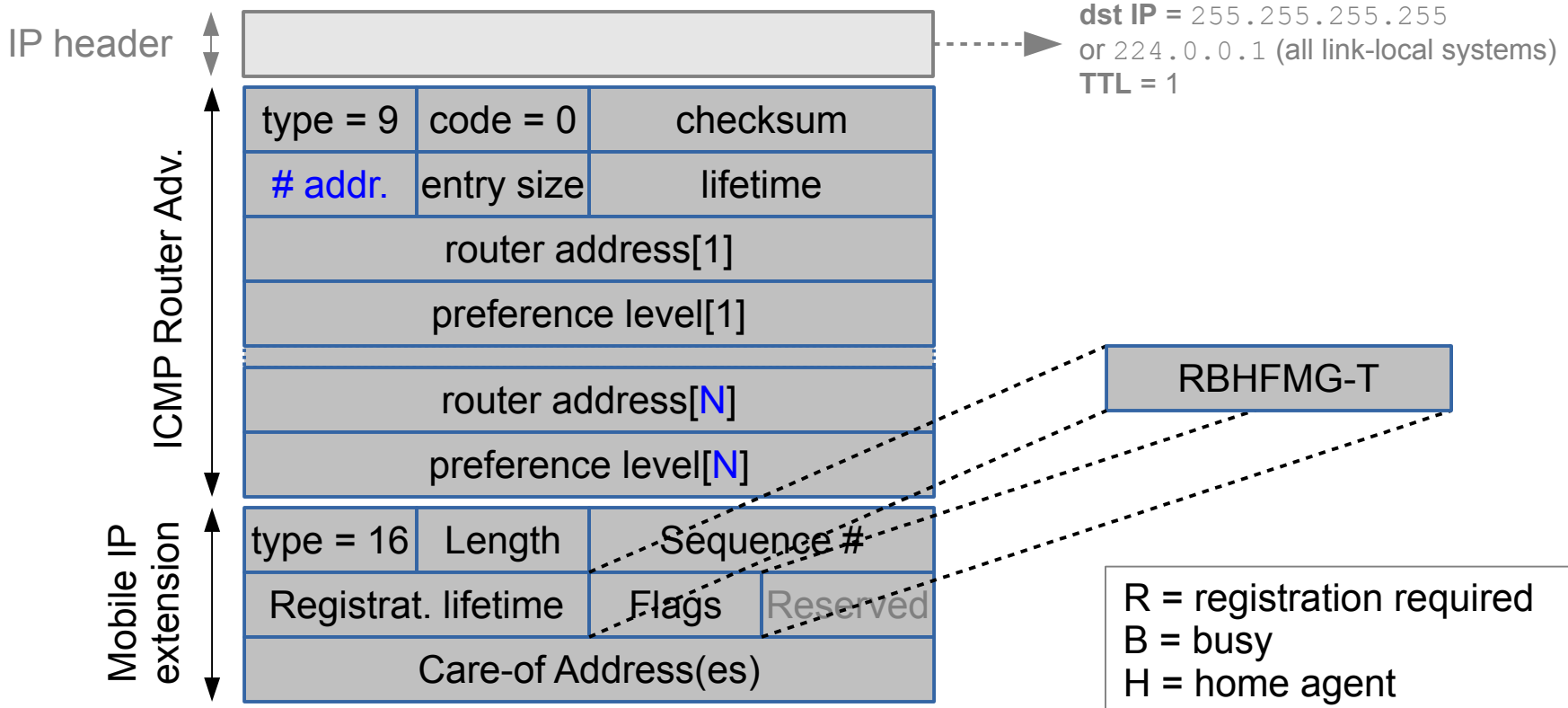
Mobile IP – 2. Agent discovery

- **Agent Advertisement / Solicitation**
  - Foreign / Home Agents advertise service by broadcasting standard ICMP messages defined in RFC1256
    - *Router Advertisement* / Router Solicitation
    - typefield = 9, code = 0
    - Mobile IP defines TLV (*Type-Length-Value*) extensions for the Router Advertisement messages





