

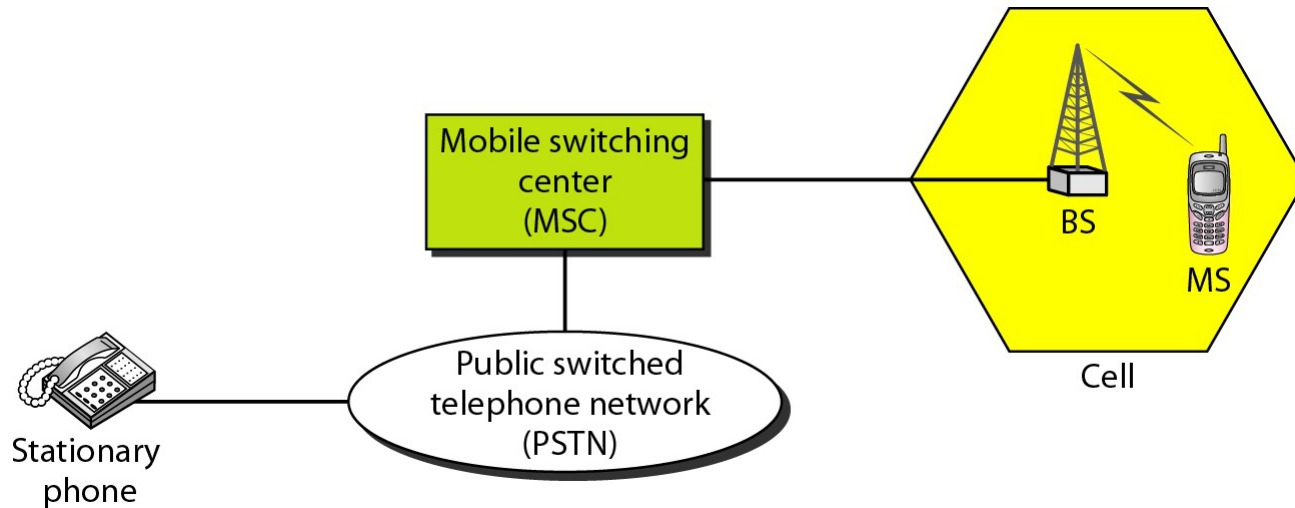
Mobilnät och satellitnät

Multipel access och kanalisering

- Kanalisering: en gemensam kanal delas på något av följande sätt
 - FDMA (Frequency Division Multiple Access)
Indelning i frekvenser
 - TDMA (Time Division Multiple Access)
Indelning i tiden
 - CDMA (Code Division Multiple Access)
Indelning genom kodning

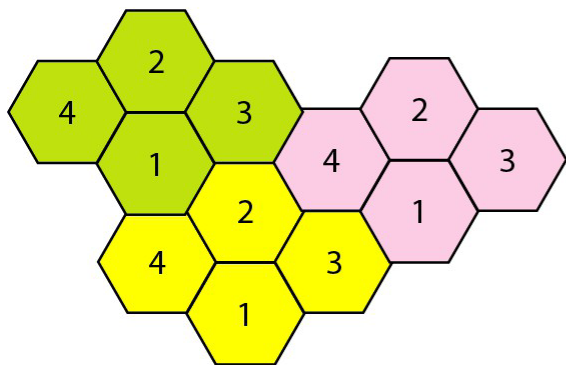
Mobilnät

- Kommunikation mellan rörliga enheter eller mellan rörliga och fasta enheter
 - Baseras på indelning i celler

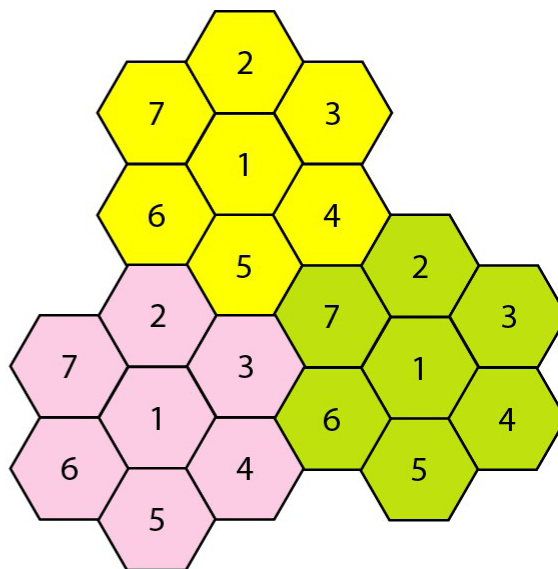


Mobilnät

- Återanvändning av frekvenser



a. Reuse factor of 4



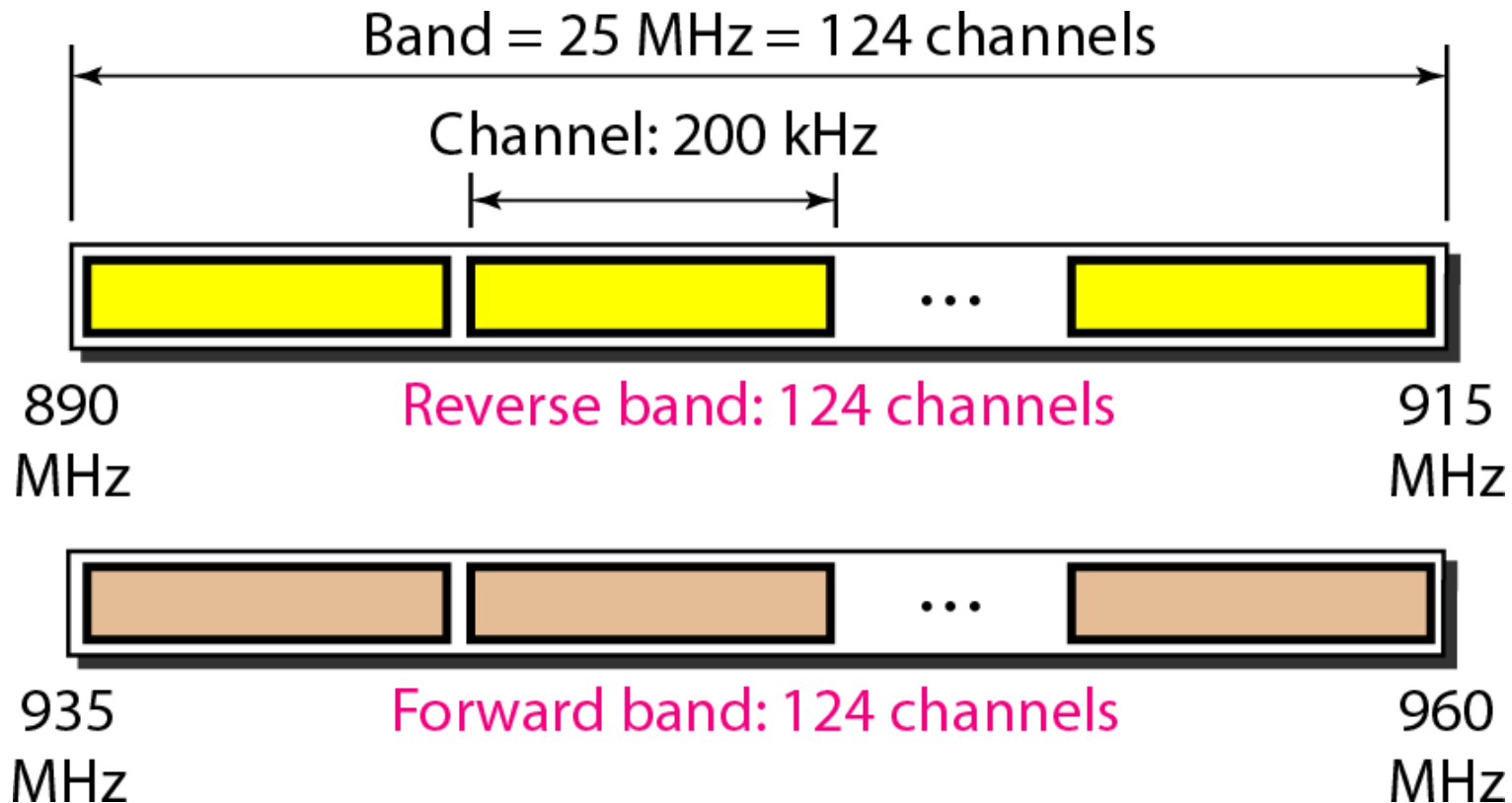
b. Reuse factor of 7

Mobilnät

- 1:a generationens mobilnät (G1)
 - AMPS (Nordamerika)
 - NMT (Europa)
- 2:a generationens mobilnät (G2)
 - D-AMPS (Nordamerika)
 - GSM (Europa)
- 3:e generationens mobilnät (G3)
 - IMT-2000 (UMTS)
- 4:e generationens mobilnät (G4)
- 5:e generationens mobilnät (G5)

Mobilnät

- GSM (Global System for Mobile communication)
 - Använder två 25 MHz band för duplexkommunikation



