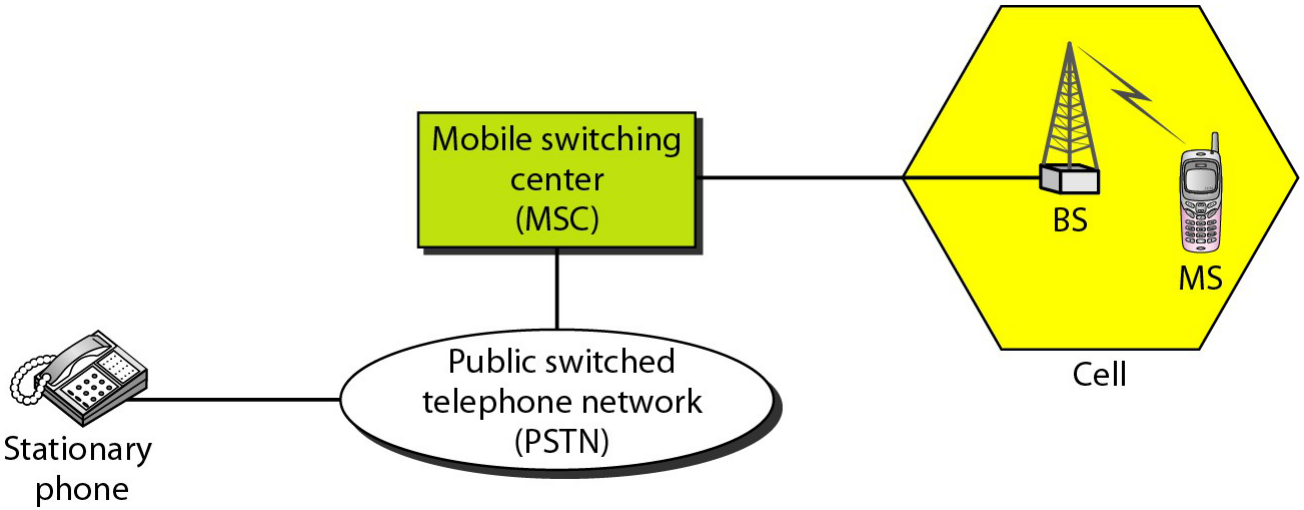
Mobilnät och satellitnät

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

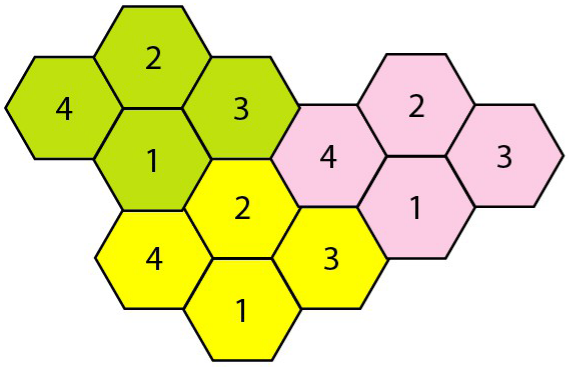
Mobilnät

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

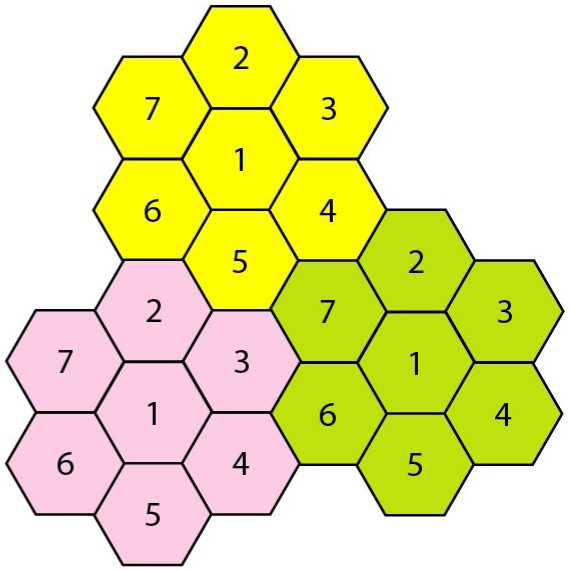


Mobilnät

- Återanvändning av frekvenser



