Mobility ...

What is mobility?

☐ spectrum of mobility, from the network perspective:

no mobility   high mobility

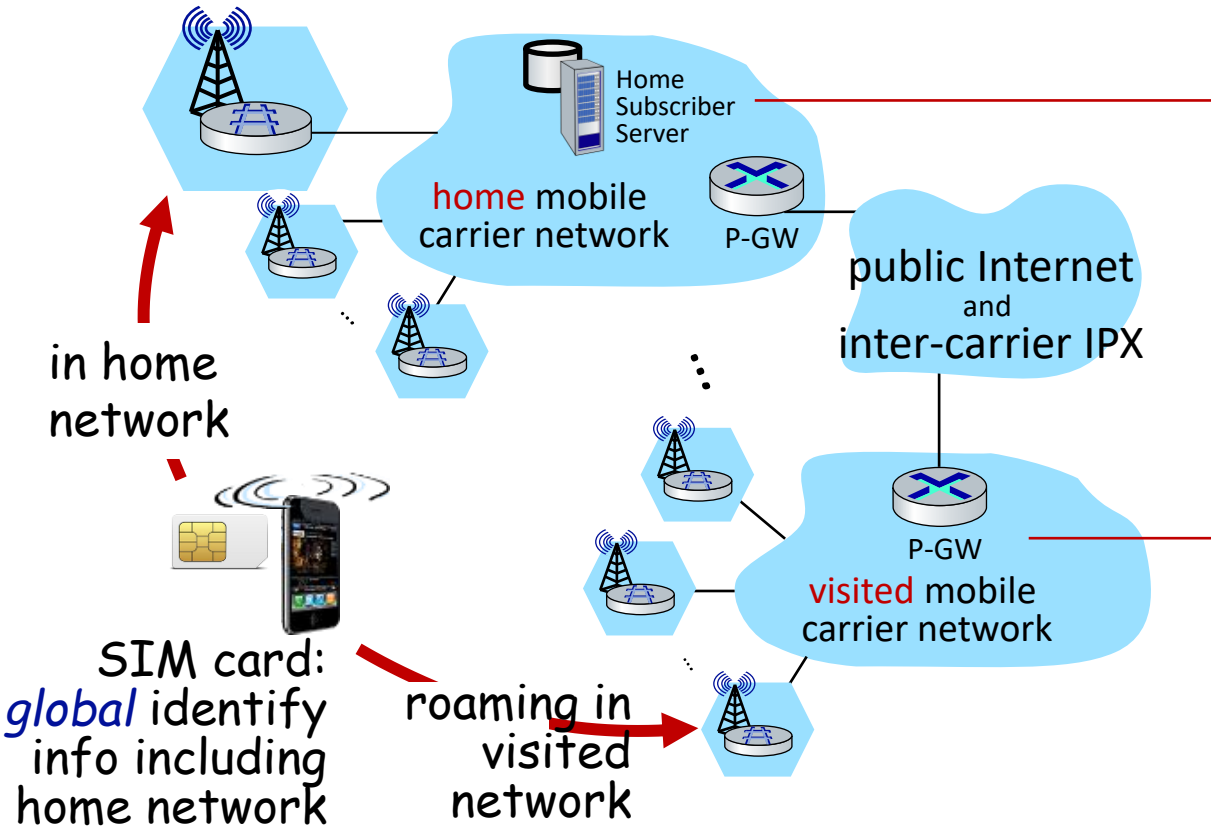device moves between networks, but powers down while moving

device moves within same AP in one provider network

device moves among APs in one provider network

device moves among multiple provider networks, while maintaining ongoing connections

We're interested in these!
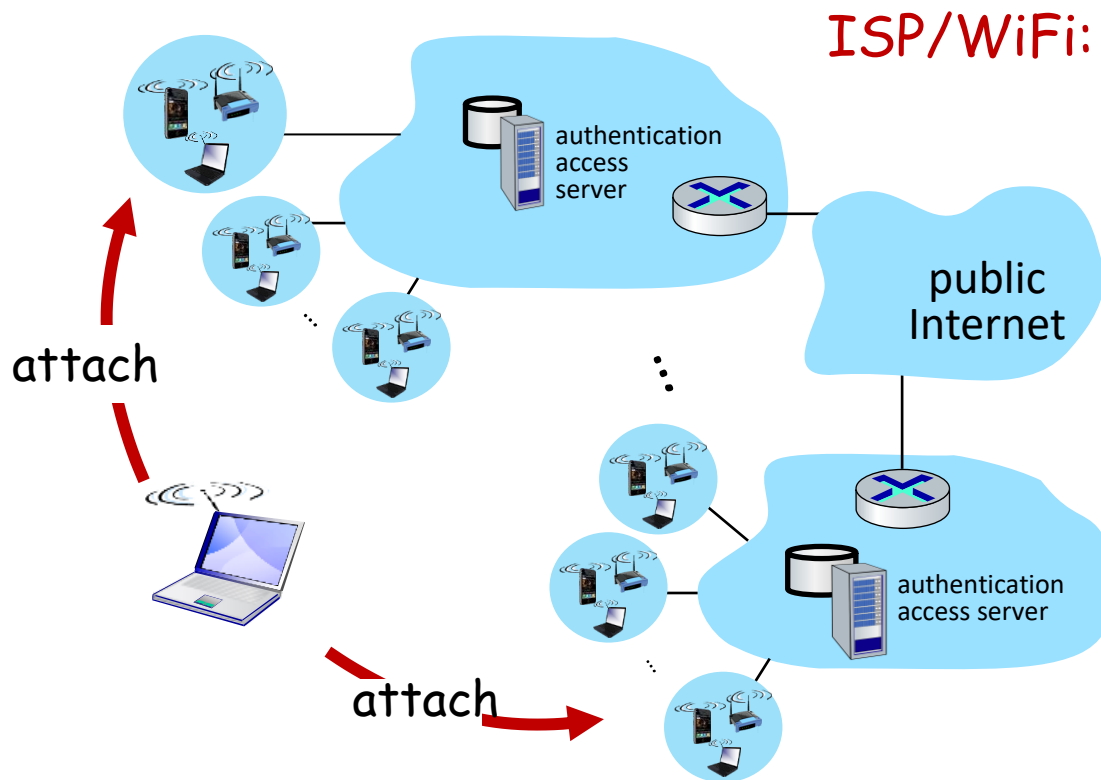
Home network, visited network: 4G/5G