3G

- Mycket snabbare, upp till 384 kbps
- Högre frekvenser, vilket ger kortare räckvidd
- Finns flera standarder:
 - UMTS
 - CDMA2000
 - WCDMA
 - TD-SCDMA

UMTS

- Universal Mobile Telecommunication System
- Utveckling av GSM
- Delvis paketbaserad, alltid uppkopplad

4G

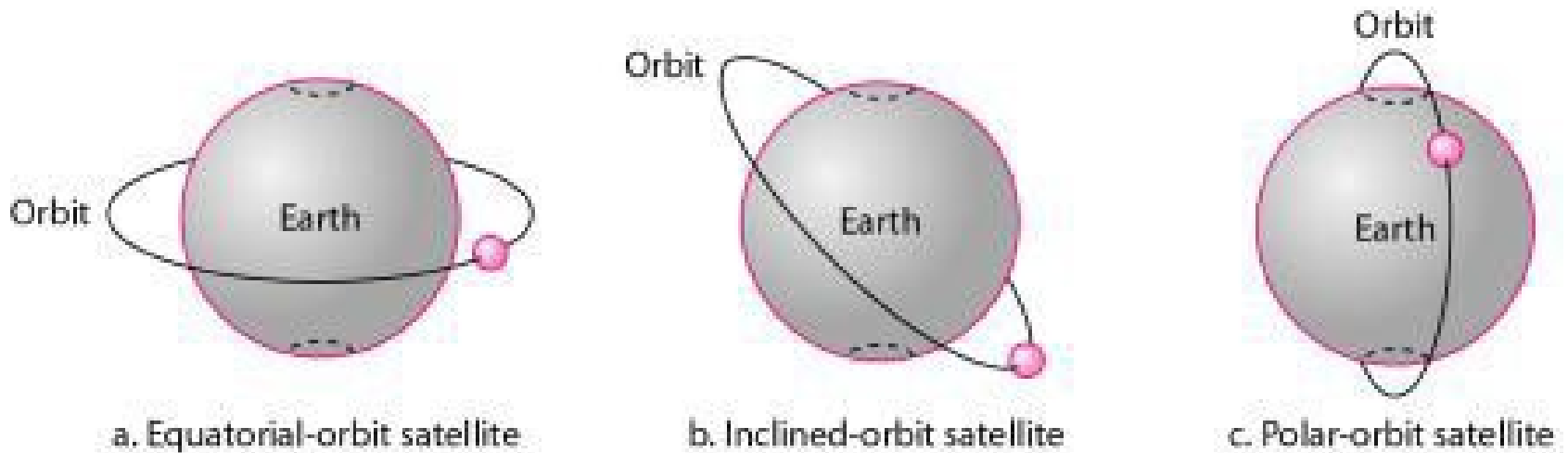
- Hastigheter på 100 Mbit/s
- Helt paketbaserad
- LTE (Long Term Evolution) är ett steg mot 4G
- Första LTE-näten startades i Oslo och Stockholm december 2009

5G

- Hastigheter på 150-250 Mbit/s
- Kortare fördröjningar
- IoT, självkörande bilar
- Inte täckning i hela landet,
antennerna har inte så lång räckvidd
- Kom marknadsmissigt 2020 i Sverige

Satellitnät

- Olika orienteringar hos satellitbanor



Satellitnät

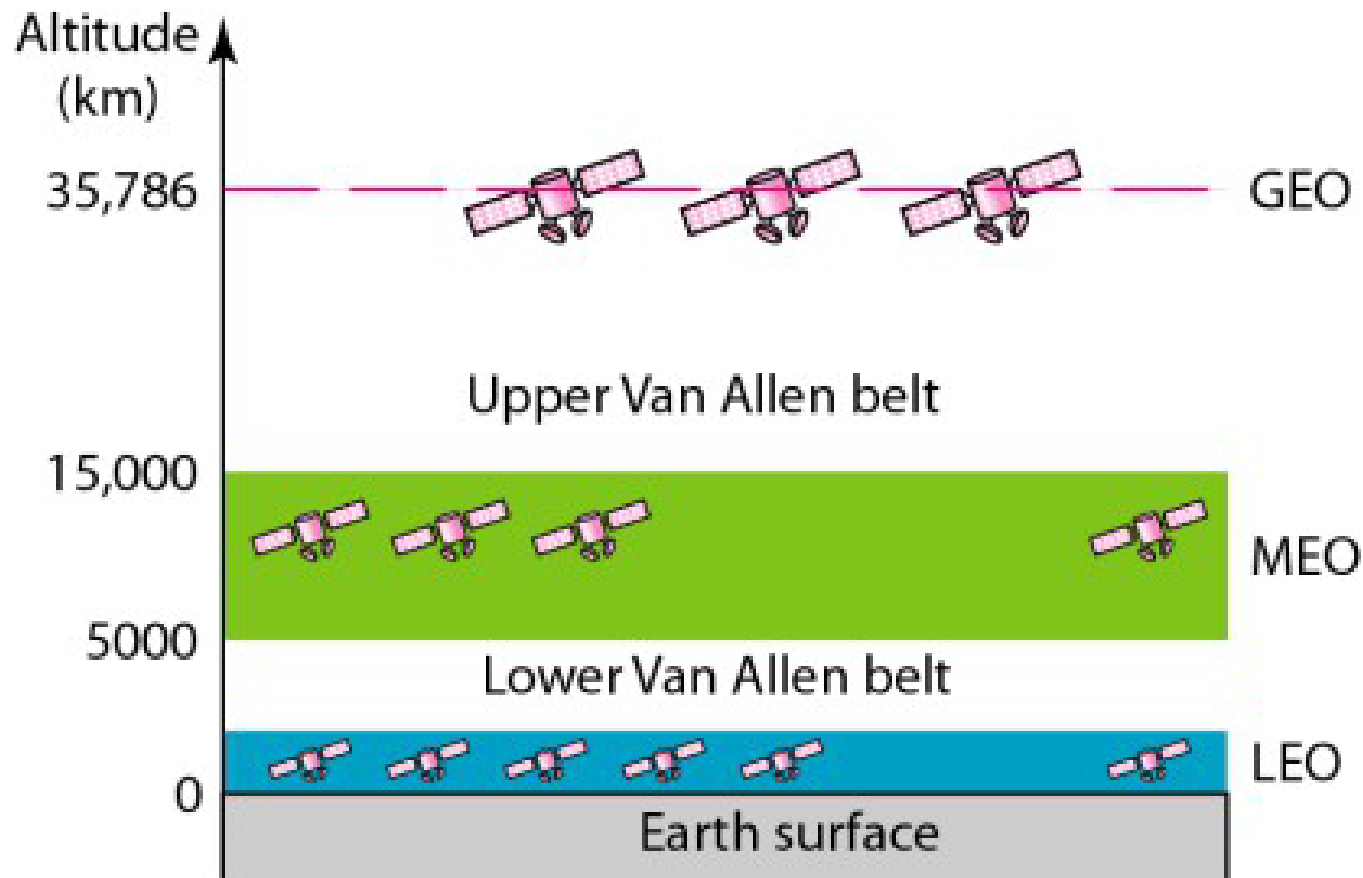
- Keplers 3:e lag gäller även för satelliter i bana runt jorden $T = k * r^{1.5}$
(T = omloppstid, k = "konstant" (g , M , m)
 r = medelavstånd på cirkulerande enhet)
 - *Månens periodtid runt jorden blir 28 dagar dvs ca 1 månad.*
 - *Satellit på höjden 35786 km får en periodtid på 24 timmar dvs ett dygn. Detta betyder att satelliten "följer med" jordens rotation.*

Satellitnät

- De tre huvudkategorierna av satelliter:
 - GEO (Geosynchronous Earth Orbit)
Höjd: 35786 km (Geostationär)
 - MEO (Medium Earth Orbit)
Höjd: 5000 – 20000 km till exempel GPS (Global Positioning System) på 18000 km höjd
 - LEO (Low Earth Orbit)
Höjd: 500 – 2000 km