a. Reuse factor of 4



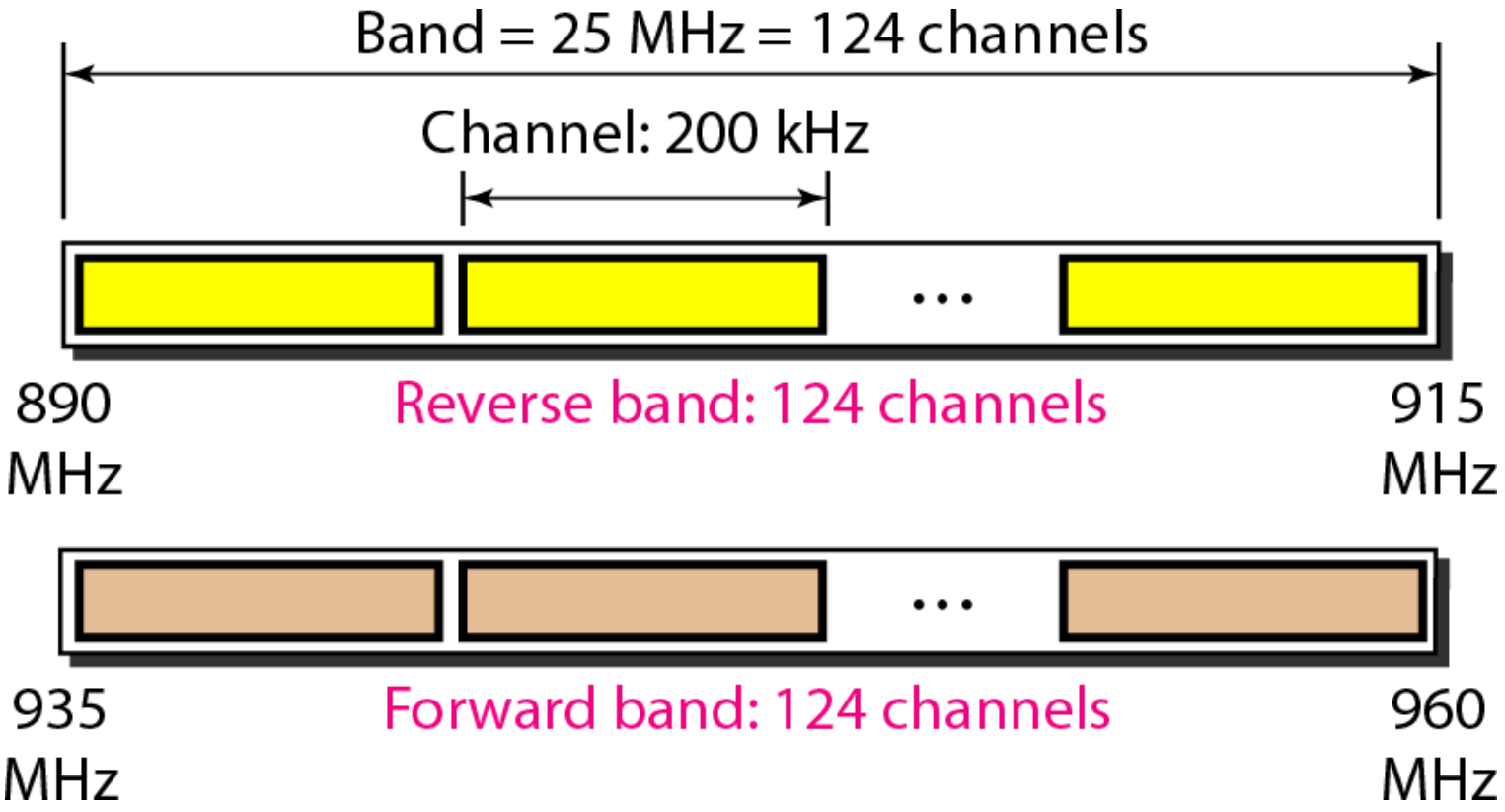
b. Reuse factor of 7

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

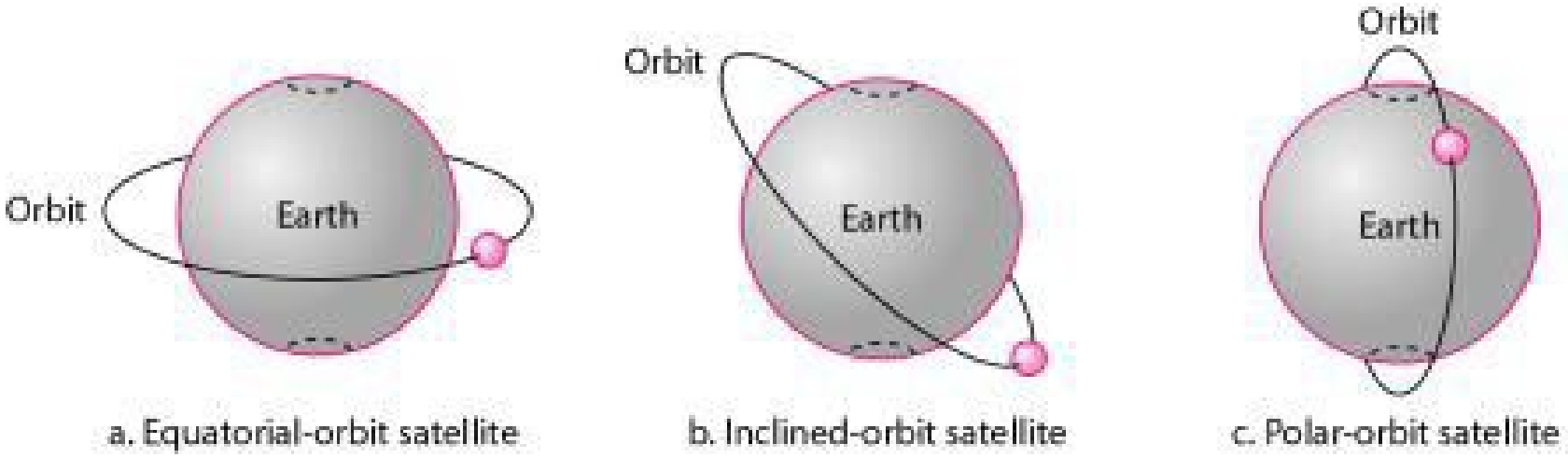
- Hastigheter på 100 Mbit/s
- Helt paketbaserad
- LTE (Long Term Evolution) är ett steg mot 4G
- Första LTE-näten startades i Oslo och Stockholm december 2009

5G

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

Satellitnät

- Olika orienteringar hos satellitbanor



a. Equatorial-orbit satellite

b. Inclined-orbit satellite

c. Polar-orbit satellite

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)

