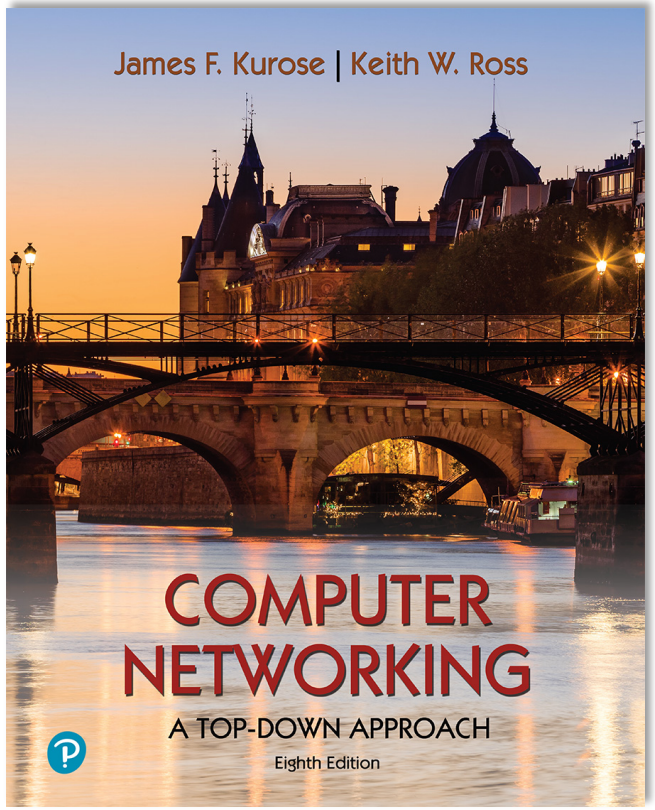
Chapter 7
Wireless and Mobile Networks



Computer Networking: A Top-Down Approach
8th edition
Jim Kurose, Keith Ross
Pearson, 2020

Acknowledgement: Based on the textbook's website:
https://gaia.cs.umass.edu/kurose_ross/index.php

Chapter 7 outline

- Introduction

Wireless

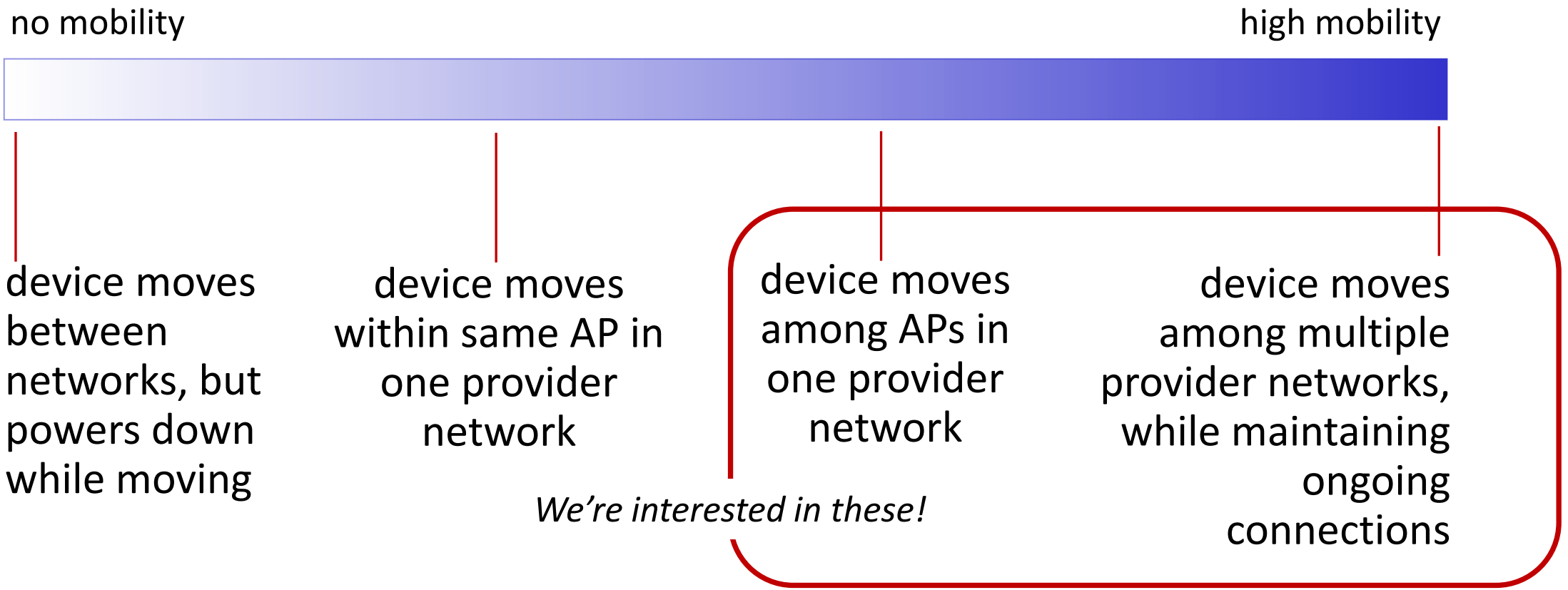
- Wireless links and network characteristics
- WiFi: 802.11 wireless LANs
- Cellular networks: 4G and 5G

Mobility

- Mobility management: principles
- Mobility management: practice
  - 4G/5G networks
  - Mobile IP
- Mobility: impact on higher-layer protocols

What is mobility?