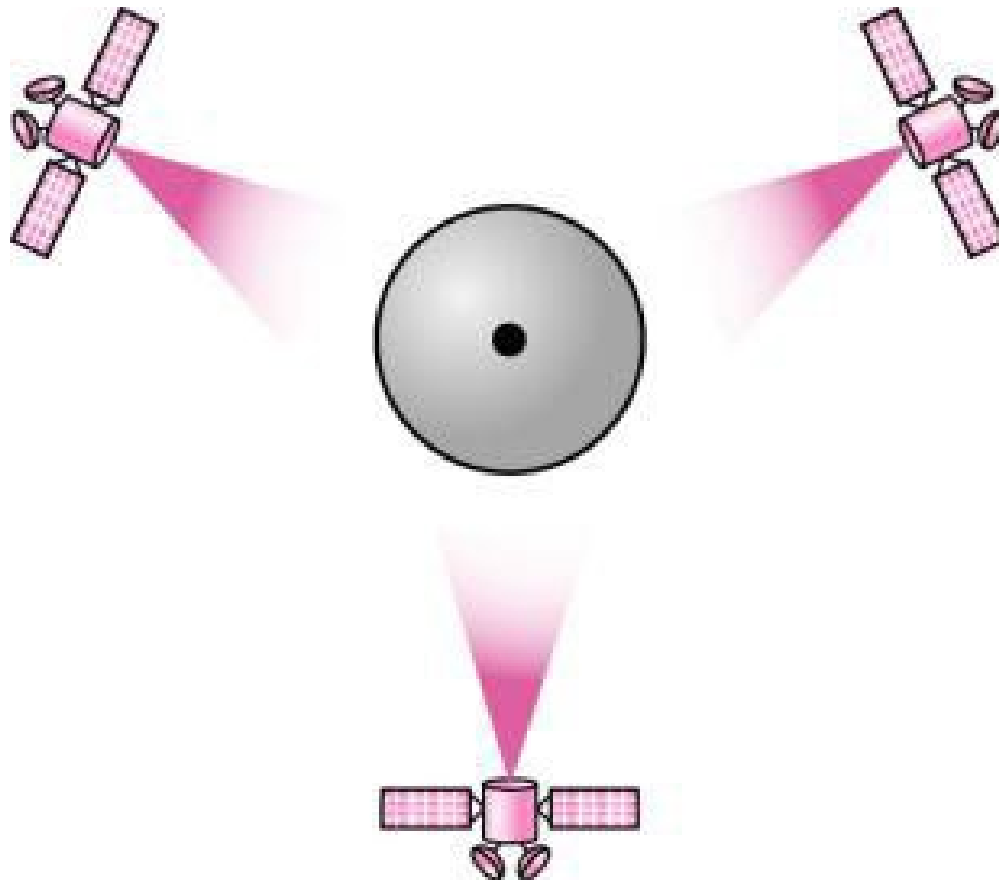
Satellitnät

- Uppdelningen i de tre typerna beror på van Allen-bältena som omger jorden



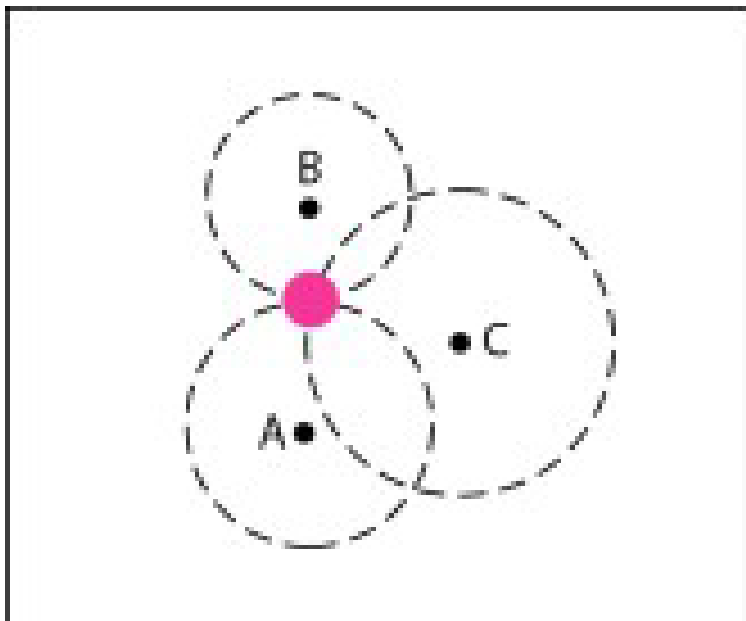
Satellitnät

- Minst tre geostationära satelliter krävs för att täcka hela jorden

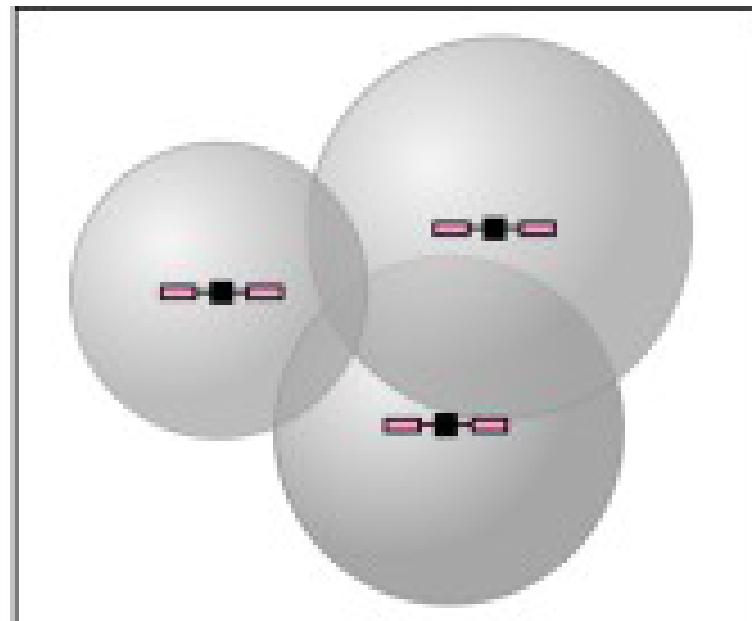


Satellitnät

- För GPS-satelliter räcker det att känna till avståndet till fyra satelliter för att bestämma en position (tre satelliter om man inte behöver höjden)