Mobile IP – 2. Agent discovery



Sequence # = count of RA sent since booting

Mobile IP – 3. Registration with home agent

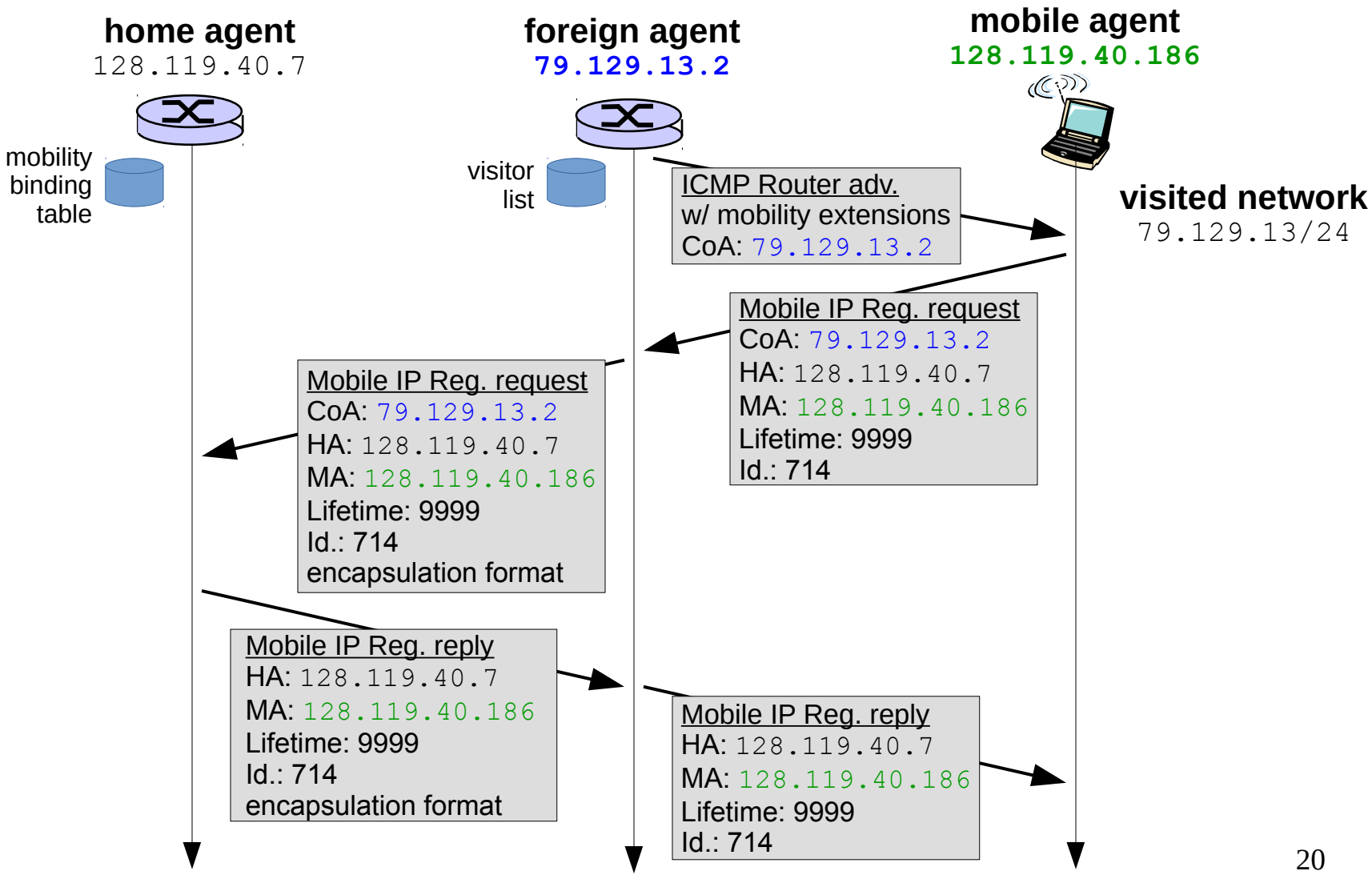
- **Registration messages**
  - UDP, to and from port 434
  - Registration Request [type = 1]
    - Care-Of-Address (COA)
    - Home-Agent Address (HA)
    - Permanent Address (MA)
    - Lifetime (in seconds)
    - Identification number (64-bits) used to map replies to requests, protect against replay attacks
    - Options: type of encapsulation (GRE, Minimal Encapsulation)
  - Registration reply [type=3]
    - HA Address, Permanent Address
    - Code: accepted, denied, errors