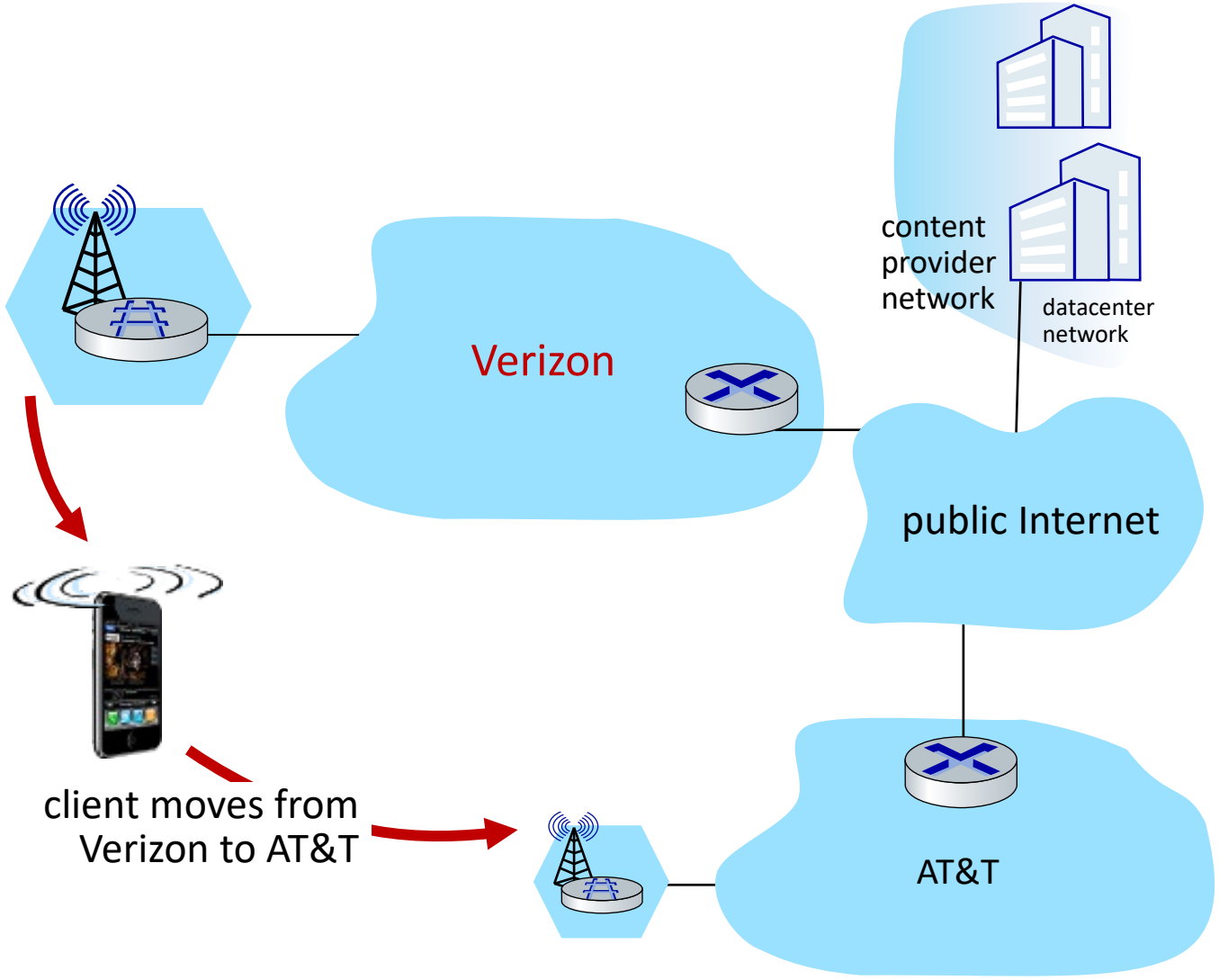
- spectrum of mobility, from the network perspective:



Mobility challenge:

If a device moves from one network another:

- How will the "network" know to forward packets to the *new* network?



Mobility approaches

- let network (routers) handle it:
  - routers advertise well-known name, address (e.g., permanent 32-bit IP address), or number (e.g., cell #) of visiting mobile node via usual routing table exchange
  - Internet routing could do this already *with no* changes! Routing tables indicate where each mobile located via longest prefix match!

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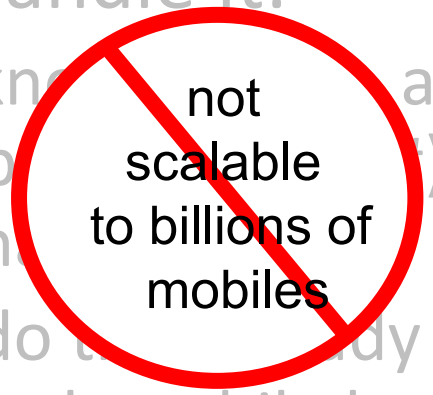


- let end-systems handle it: functionality at the "edge"
  - *indirect routing:* communication from correspondent to mobile goes through home network, then forwarded to remote mobile
  - *direct routing:* correspondent gets foreign address of mobile, send directly to mobile

Contacting a mobile friend:

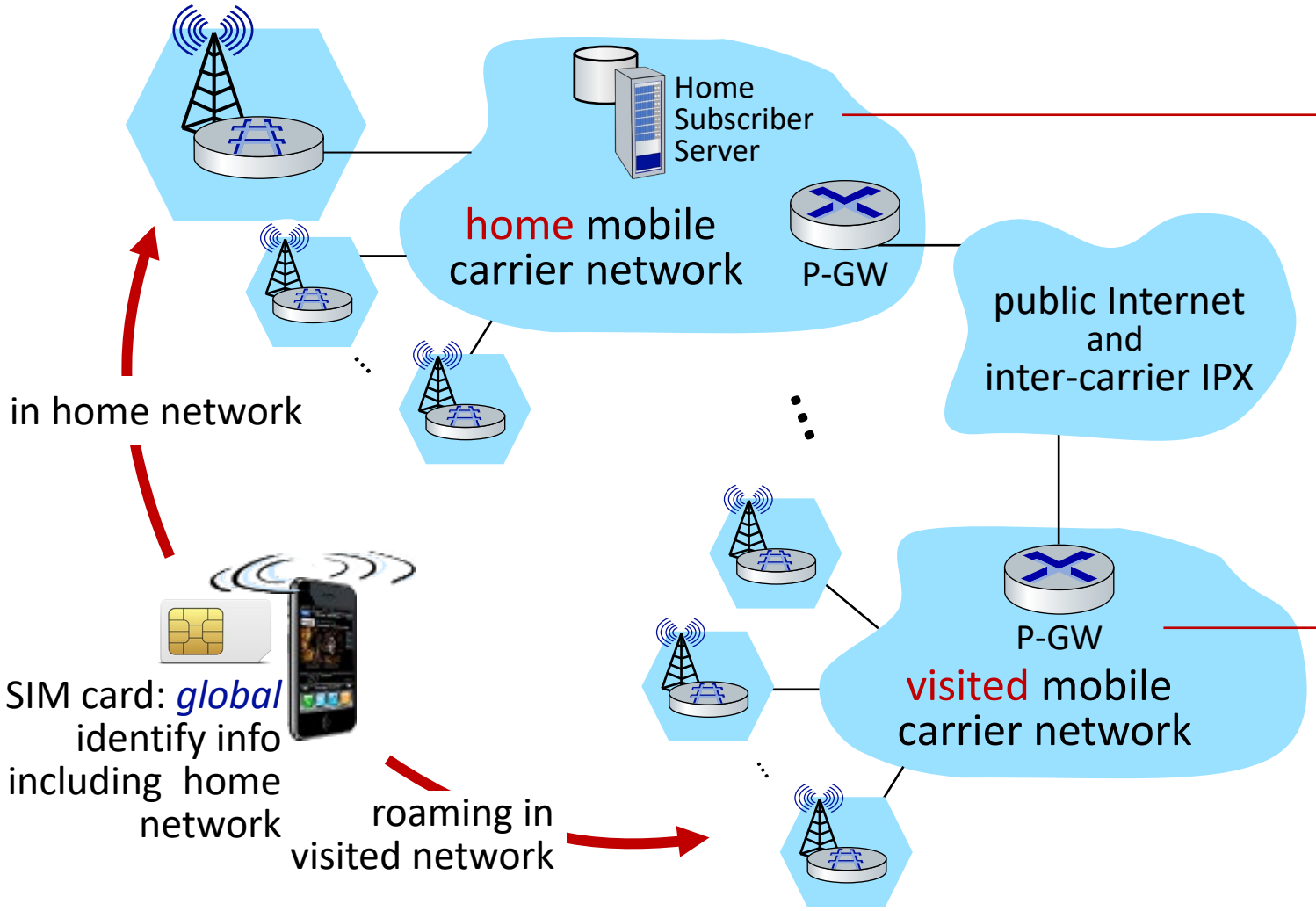
Consider friend frequently changing locations, how do you find him/her?

- search all phone books?
- expect her to let you know where he/she is?
- call his/her parents?
- Facebook!

The importance of having a "home":

- a definitive source of information about you
- a place where people can find out where you are

Home network, visited network: 4G/5G



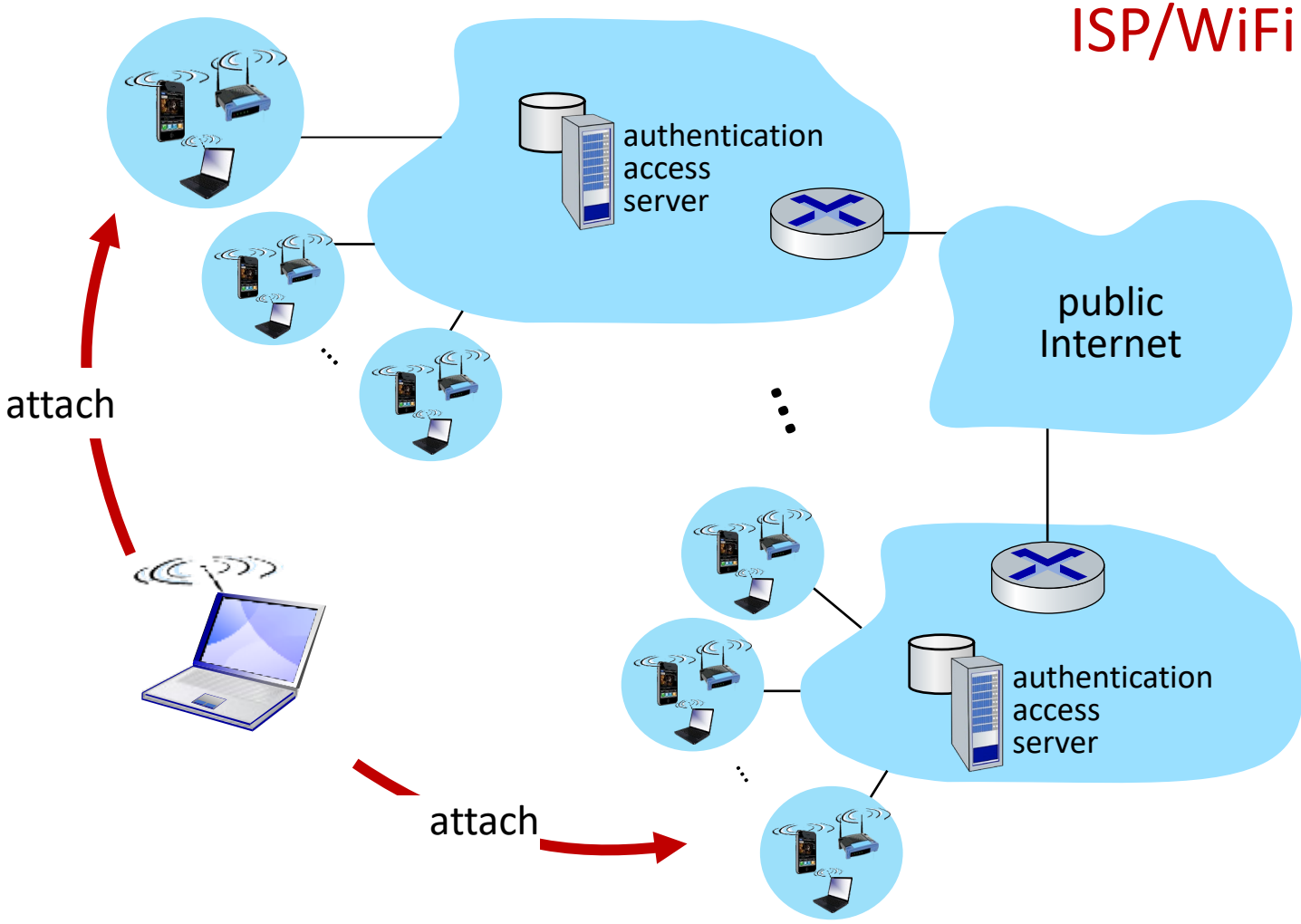
home network:

- (paid) service plan with cellular provider, e.g., Verizon, Orange
- home network HSS stores identify & services info

visited network:

- any network other than your home network
- service agreement with other networks: to provide access to visiting mobile

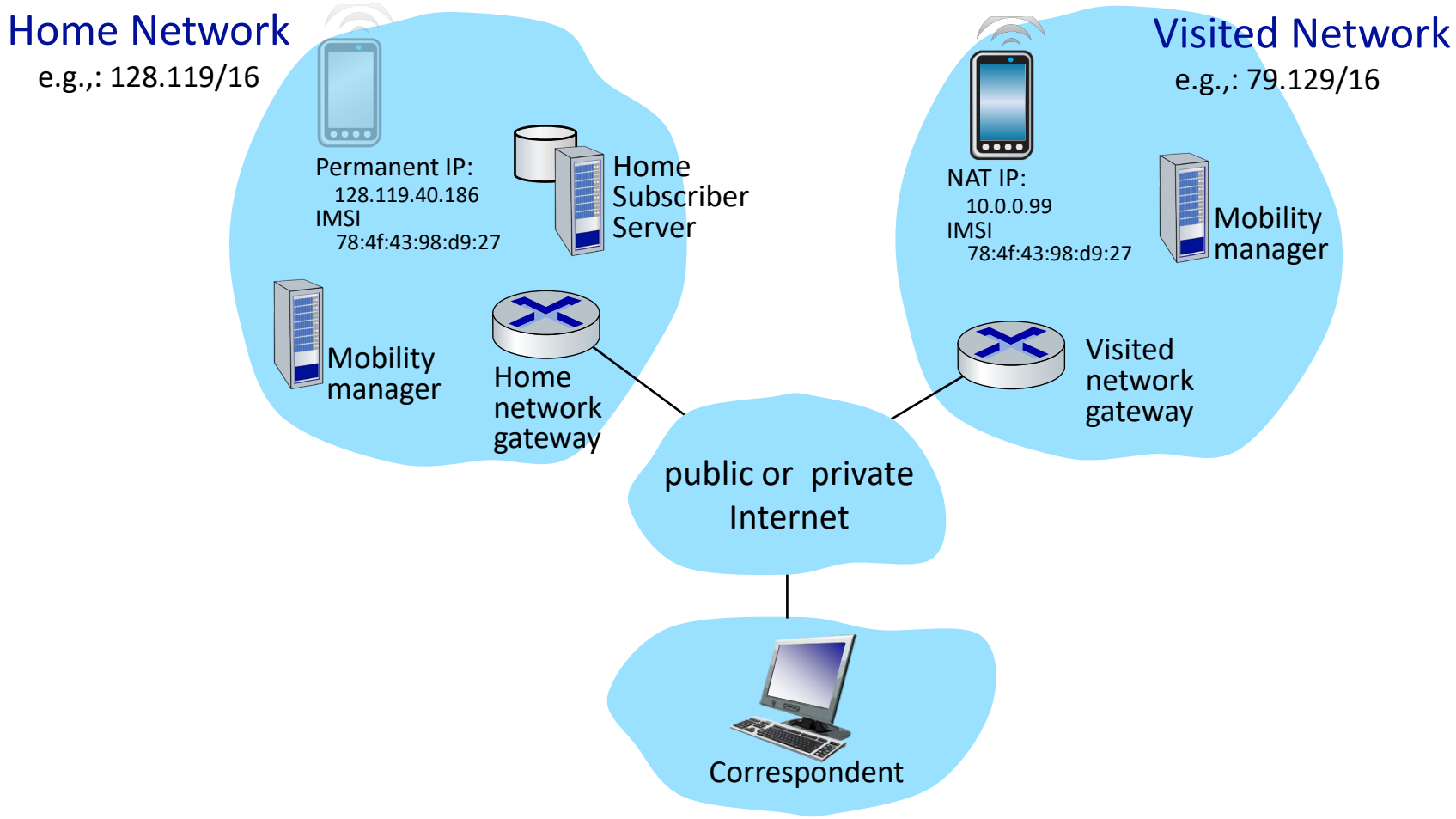
Home network, visited network: ISP/WiFi



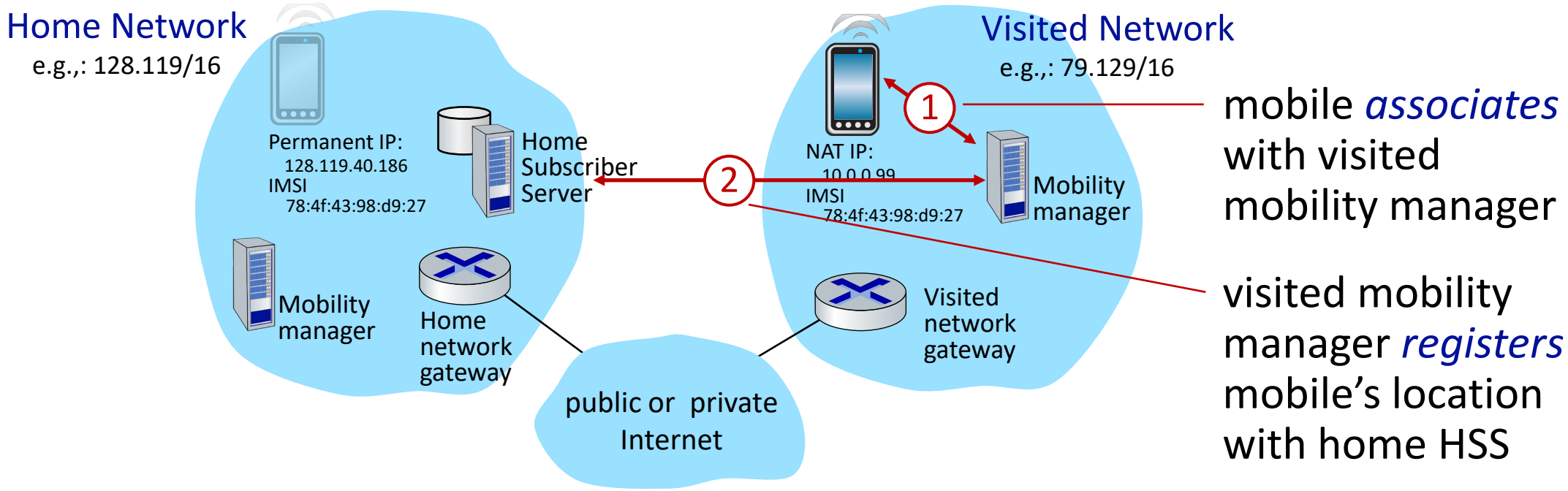
ISP/WiFi: no notion of global "home"