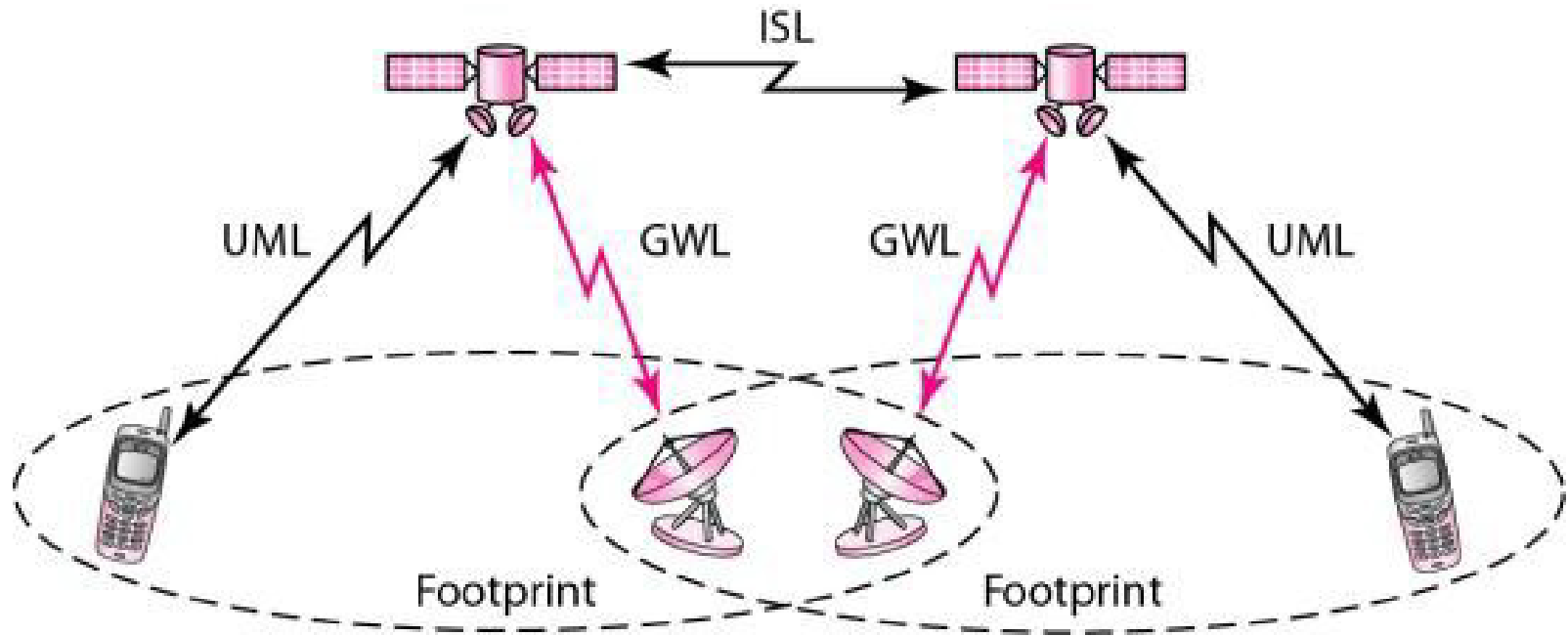
a. Two-dimensional trilateration



b. Three-dimensional trilateration

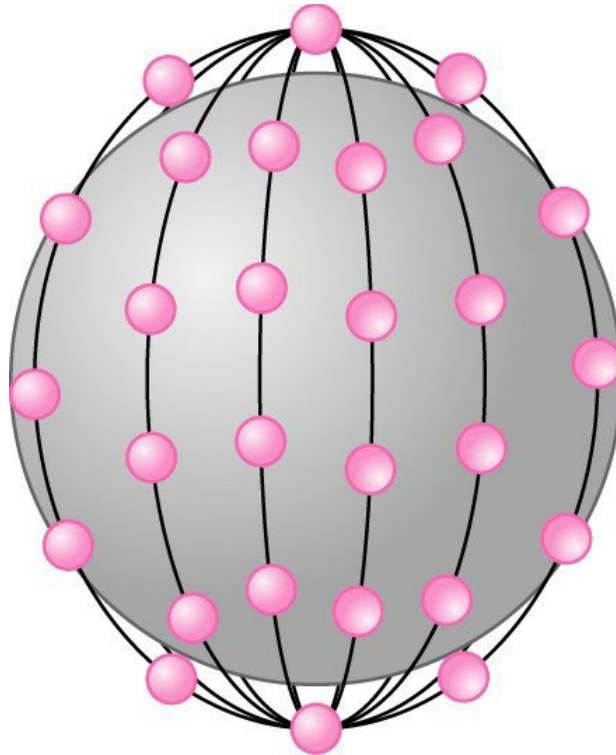
Satellitnät

- LEO-satelliter används p.g.a. låg fördröjning till kommunikation



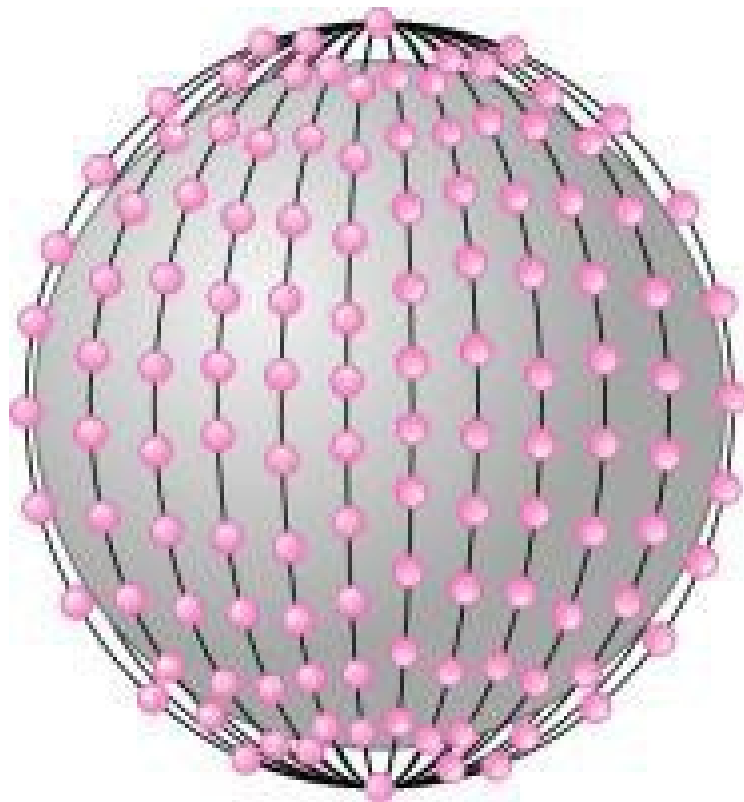
Satellitnät

- LEO-systemet Iridium startades 1990 med 77 satelliter men reducerades 1998 till 66 satelliter i 6 banor på 750 km höjd. Det används till satellittelefoni.



Satellitnät

- Teledesic-systemet består av 288 satelliter i 12 banor på 1350 km höjd. Det är avsett för bredbandsinternet.



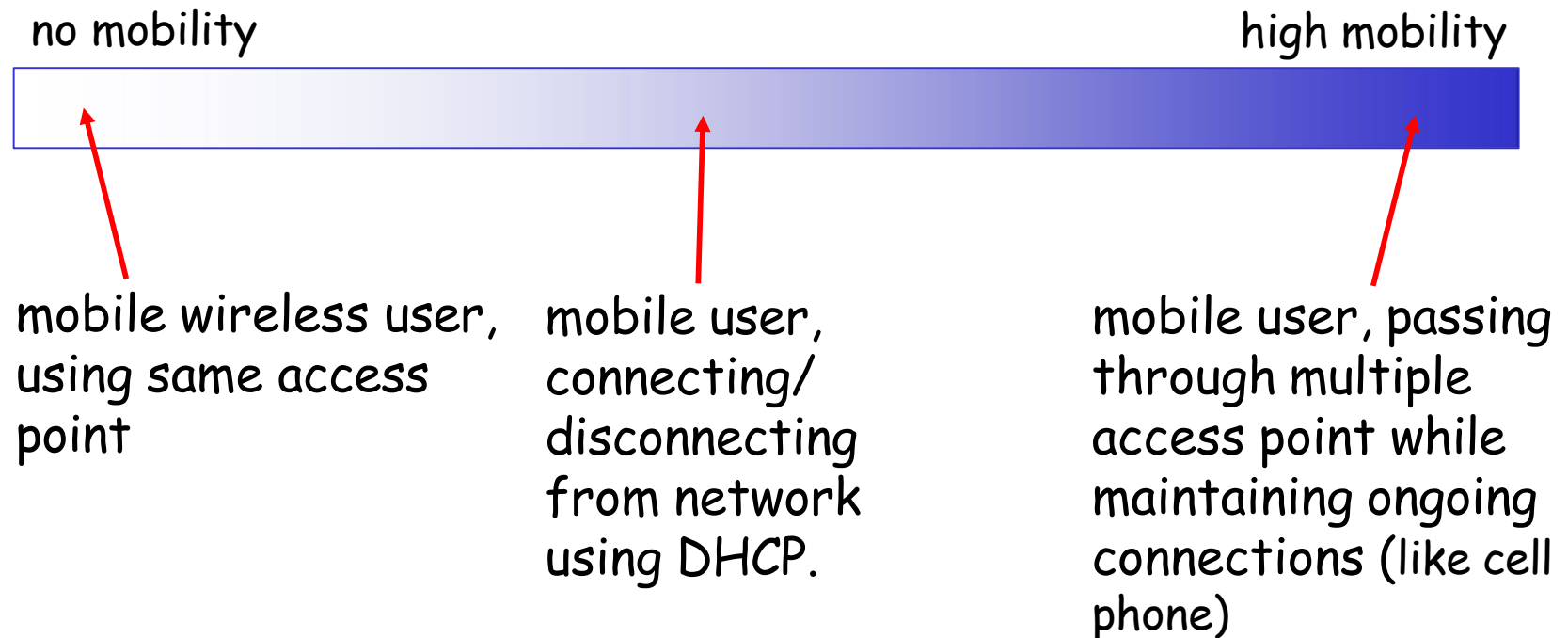
Satellitnät

- "Starlink (Space-X)-systemet består av just nu av ca 3000 satelliter på 550 km höjd (Hubbleteleskop 540 km). Det är avsett för bredbandsinternet för hela jorden och konkurrera med mobiltäckning.



What is mobility?

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

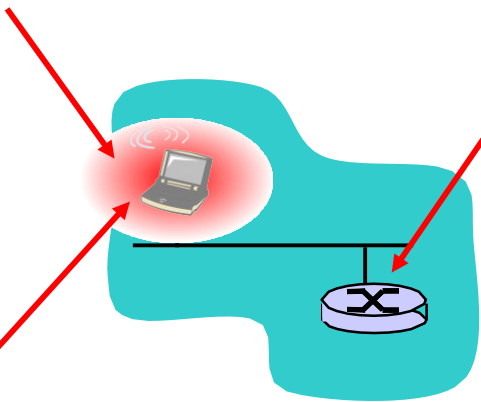


Mobility: Vocabulary

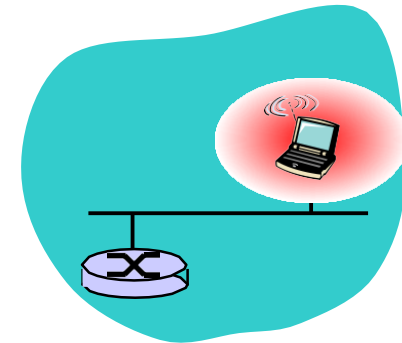
home network: permanent
"home" of mobile
(e.g., 128.119.40/24)

home agent: 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)

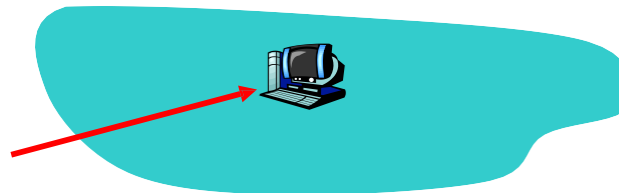
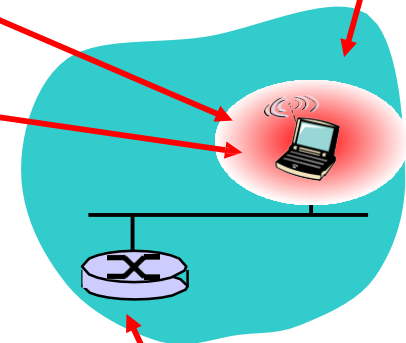
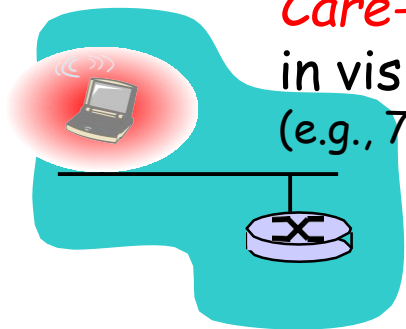
visited network: network in which mobile currently resides (e.g., 79.129.13/24)