Mobile IP - State tables

- **Home Agent**
  - Maintains a *Mobility Binding Table*
    - For each registered MN
    - (Permanent Address, Care-Of-Address, Lifetime, Encapsulation type)
- **Foreign Agent**
  - Maintains a *Visitor Table*
    - For each registered MN
    - (Permanent Address, Home-Agent Address, MAC Address, Lifetime, Encapsulation type)

Note : when lifetime expires, state is removed from tables (soft state)

Mobile IP - Registration example



Mobile IP - Other aspects

- **There are a lot of other details in Mobile IP**
  - How does the HA capture traffic for mobile node ?
    - typically using gratuitous ARP (or proxy ARP)
  - Issues with traffic from mobile node to correspondent
    - e.g. RPF checks used against IP spoofing (RFC2267)
    - solution: use of reverse tunneling (RFC3024)
  - Security ?
    - HA, FA, MN authentication extensions exist
  - Route Optimization (Direct routing) ?
    - included in Mobile IPv6, more recent in IPv4 (RFC6521)
  - NAT traversal ?
  - ...

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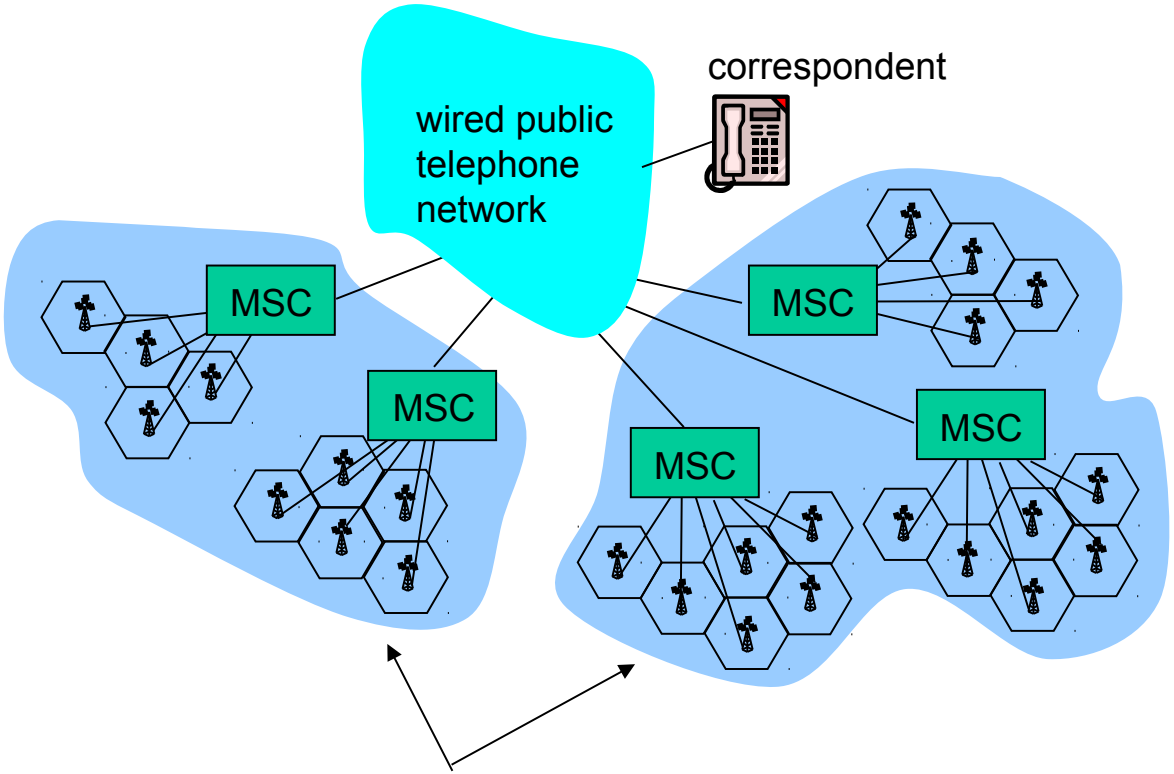
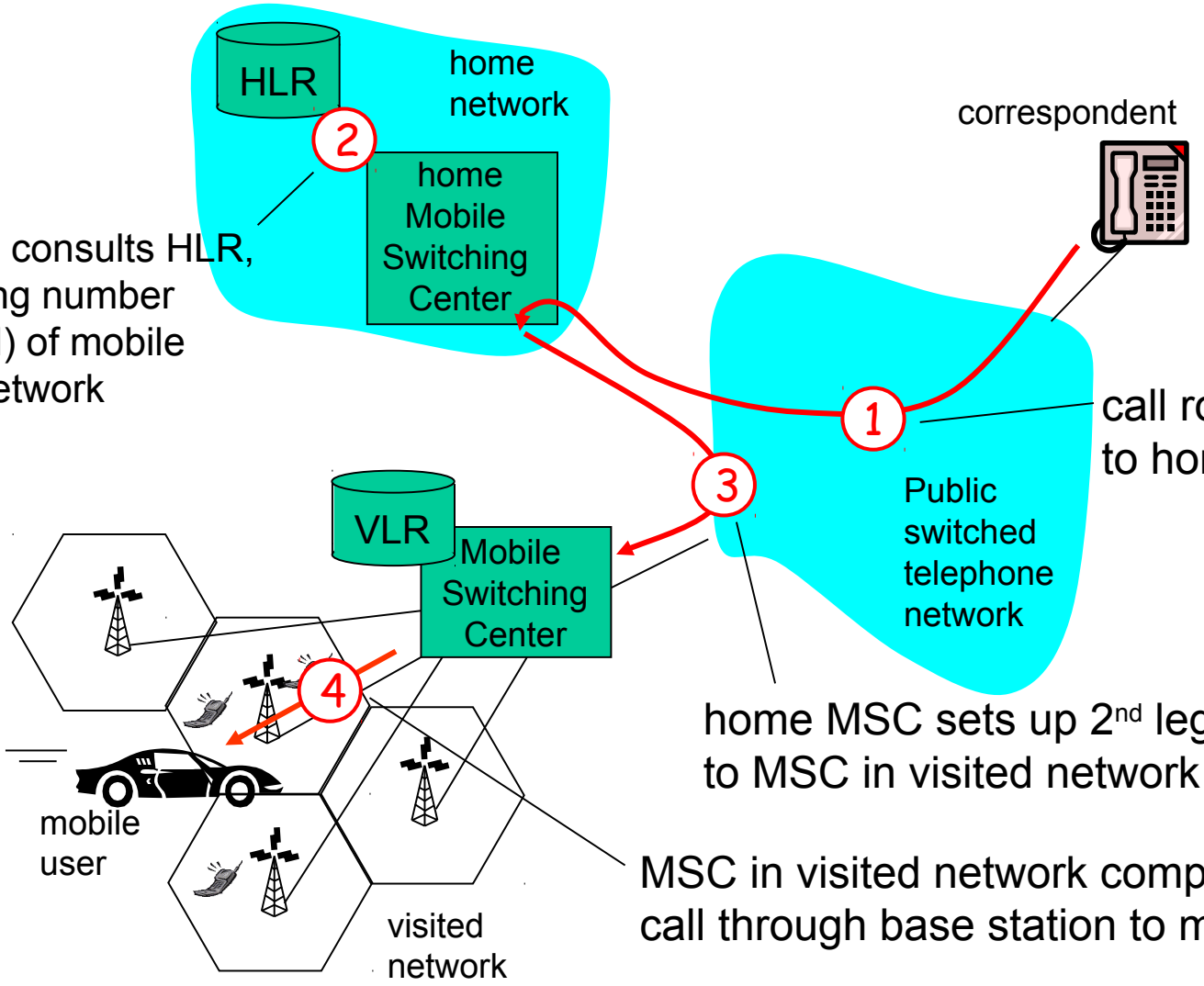
Components of cellular network architecture