- credentials from ISP (e.g., username, password) stored on device or with user
- ISPs may have national, international presence
- different networks: different credentials
  - some exceptions (e.g., eduroam)
  - architectures exist (mobile IP) for 4G-like mobility, but not used

Home network, visited network: generic



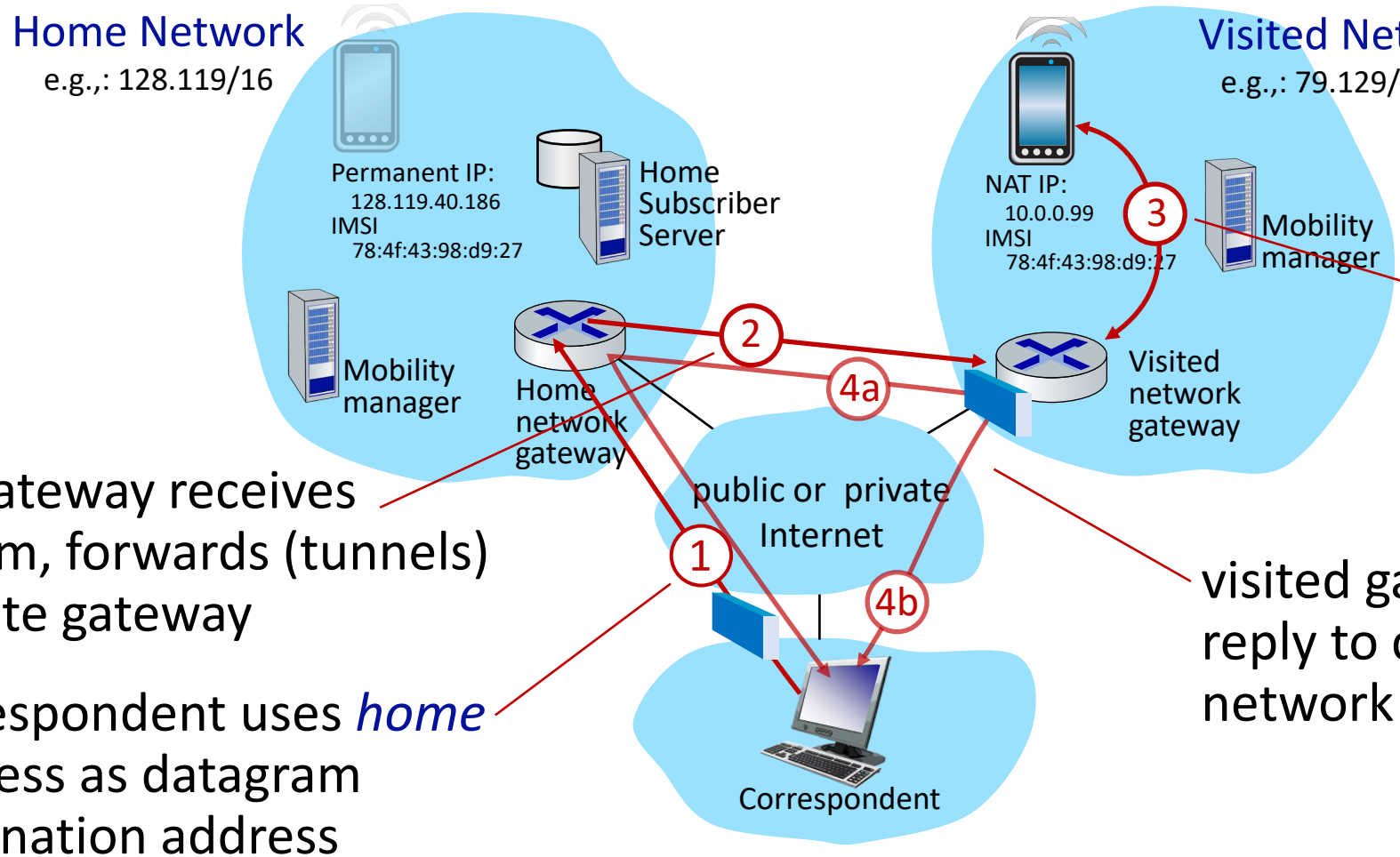
Registration: home needs to know where you are!



end result:

- visited mobility manager knows about mobile
- home HSS knows location of mobile

Mobility with indirect routing



visited gateway router forwards to mobile

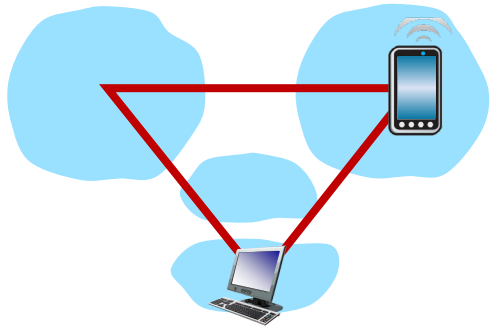
home gateway receives datagram, forwards (tunnels) to remote gateway

correspondent uses *home* address as datagram destination address

visited gateway router forwards reply to correspondent via home network (4a) or directly (4b)