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

wide area network

correspondent: wants to communicate with mobile

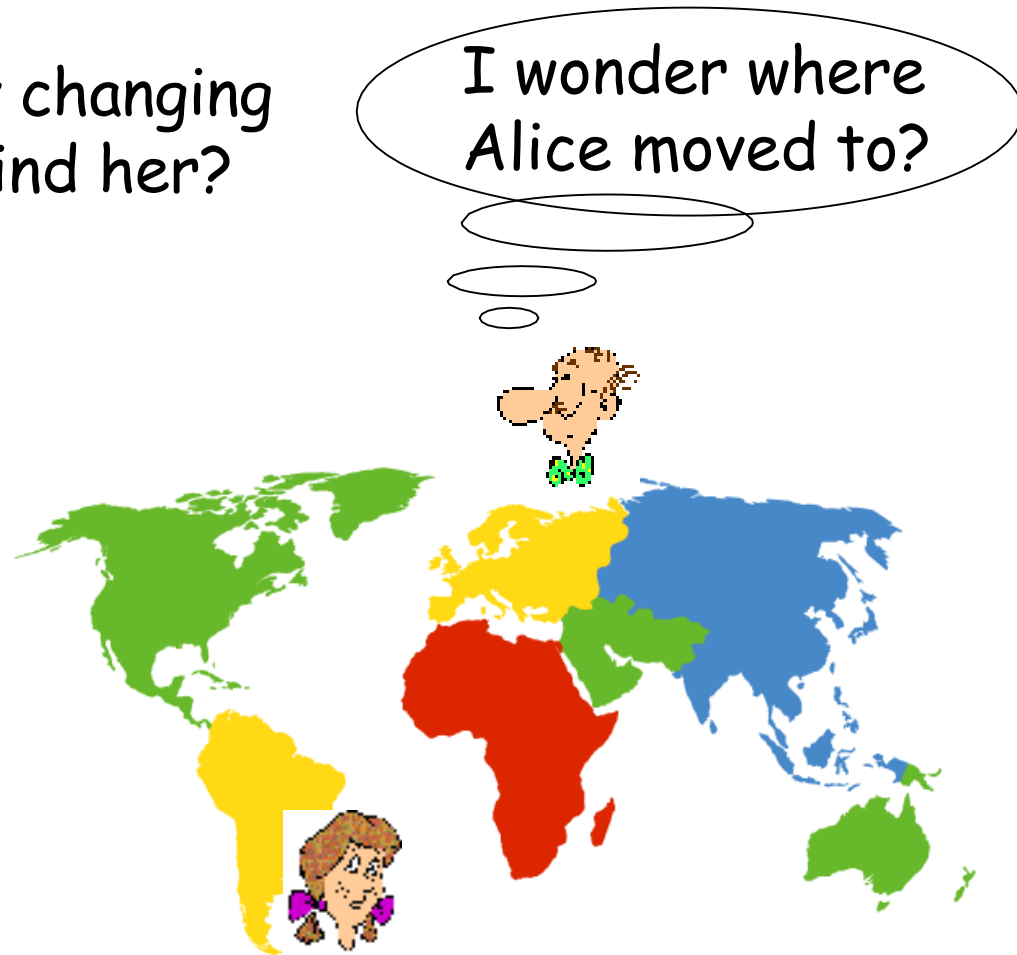
foreign agent: entity in visited network that performs mobility functions on behalf of mobile.



How do you contact a mobile friend?