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 Subscriber Server

home mobile carrier network

P-GW

public Internet and inter-carrier IPX

P-GW

visited mobile carrier network

in home network

SIM card: *global* identify info including home network
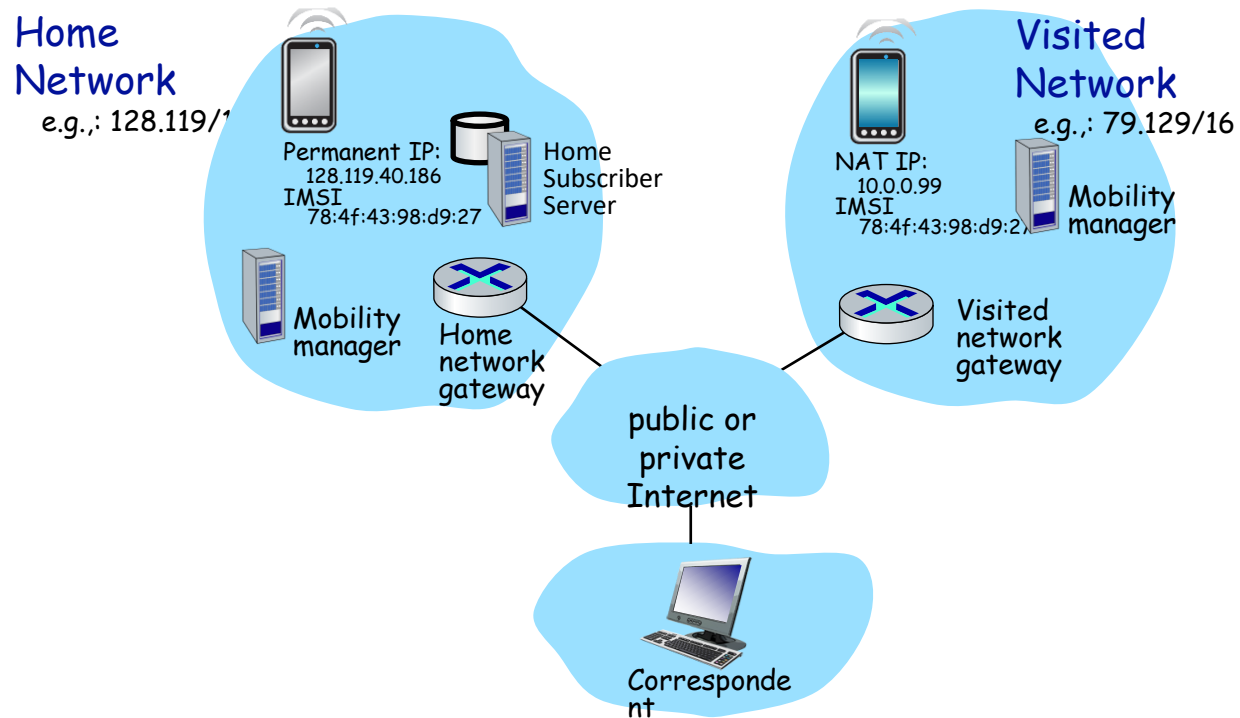
roaming in visited network
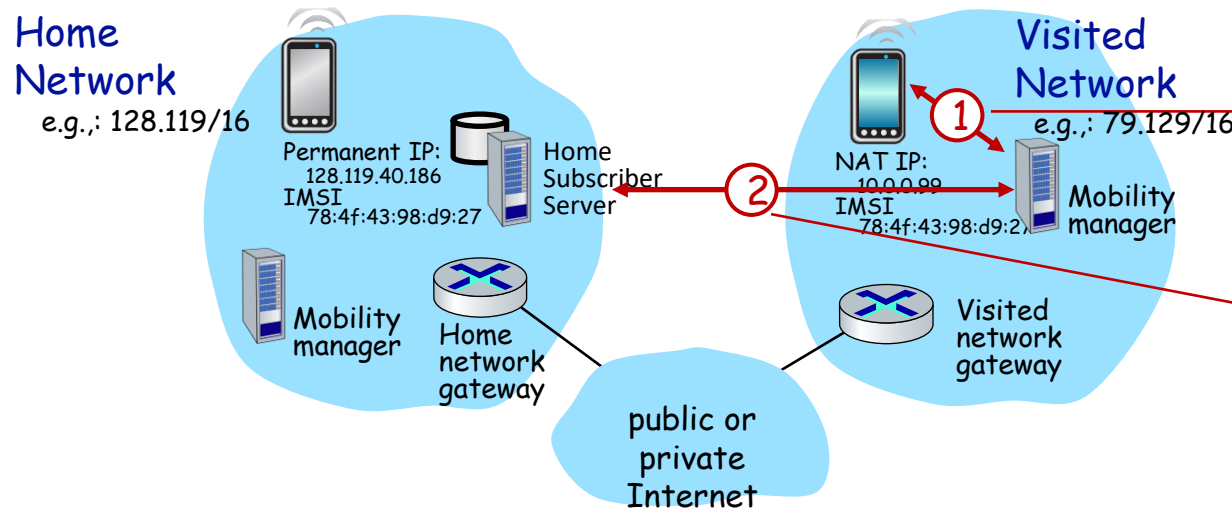
Home network, visited network: ISP/WiFi