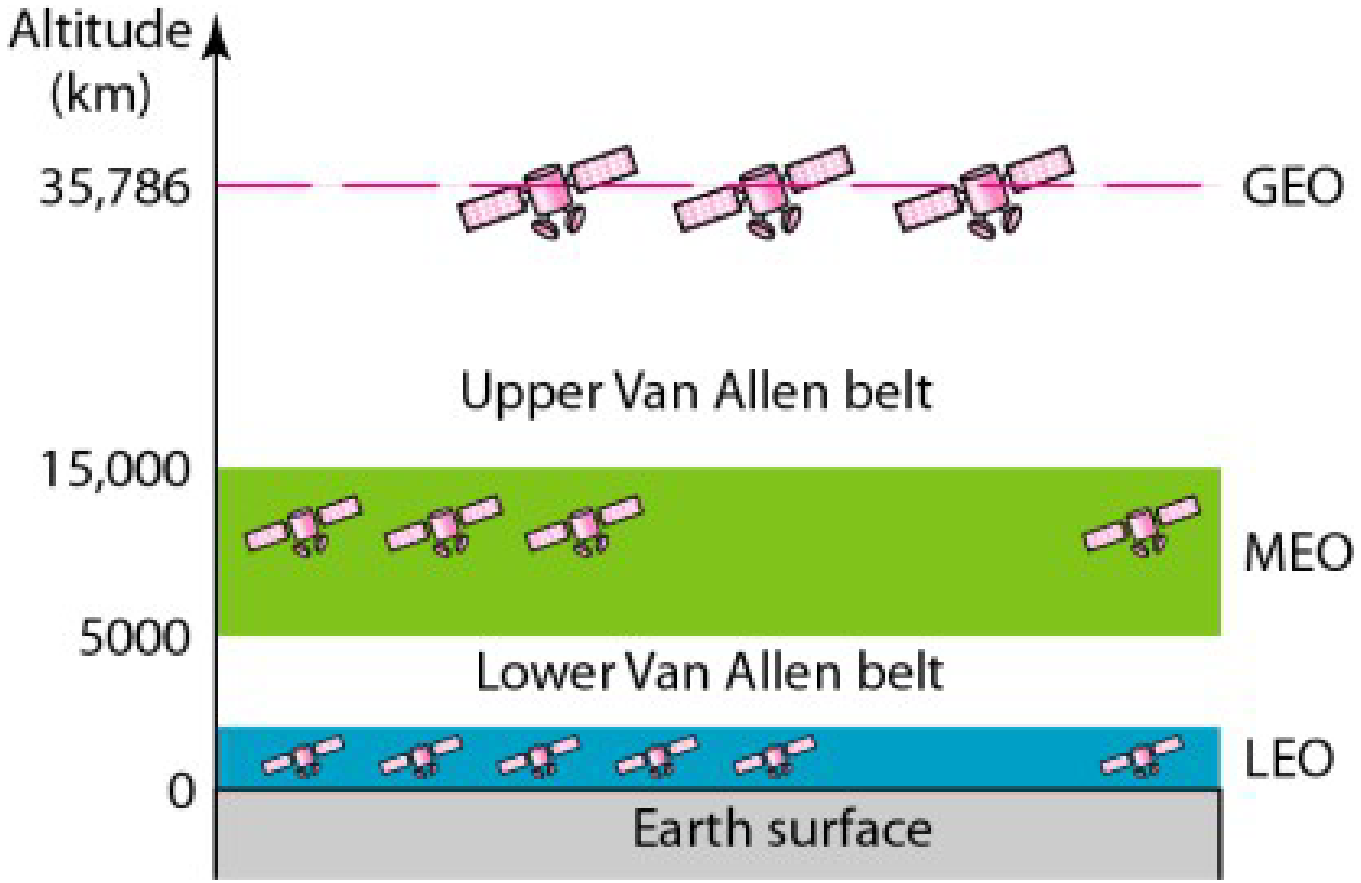
  - *Månens periodtid runt jorden blir 28 dagar dvs ca 1 månad.*
  - *Satellit på höjden 35786 km får en periodtid på 24 timmar dvs ett dygn. Detta betyder att satelliten “följer med” jordens rotation.*