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

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



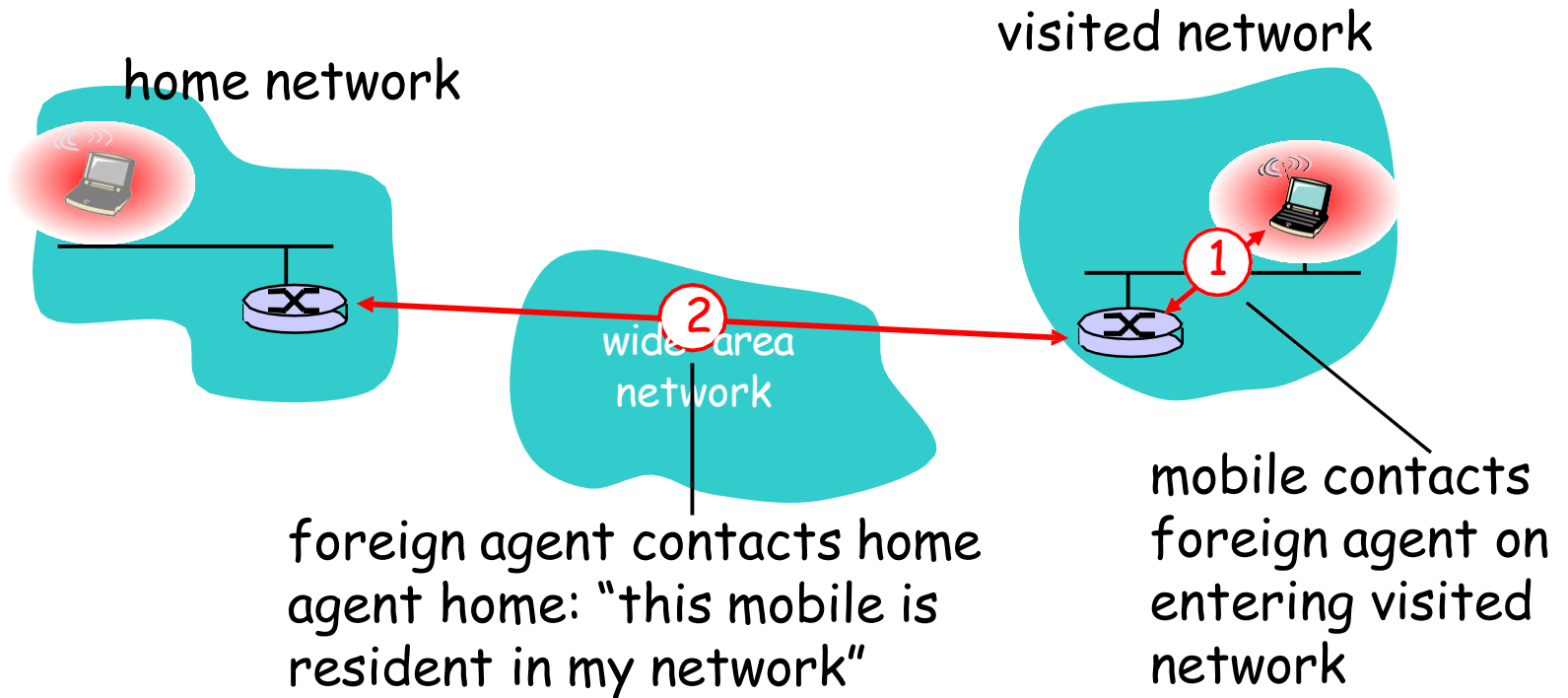
Mobility: approaches

- ❖ *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:* routers advertise permanent address of mobile-nots-in-residence via usual routing table exchange
 - routing tables indicate where each mobile located
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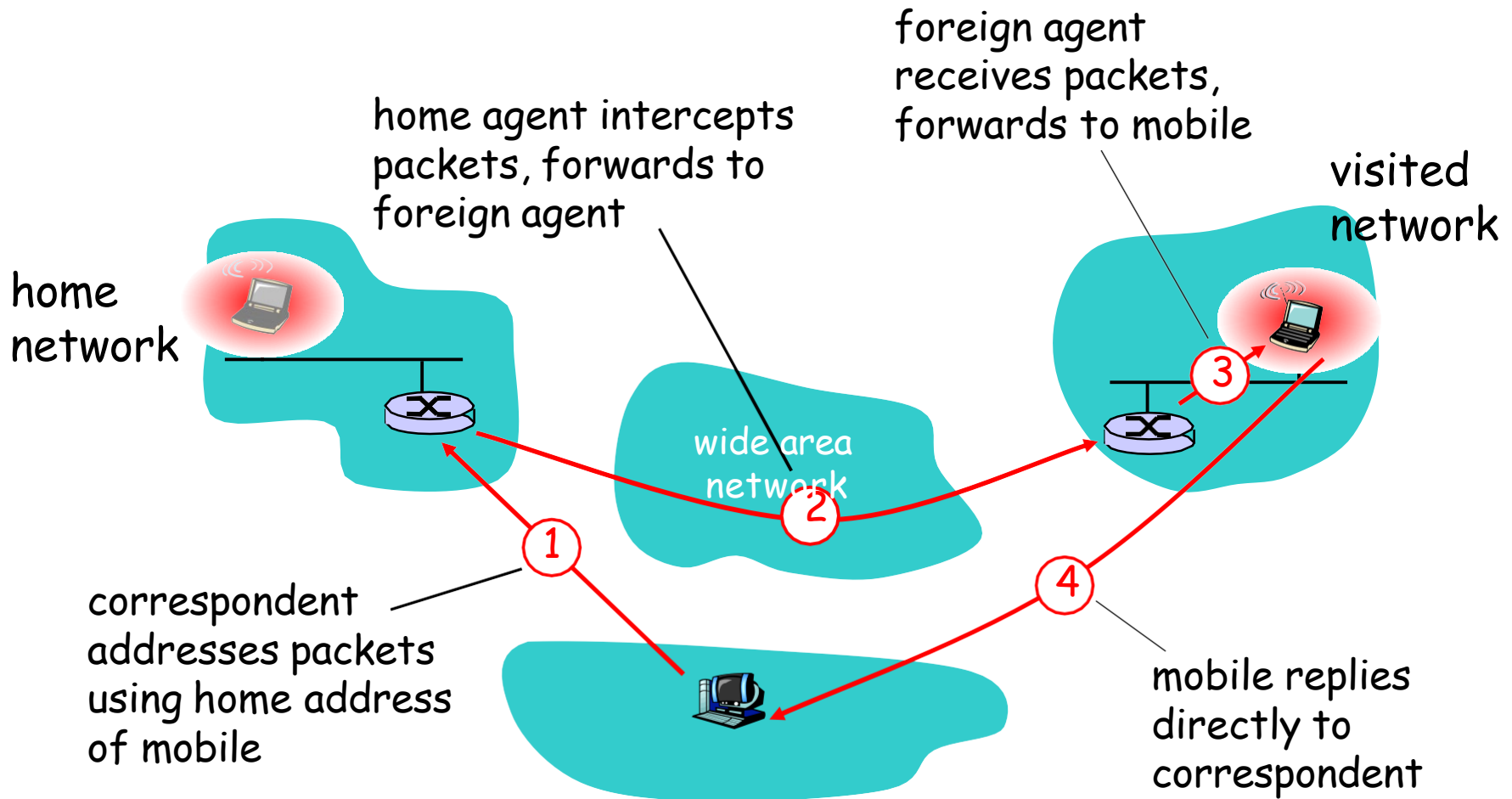
Mobility: registration



End result:

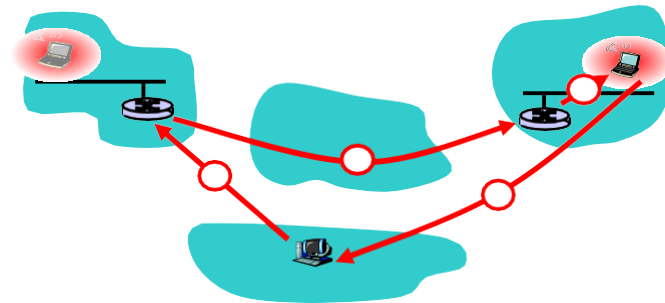
- ❖ Foreign agent knows about mobile
- ❖ Home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing: comments

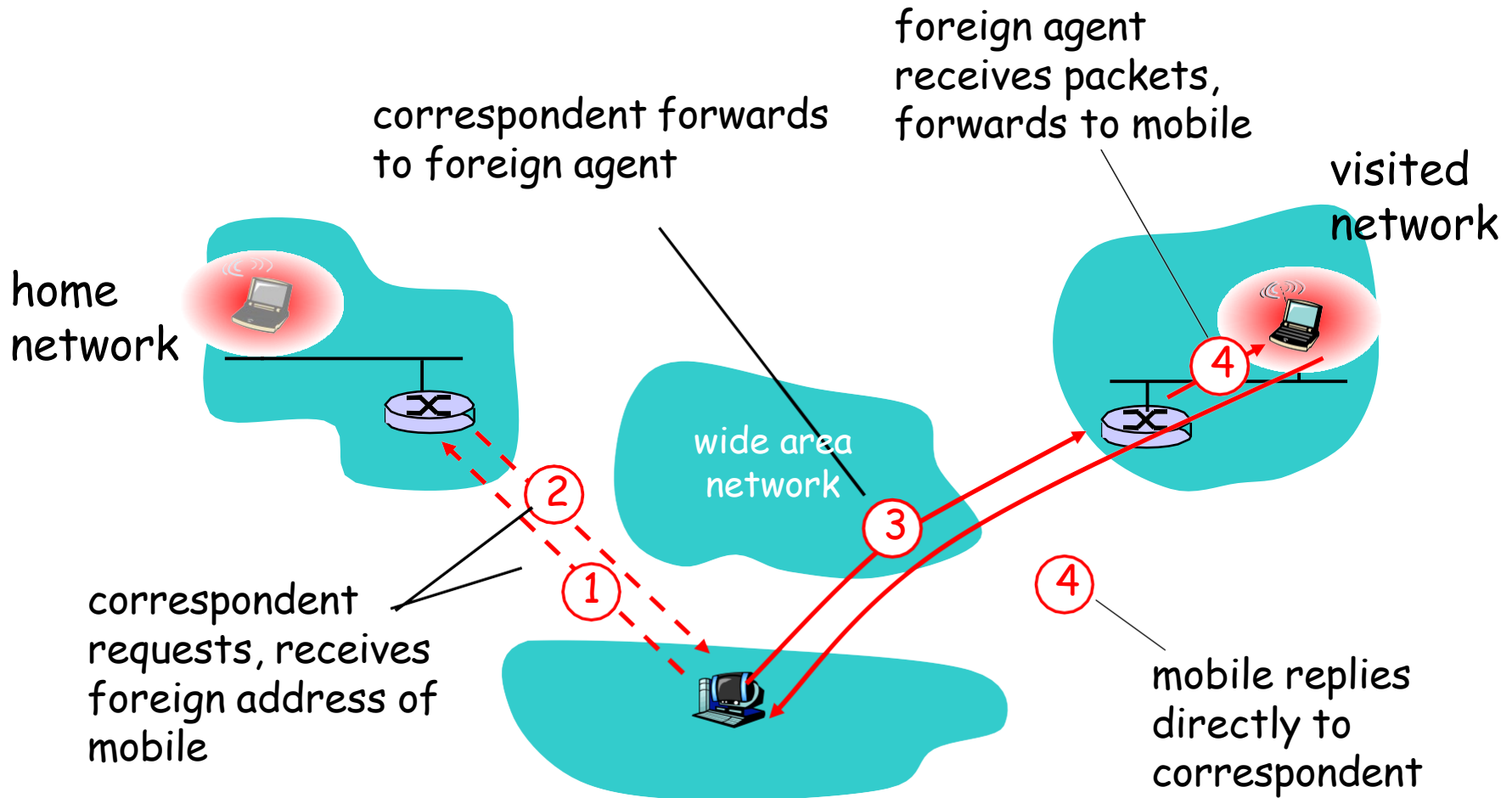
- ❖ Mobile uses two addresses:
 - **permanent address**: used by correspondent (hence mobile location is **transparent** to correspondent)
 - **care-of-address**: used by home agent to forward datagrams to mobile
- ❖ foreign agent functions may be done by mobile itself
- ❖ **triangle routing**: correspondent-home-network-mobile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



Indirect Routing: moving between networks

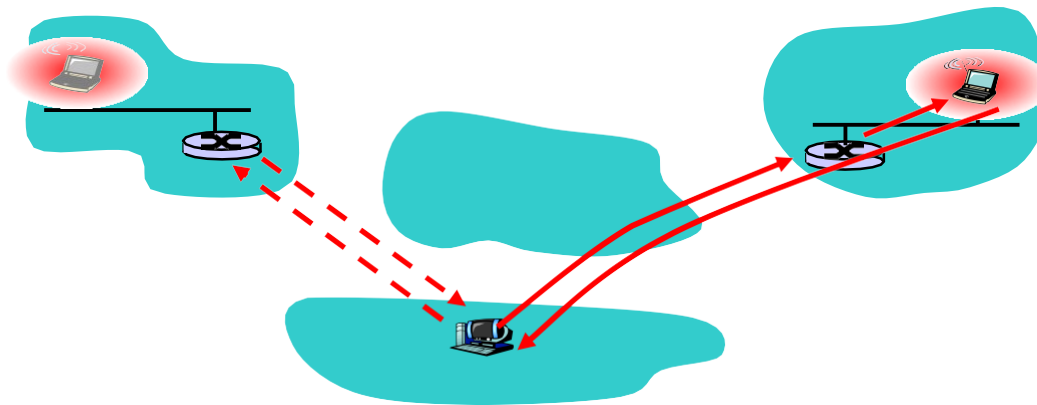
- ❖ suppose mobile user moves to another network
 - registers with new foreign agent
 - new foreign agent registers with home agent
 - home agent update care-of-address for mobile
 - packets continue to be forwarded to mobile (but with new care-of-address)
- ❖ mobility, changing foreign networks
transparent: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