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

Home
Network
e.g.,: 128.119/1

Permanent IP:
128.119.40.186
IMSI
78:4f:43:98:d9:27

Home
Subscriber
Server

Mobility
manager

Home
network
gateway

Visited
Network
e.g.,: 79.129/16

NAT IP:
10.0.0.99
IMSI
78:4f:43:98:d9:27

Mobility
manager

Visited
network
gateway

public or
private
Internet

Corresponde
nt

Registration: home needs to know where you are!

Home Network e.g.,: 128.119/16

Permanent IP: 128.119.40.186
IMSI 78:4f:43:98:d9:27

Home Subscriber Server

Mobility manager

Home network gateway

public or private Internet

Visited Network e.g.,: 79.129/16

NAT IP: 10.0.0.99
IMSI 78:4f:43:98:d9:2x

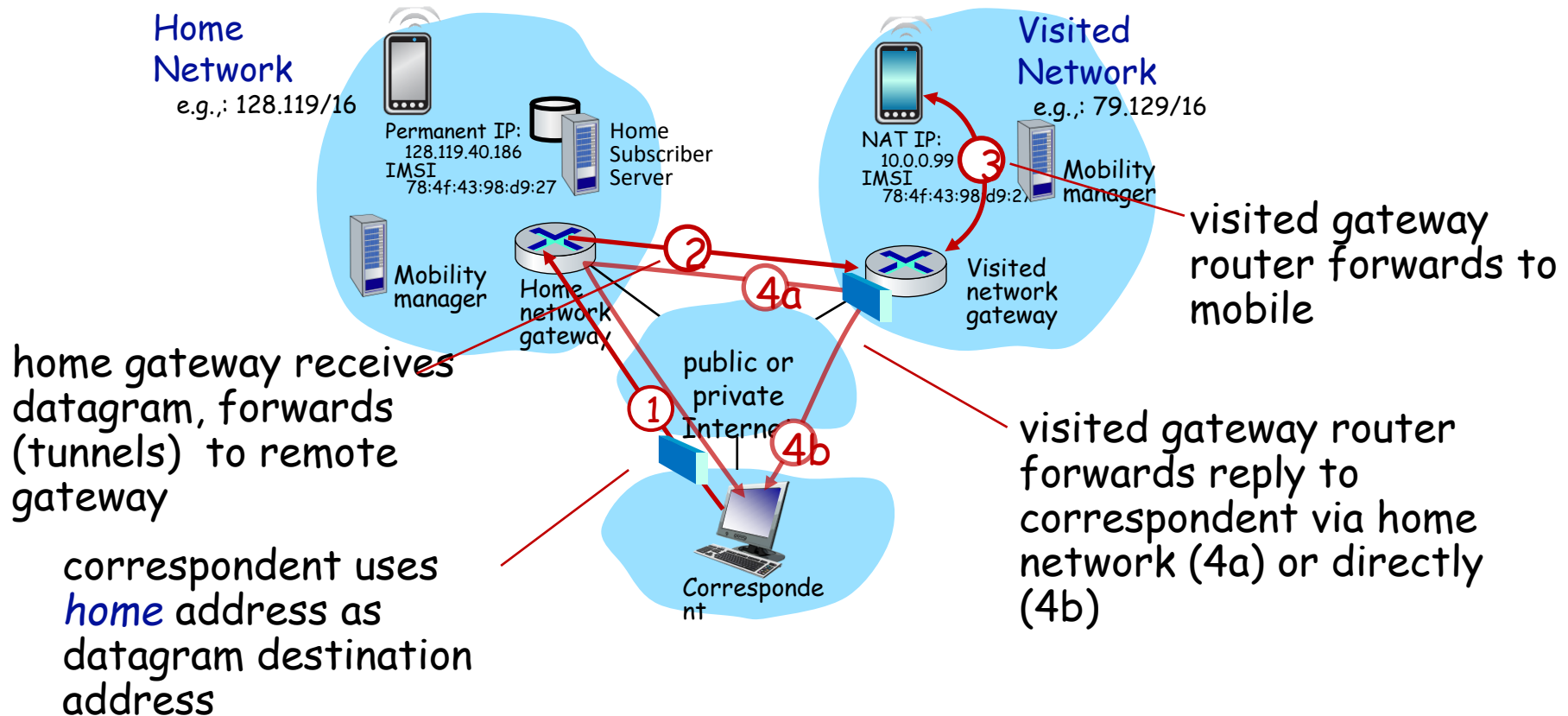Mobility manager

Visited network gateway