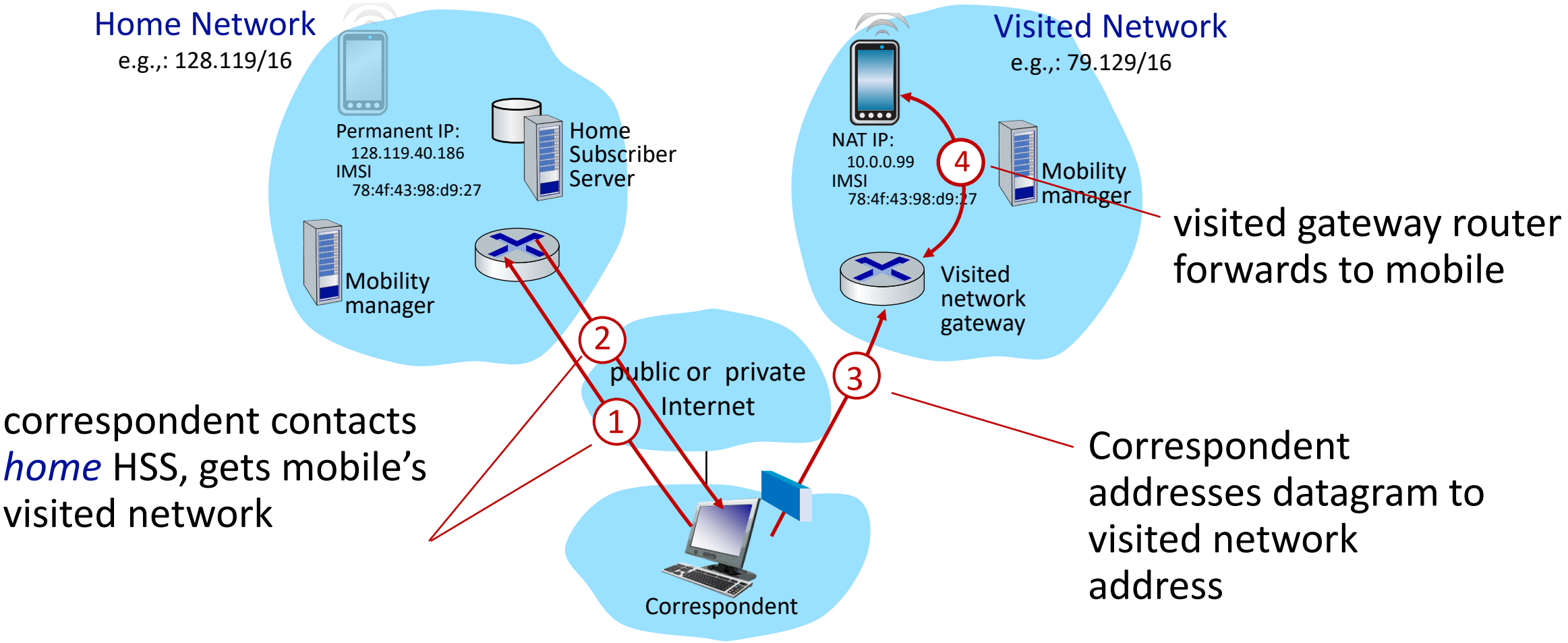
Mobility with indirect routing: comments

- triangle routing:
  - inefficient when correspondent and mobile are in same network



- mobile moves among visited networks: transparent to correspondent!
  - registers in new visited network
  - new visited network registers with home HSS
  - datagrams continue to be forwarded from home network to mobile in new network
  - *on-going (e.g., TCP) connections between correspondent and mobile can be maintained!*

Mobility with direct routing



Mobility with direct routing: comments

- overcomes triangle routing inefficiencies
- *non-transparent to correspondent:* correspondent must get care-of-address from home agent
- what if mobile changes visited network?
  - can be handled, but with additional complexity

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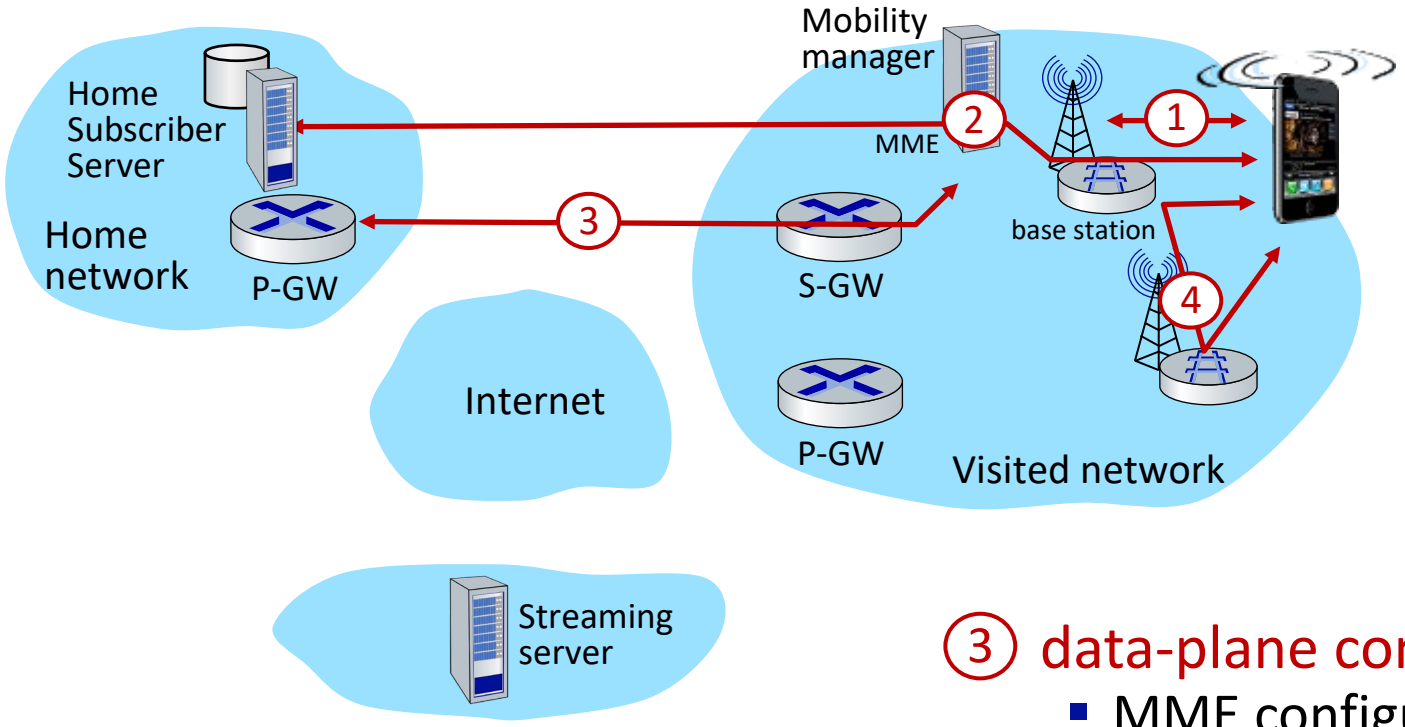
Mobility in 4G networks: major mobility tasks