Mobility via Direct Routing



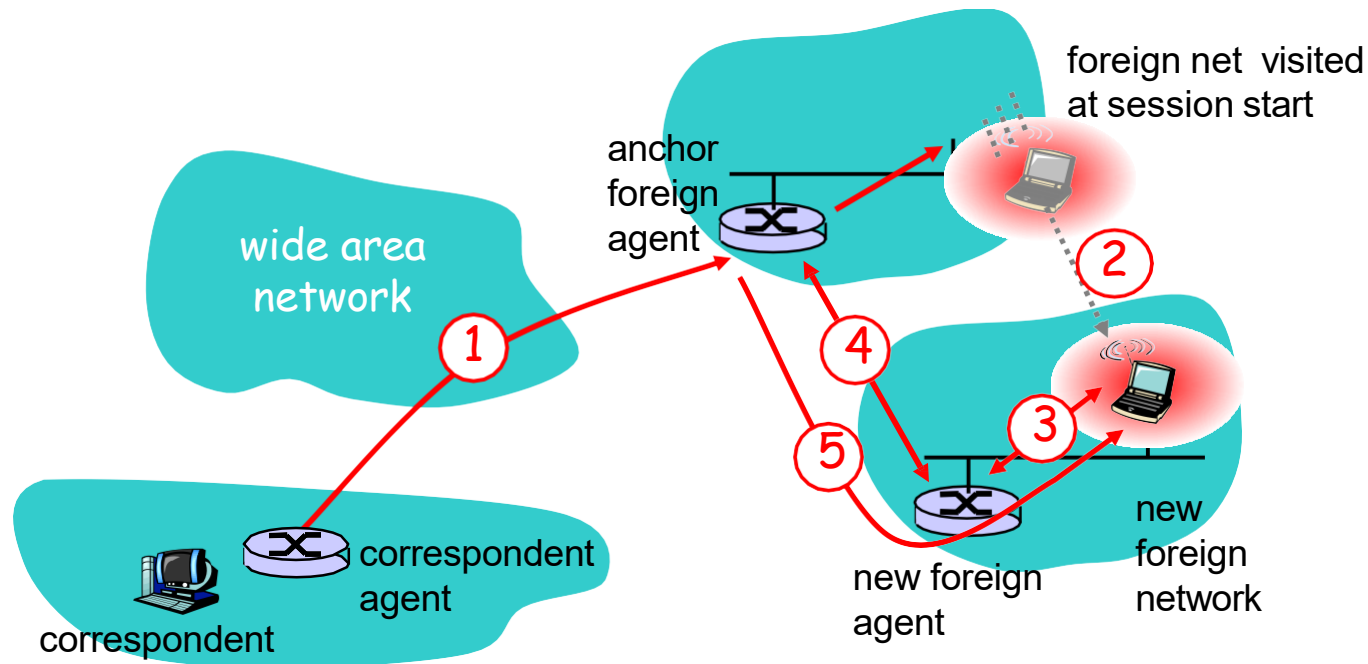
Mobility via Direct Routing: comments

- ❖ 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)

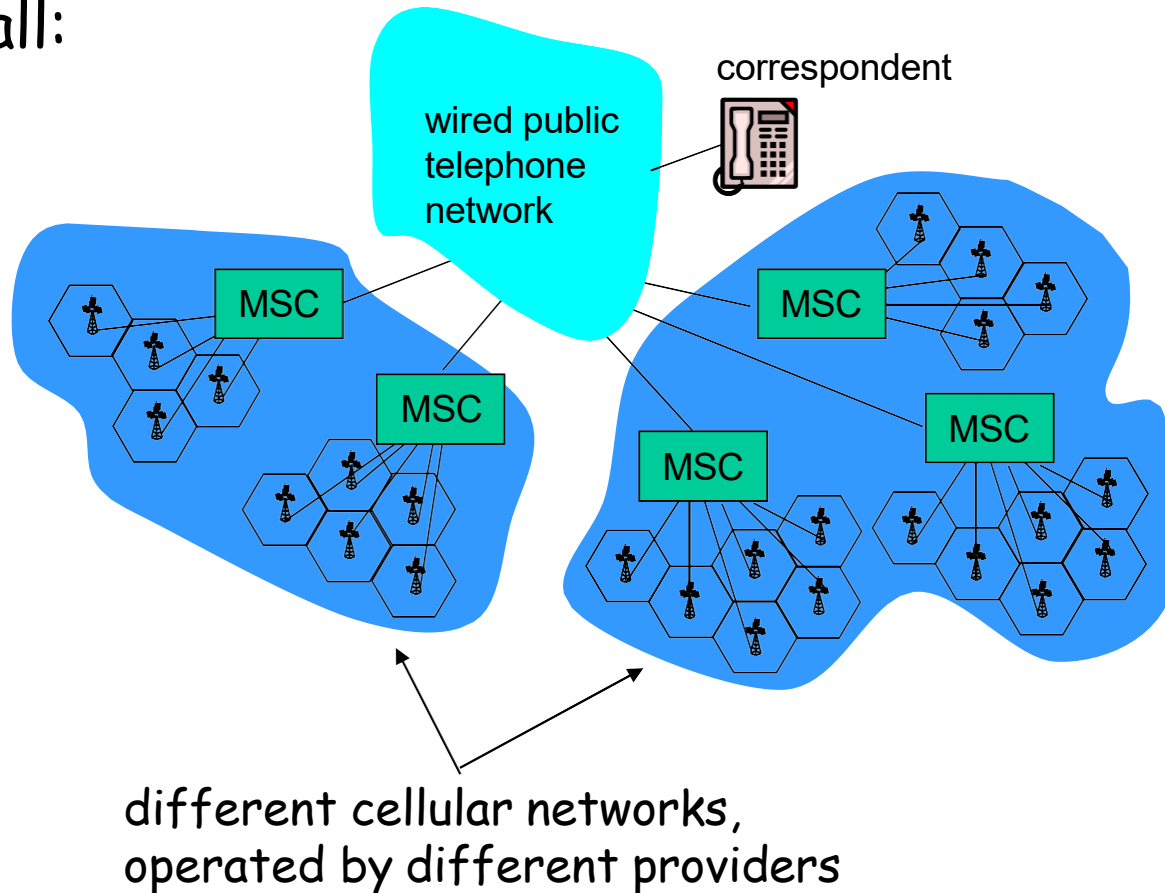


Mobile IP

- ❖ 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

Components of cellular network architecture

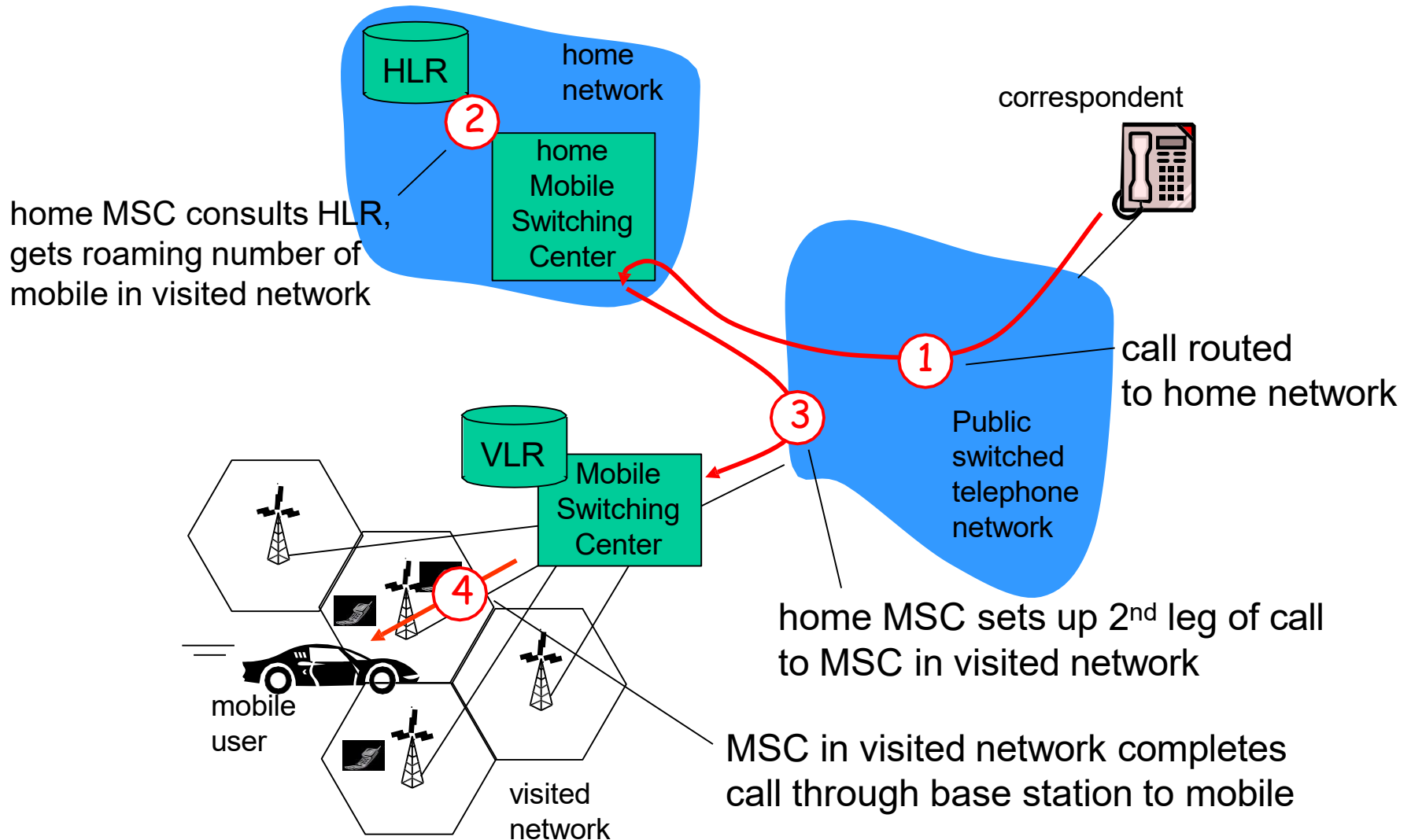
recall:



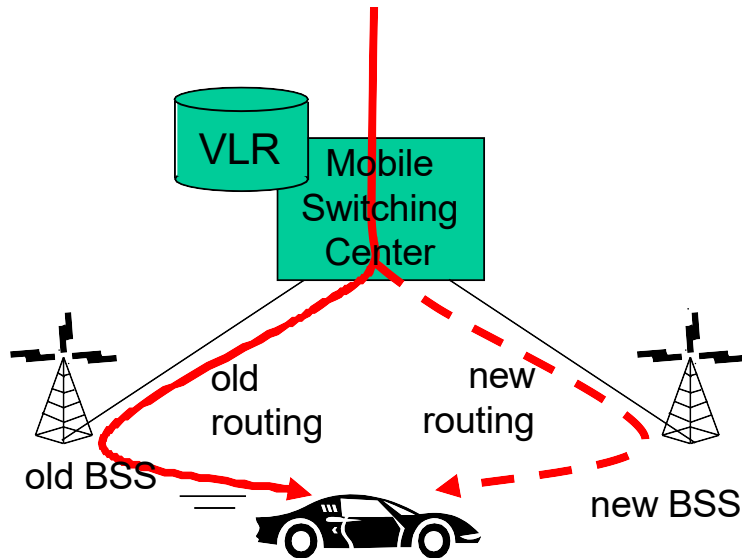
Handling mobility in cellular networks

- ❖ *home network*: network of cellular provider you subscribe to (e.g., Telia, Telenor,...)
 - *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

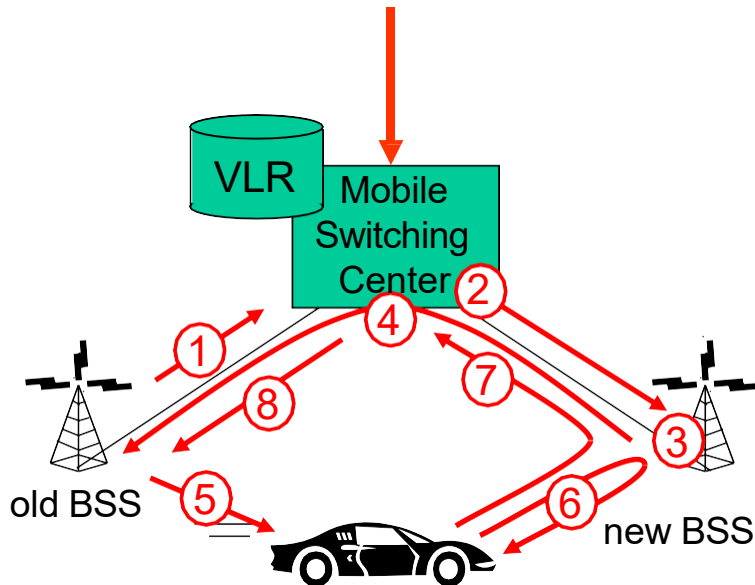


GSM: handoff with common MSC



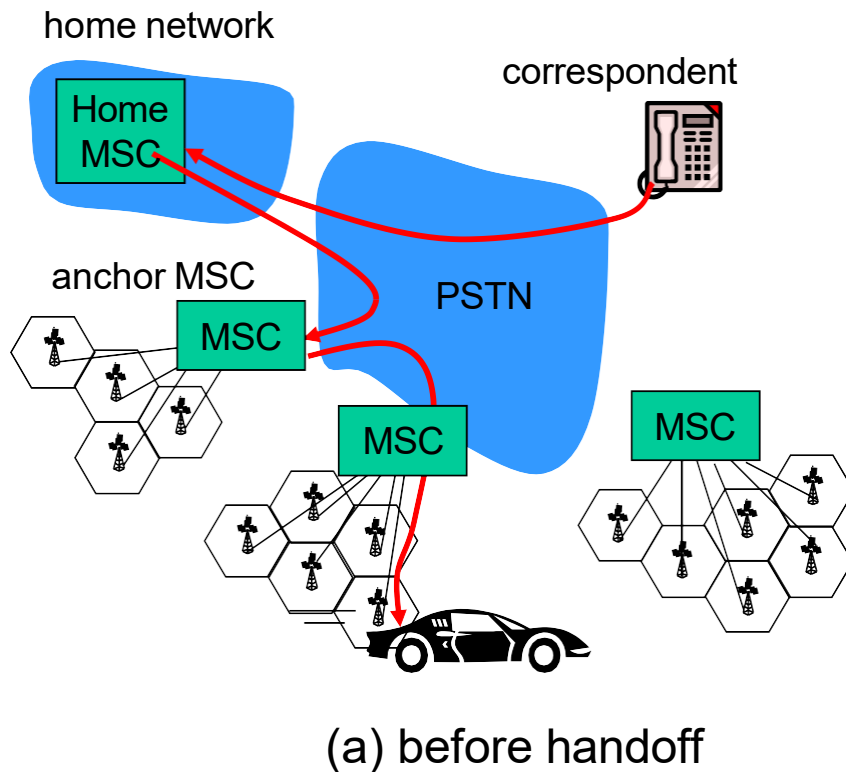
- ❖ Handoff goal: route call via new base station (without interruption)
- ❖ reasons for handoff:
 - stronger signal to/from new BSS (continuing connectivity, less battery drain)
 - load balance: free up channel in current BSS
 - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)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

GSM: handoff with common MSC



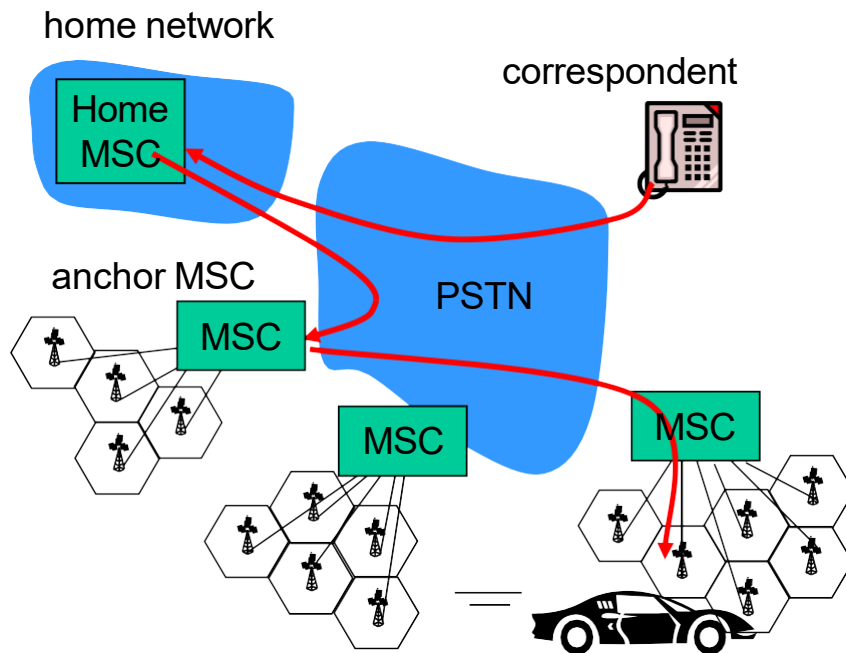
1. old BSS informs MSC of impending handoff, provides list of 1+ new BSSs
2. MSC sets up path (allocates resources) to new BSS
3. new BSS allocates radio channel for use by mobile
4. new BSS signals MSC, old BSS: ready
5. old BSS tells mobile: perform handoff to new BSS
6. mobile, new BSS signal to activate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



- ❖ *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

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

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