(1) mobile *associates* with visited mobility manager

visited mobility manager *registers* mobile's location with home HSS

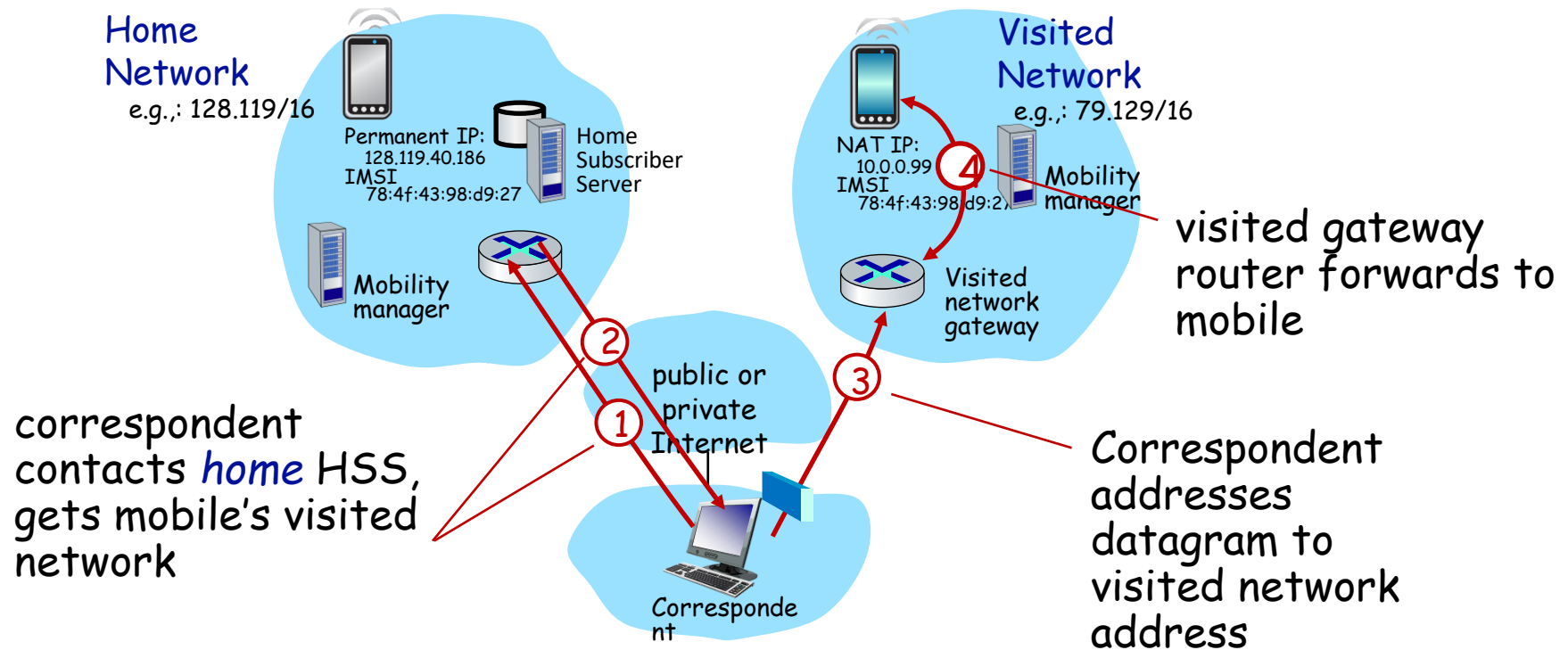**end result:**
- visited mobility manager knows about mobile
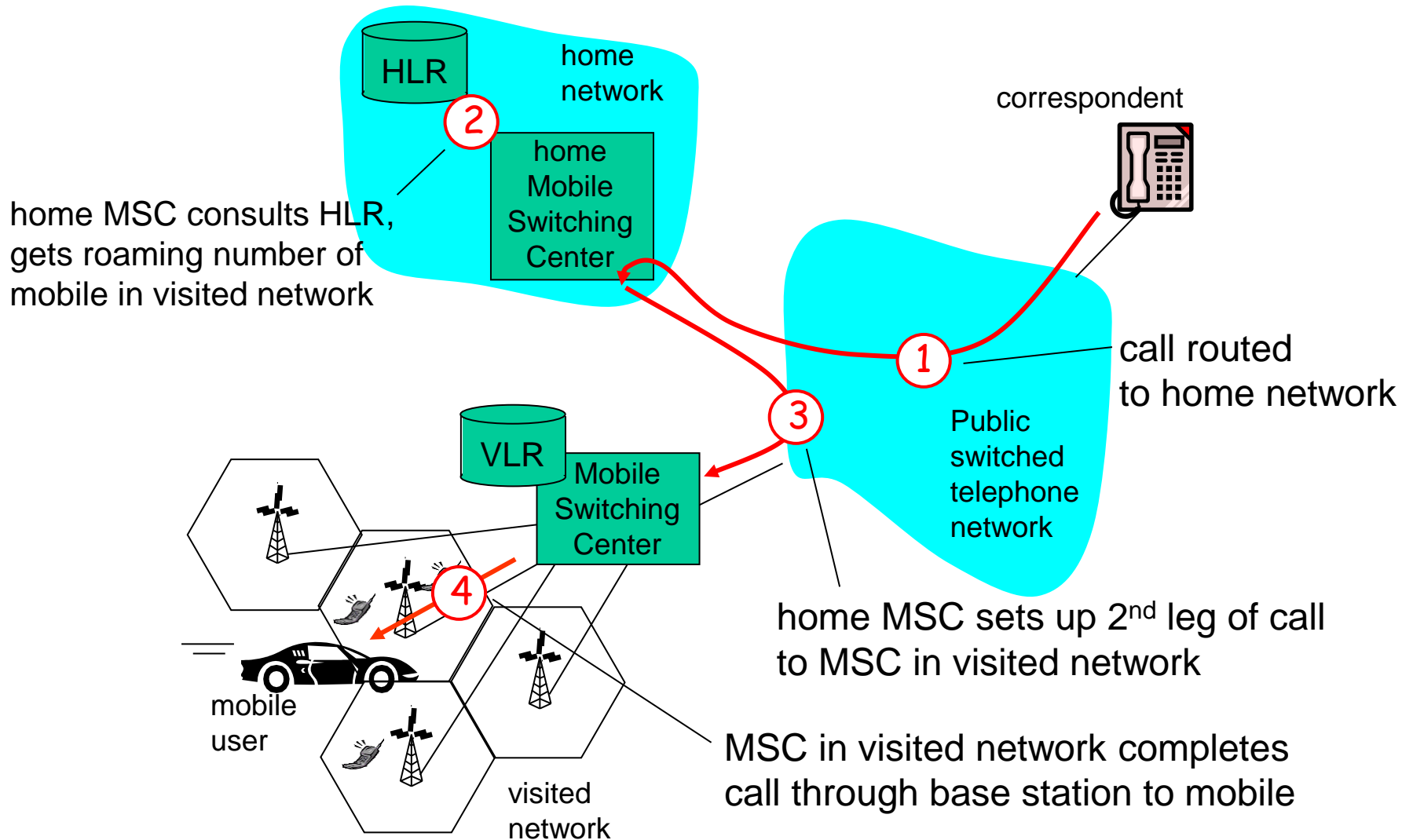- home HSS knows location of mobile
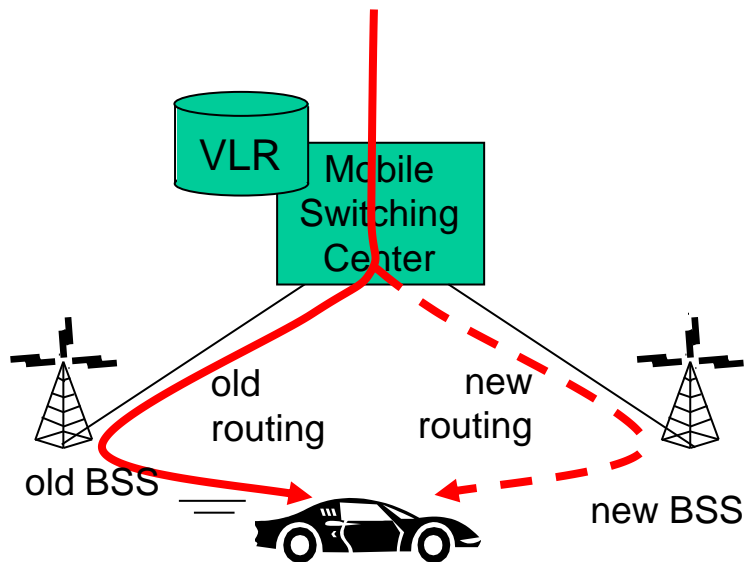
Mobility with indirect routing