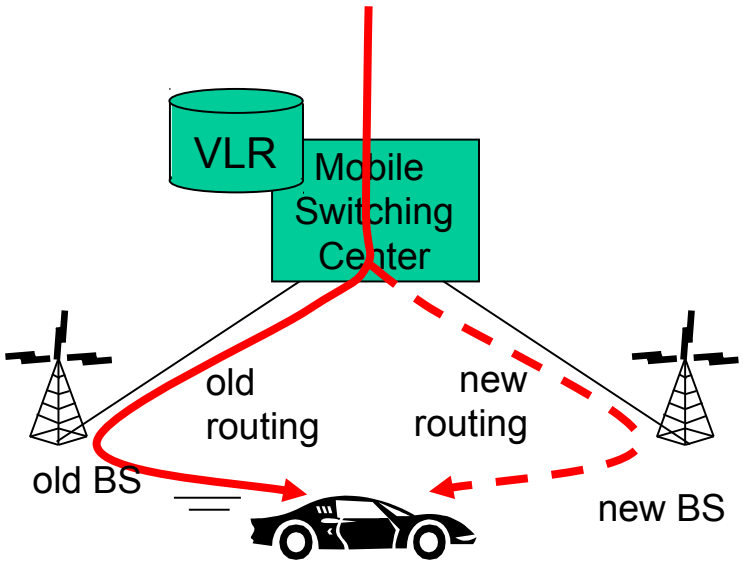
Handling mobility in cellular networks

- *home network:* network of cellular provider you subscribe to (e.g., Mobistar, Proximus, Base, ...)
  - *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

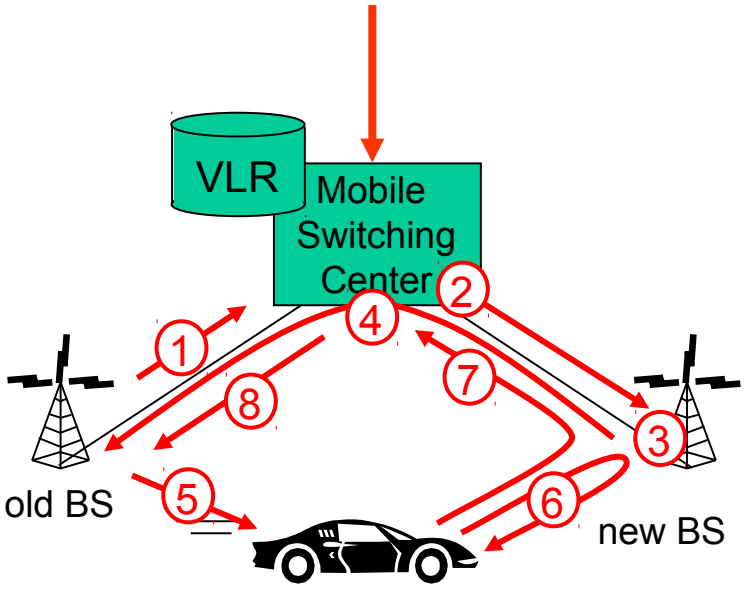


GSM: handoff with common MSC



- Handoff goal: route call via new base station (without interruption)
- reasons for handoff:
  - stronger signal to/from new BS (continuing connectivity, less battery drain)
  - load balance: free up channel in current BS
  - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)
- handoff initiated by old BS