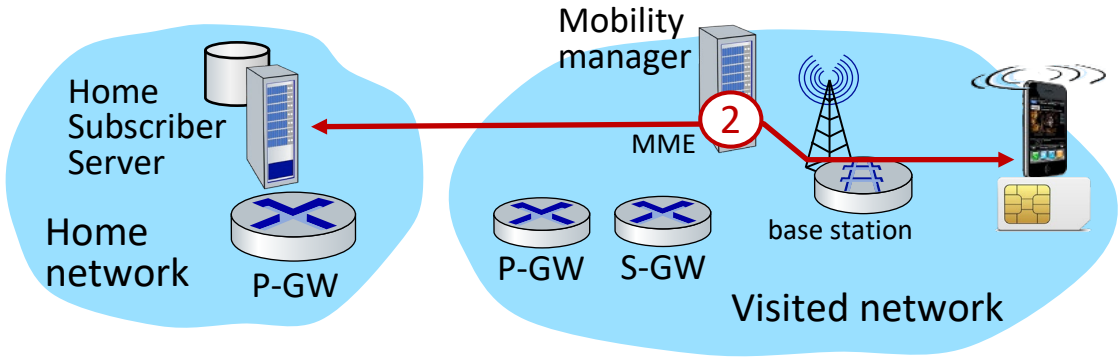
① base station association:
- covered earlier
- mobile provides IMSI – identifying itself, home network

② control-plane configuration:
- MME, home HSS establish control-plane state - mobile is in visited network

③ data-plane configuration:
- MME configures forwarding tunnels for mobile
- visited, home network establish tunnels from home P-GW to mobile

④ mobile handover:
- mobile device changes its point of attachment to visited network

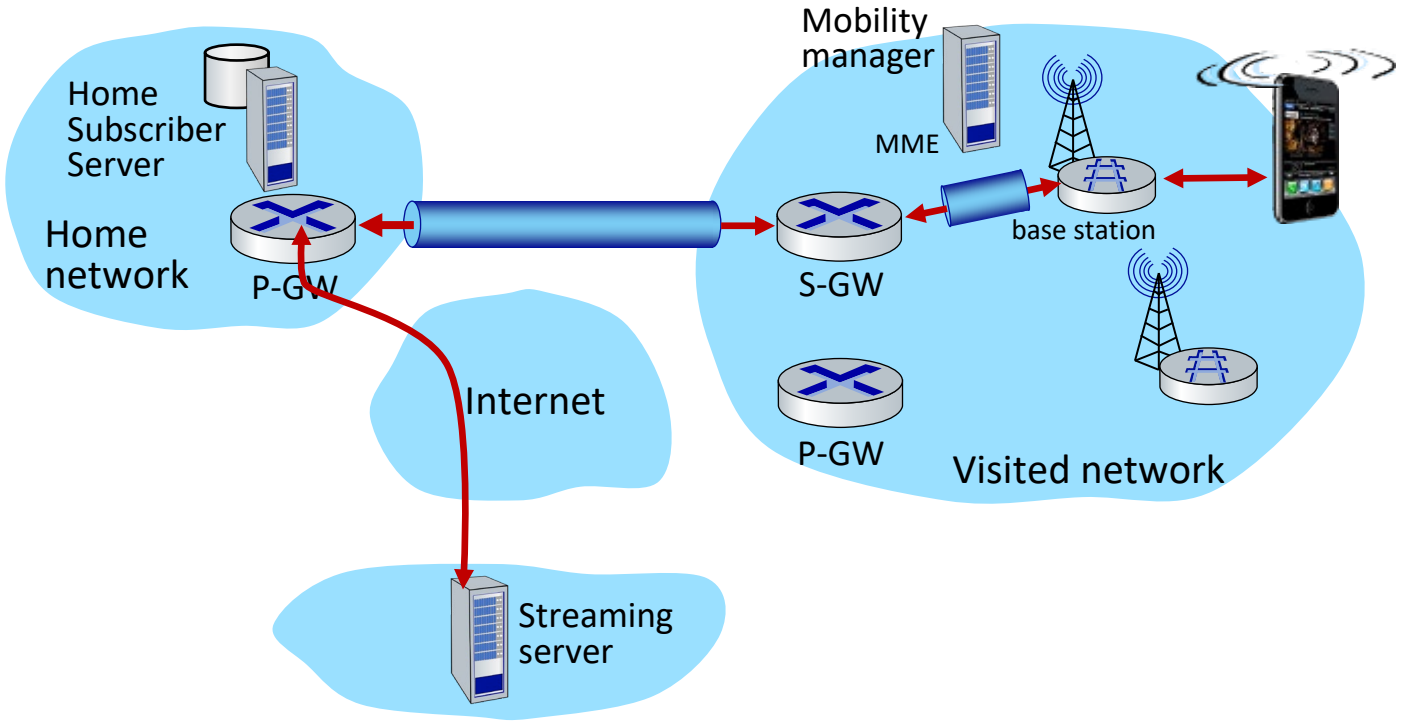
Configuring LTE control-plane elements



- Mobile communicates with local MME via BS control-plane channel
- MME uses mobile's IMSI info to contact mobile's home HSS
  - retrieve authentication, encryption, network service information
  - home HHS knows mobile now resident in visited network
- BS, mobile select parameters for BS-mobile data-plane radio channel