Home Network
e.g.,: 128.119/16

Permanent IP:
128.119.40.186
IMSI
78:4f:43:98:d9:27

Home Subscriber Server

Mobility manager

Home network gateway

Visited Network
e.g.,: 79.129/16

NAT IP:
10.0.0.99
IMSI
78:4f:43:98:d9:2✗

③

Mobility manager

Visited network gateway

public or private Internet

①

④a

④b

②

Corresponde nt

visited gateway router forwards to mobile

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

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

correspondent uses *home* address as datagram destination address

Mobility with direct routing

Home
Network
e.g.,: 128.119/16

Permanent IP:
128.119.40.186
IMSI
78:4f:43:98:d9:27

Home
Subscriber
Server

Mobility
manager

Visited
Network
e.g.,: 79.129/16

NAT IP:
10.0.0.99
IMSI
78:4f:43:98:d9:27

Mobility
manager

Visited
network
gateway

public or
private
Internet

Correspondent

correspondent contacts *home* HSS, gets mobile's visited network

visited gateway router forwards to mobile

Correspondent addresses datagram to visited network address

GSM: indirect routing to mobile

HLR

home network

correspondent

2

home Mobile Switching Center

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

1

call routed to home network

3

Public switched telephone network

VLR

Mobile Switching Center

4

mobile user

visited network

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

MSC in visited network completes call through base station to mobile

GSM: handoff with common MSC

VLR

Mobile Switching Center

old routing

new routing

old BSS

new BSS

- 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
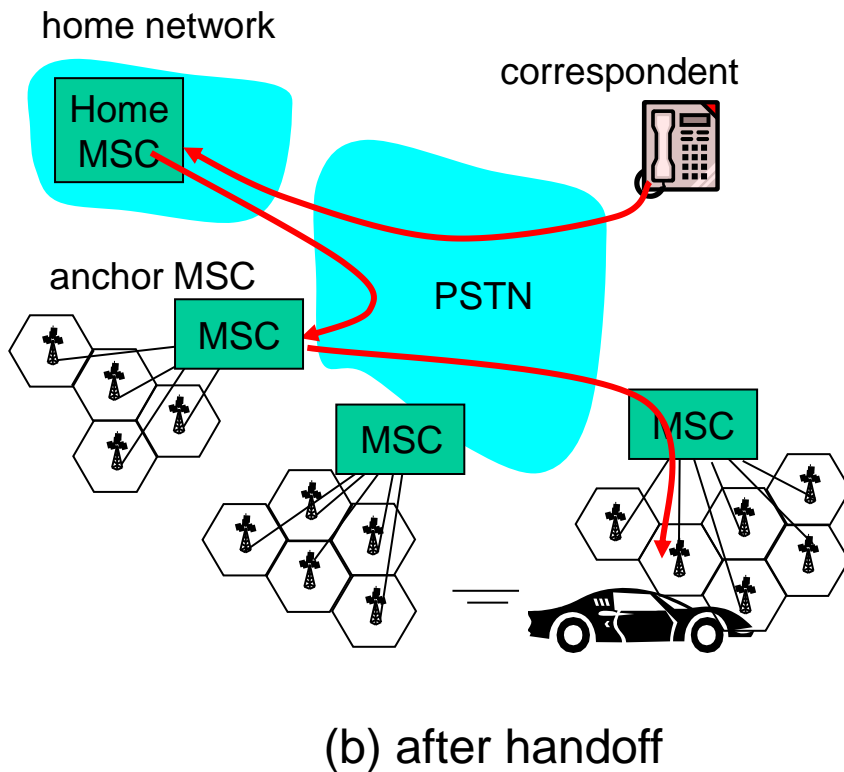
17

GSM: handoff with common MSC
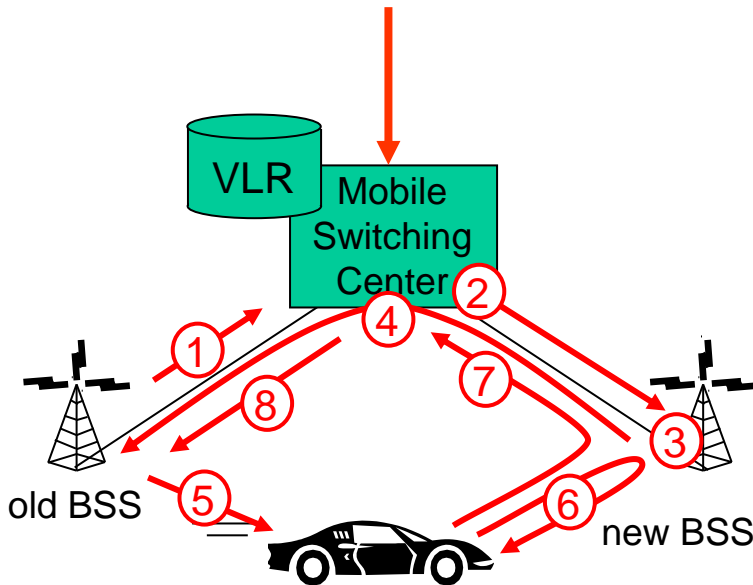
1. old BSS informs MSC of impending handoff, provides list of 1+ new BSSs
2. MSC sets up path (allocates resources) to new BSS
3. new BSS allocates radio channel for use by mobile
4. new BSS signals MSC, old BSS: ready
5. old BSS tells mobile: perform handoff to new BSS
6. mobile, new BSS signal to activate 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
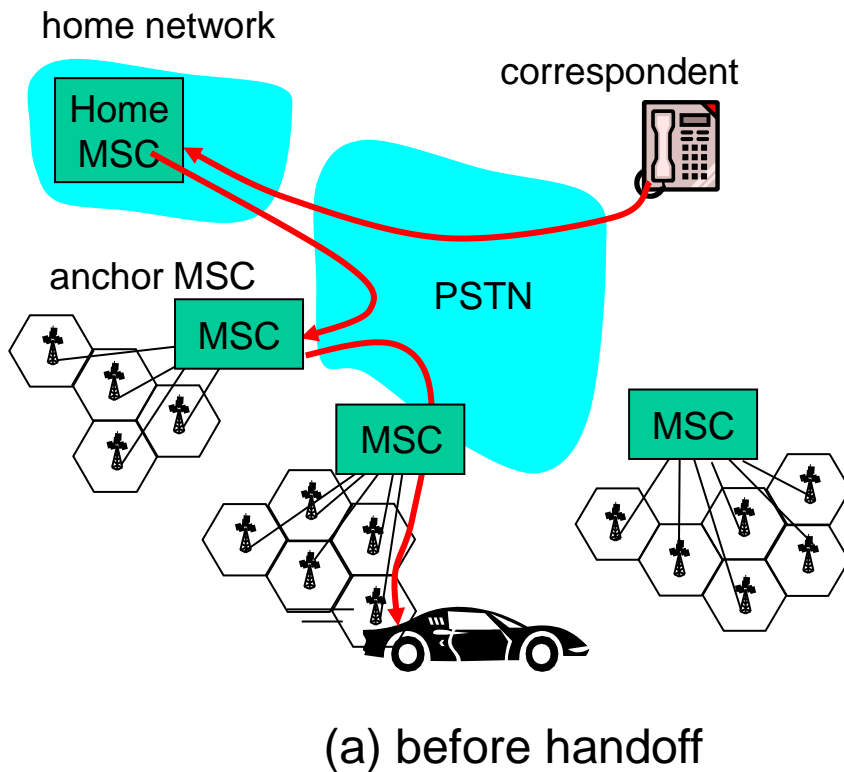
home network