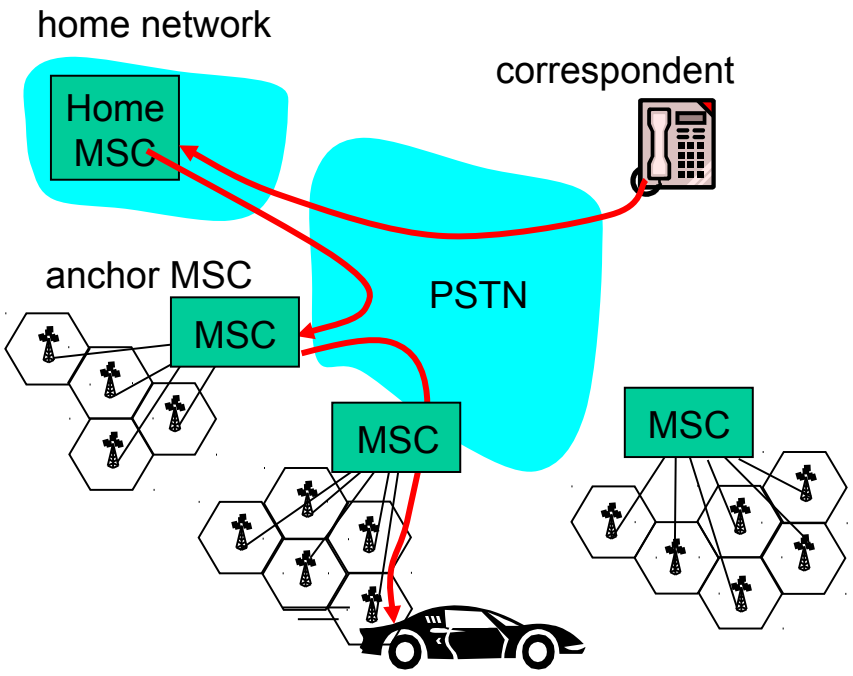
GSM: handoff with common MSC



1. old BS informs MSC of impending handoff, provides list of 1^+ new BSs
2. MSC sets up path (allocates resources) to new BS
3. new BS allocates radio channel for use by mobile
4. new BS signals MSC, old BS: ready
5. old BS tells mobile: perform handoff to new BS
6. mobile and new BS exchange messages to activate new channel
7. mobile signals via new BS to MSC: handoff complete. MSC reroutes call

8 MSC-old-BS resources released

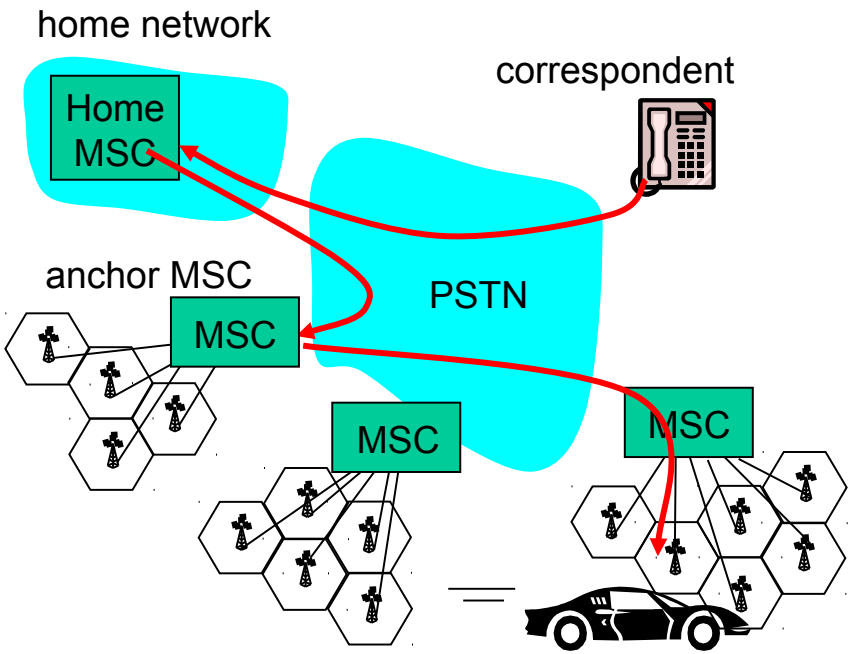
GSM: handoff between MSCs



(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 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

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, 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