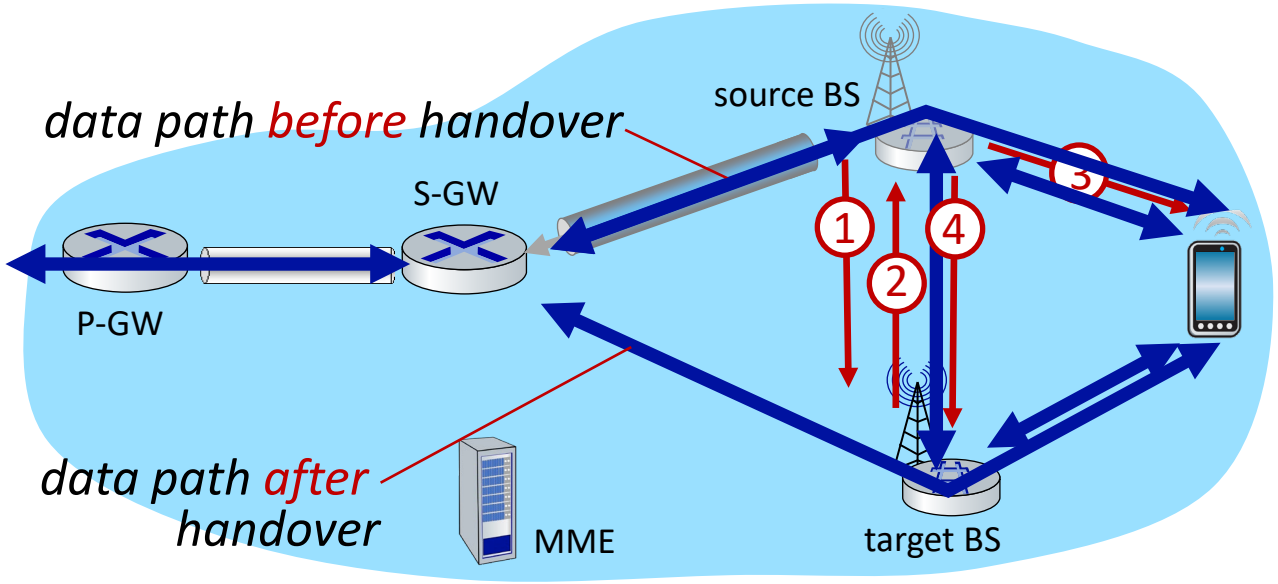
Configuring data-plane tunnels for mobile

- S-GW to BS tunnel: when mobile changes base stations, simply change endpoint IP address of tunnel
- S-GW to home P-GW tunnel: implementation of indirect routing



- tunneling via GTP (GPRS tunneling protocol): mobile's datagram to streaming server encapsulated using GTP inside UDP, inside datagram

Handover between BSs in same cellular network



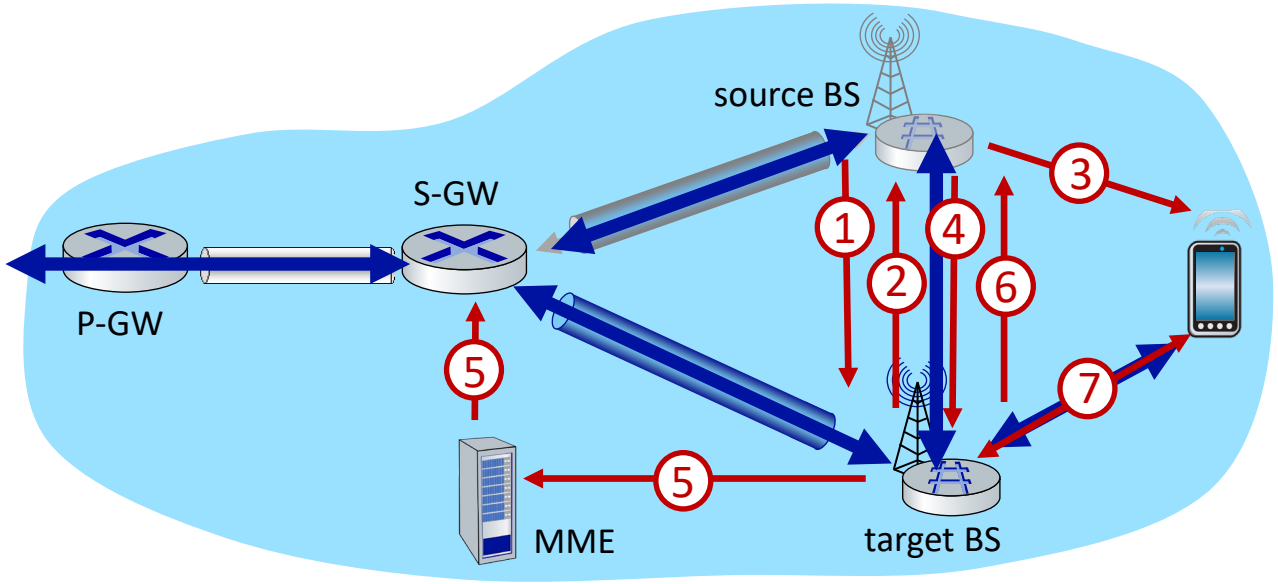
1. current (source) BS selects target BS, sends *Handover Request message* to target BS

2. target BS pre-allocates radio time slots, responds with HR ACK with info for mobile

3. source BS informs mobile of new BS
   - mobile can now send via new BS - handover *looks* complete to mobile

4. source BS stops sending datagrams to mobile, instead forwards to new BS (who forwards to mobile over radio channel)

Handover between BSs in same cellular network



5 target BS informs MME that it is new BS for mobile
- MME instructs S-GW to change tunnel endpoint to be (new) target BS

6 target BS ACKs back to source BS: handover complete, source BS can release resources

7 mobile's datagrams now flow through new tunnel from target BS to S-GW

Mobile IP

- mobile IP architecture standardized ~20 years ago [RFC 5944]
  - long before ubiquitous smartphones, 4G support for Internet protocols
  - did not see wide deployment/use
  - perhaps WiFi for Internet, and 2G/3G phones for voice were “good enough” at the time
- mobile IP architecture:
  - indirect routing to node (via home network) using tunnels
  - mobile IP home agent: combined roles of 4G HSS and home P-GW
  - mobile IP foreign agent: combined roles of 4G MME and S-GW
  - protocols for agent discovery in visited network, registration of visited location in home network via ICMP extensions

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 handover loss
  - TCP interprets loss as congestion, will decrease congestion window un-necessarily
  - delay impairments for real-time traffic
  - bandwidth a scare resource for wireless links

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