correspondent

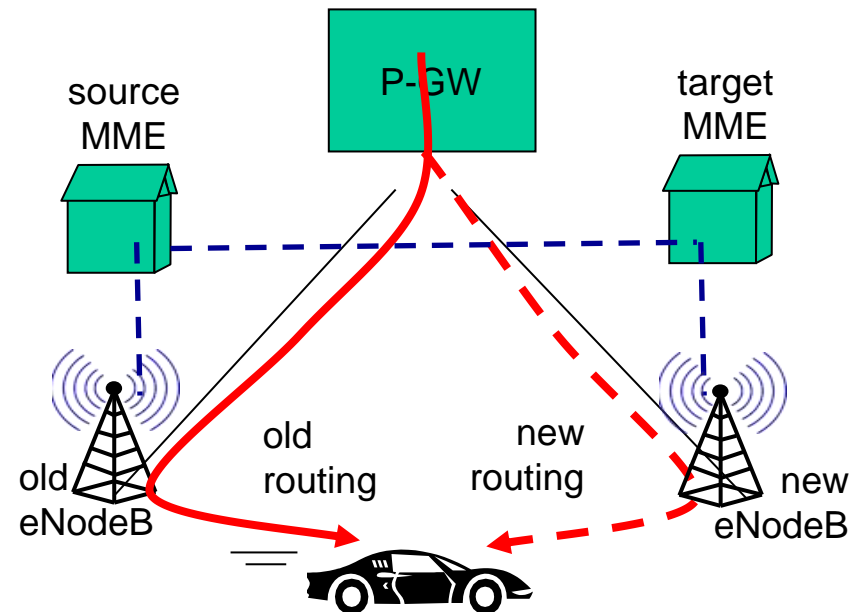Home MSC

anchor MSC

PSTN

MSC

MSC

MSC

(a) before 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

GSM: handoff between MSCs

home network

Home MSC

correspondent

anchor MSC

MSC

PSTN

MSC

MSC

(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
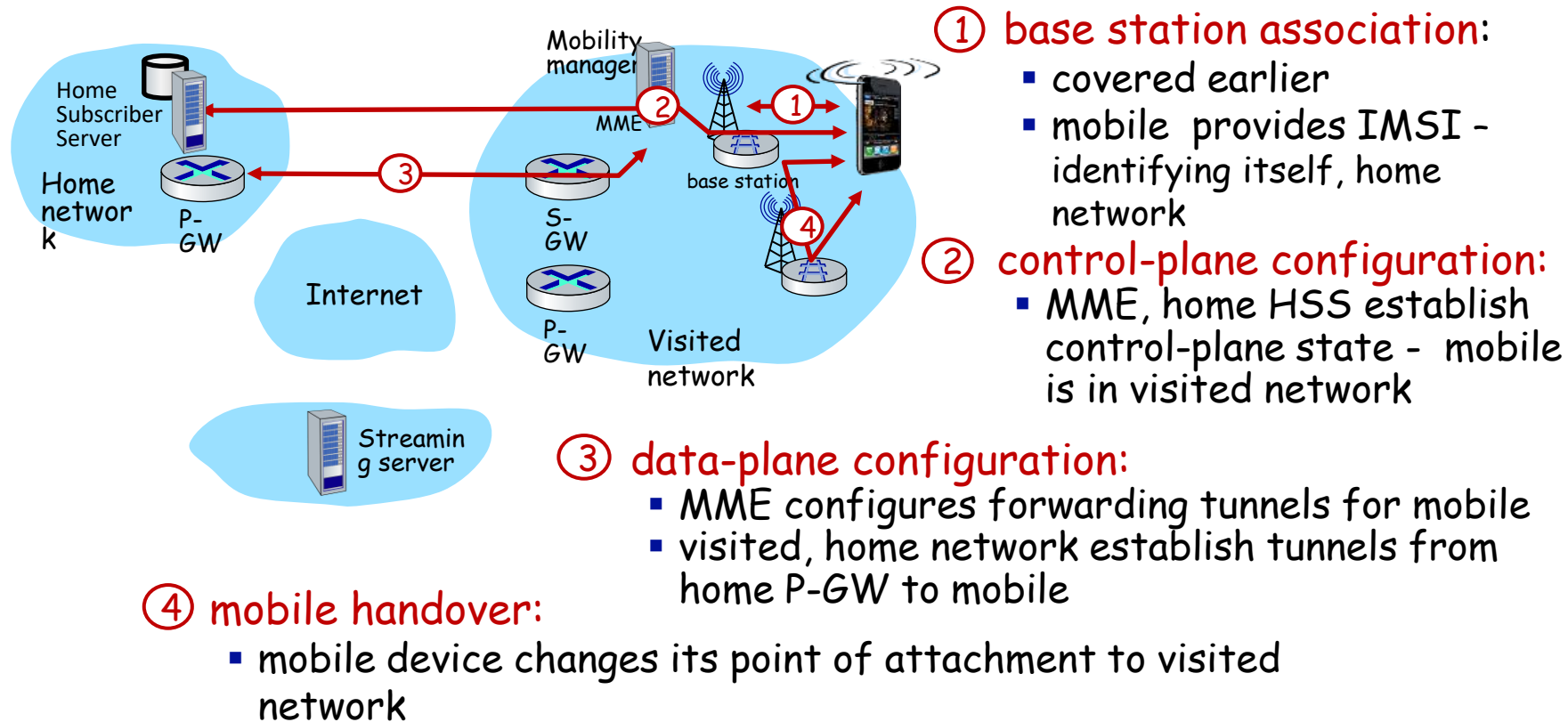
Handling Mobility in LTE
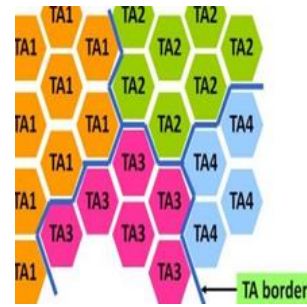
□ Paging: idle UE may move from cell to cell: network does not know where the idle UE is resident

○ paging message from MME broadcast by all eNodeB to locate UE

■ handoff: similar to 3G:
- preparation phase
- execution phase
- completion phase

❖ But hard handover

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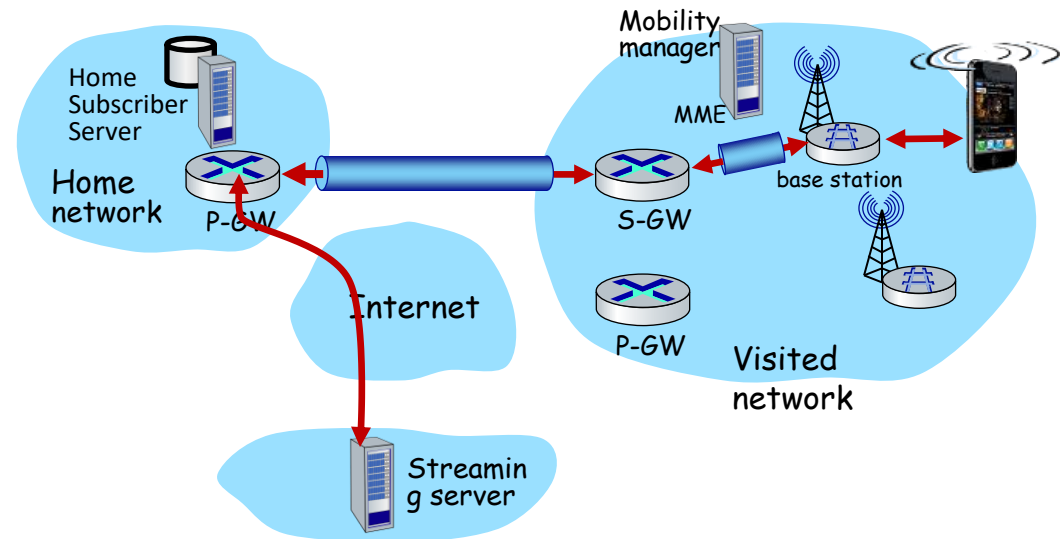
▪ **tunneling via GTP** (GPRS tunneling protocol): mobile's datagram to streaming server encapsulated using GTP inside UDP, inside datagram

Handover between BSs in same cellular network

data path *before* handover

source BS

S-GW

P-GW

data path *after* handover

MME
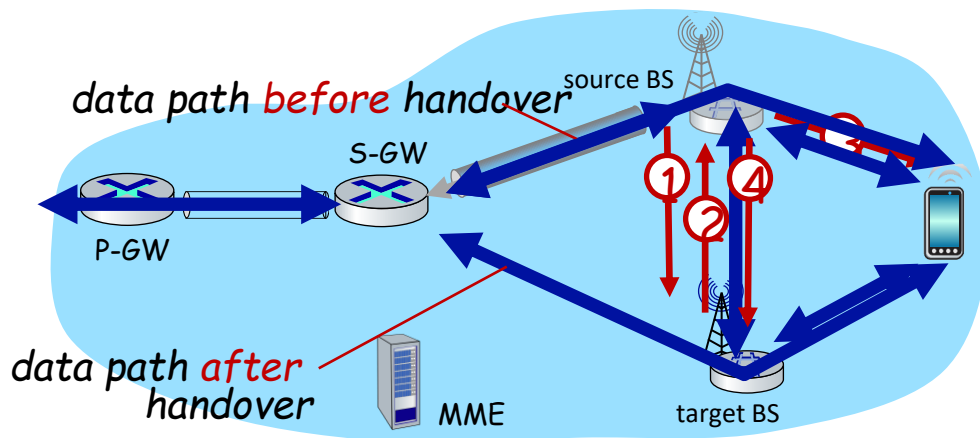
target BS

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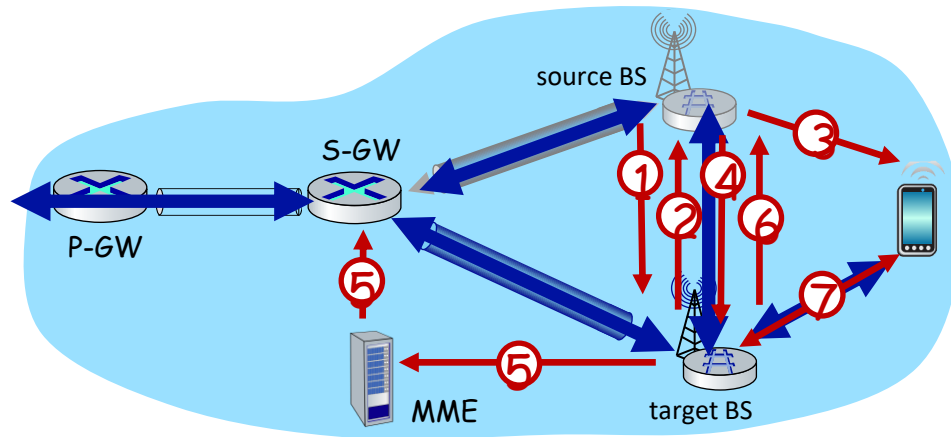
⑤ target BS informs MME that it is new BS for mobile
- MME instructs S-GW to change tunnel endpoint to be (new) target BS

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

LTE Handover