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

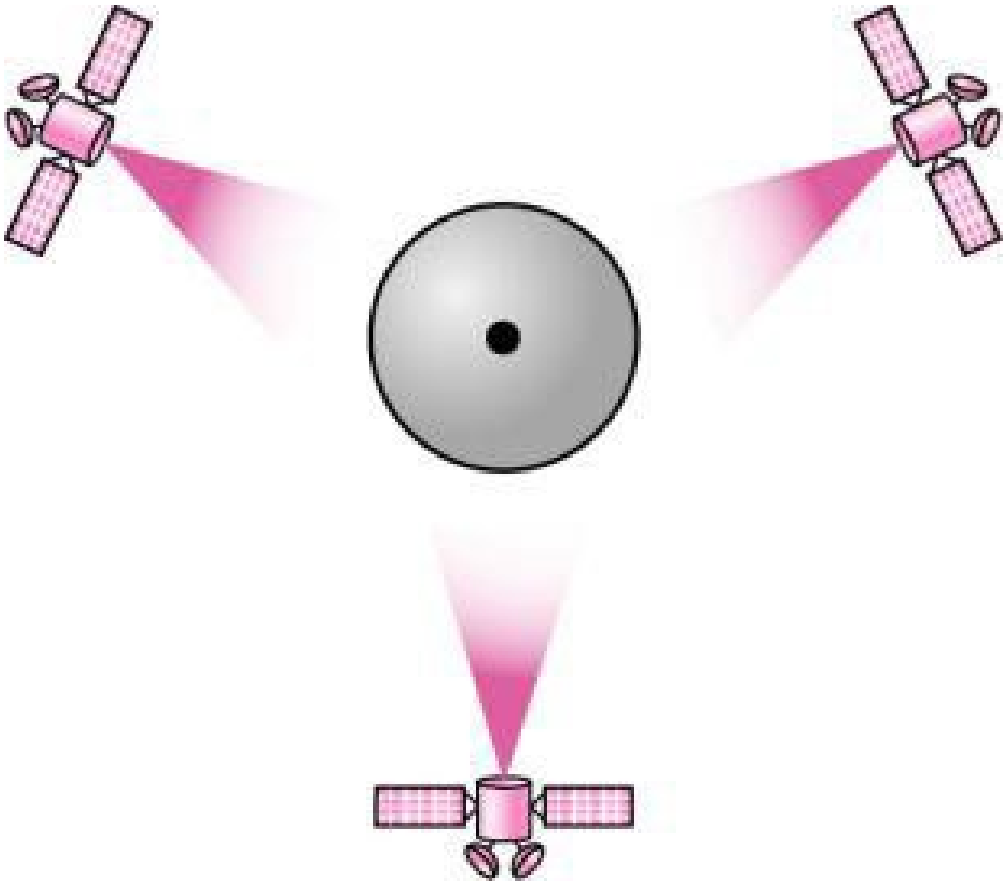
Satellitnät

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



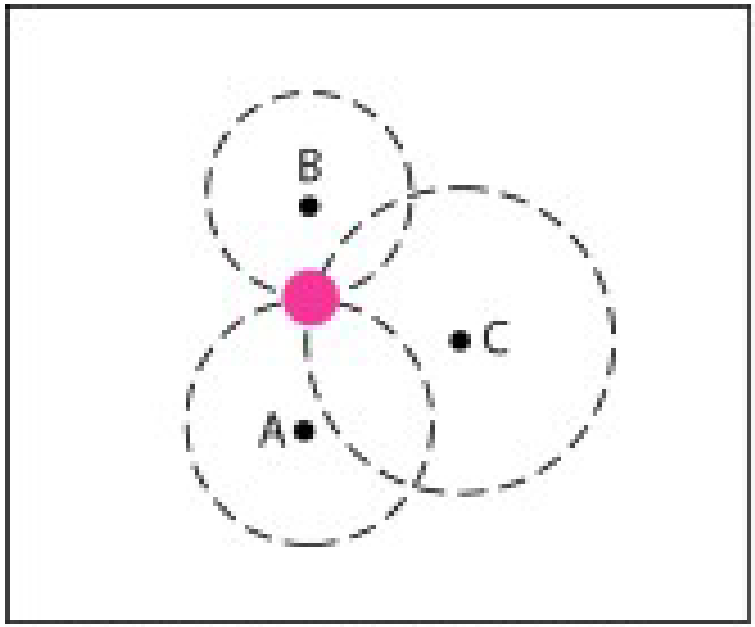
Satellitnät

- Minst tre geostationära satelliter krävs för att täcka hela jorden

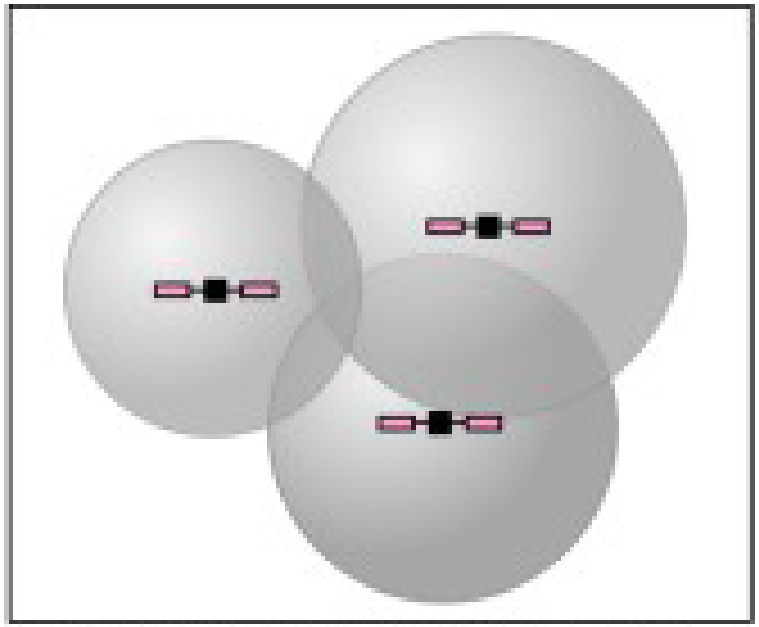


Satellitnät

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

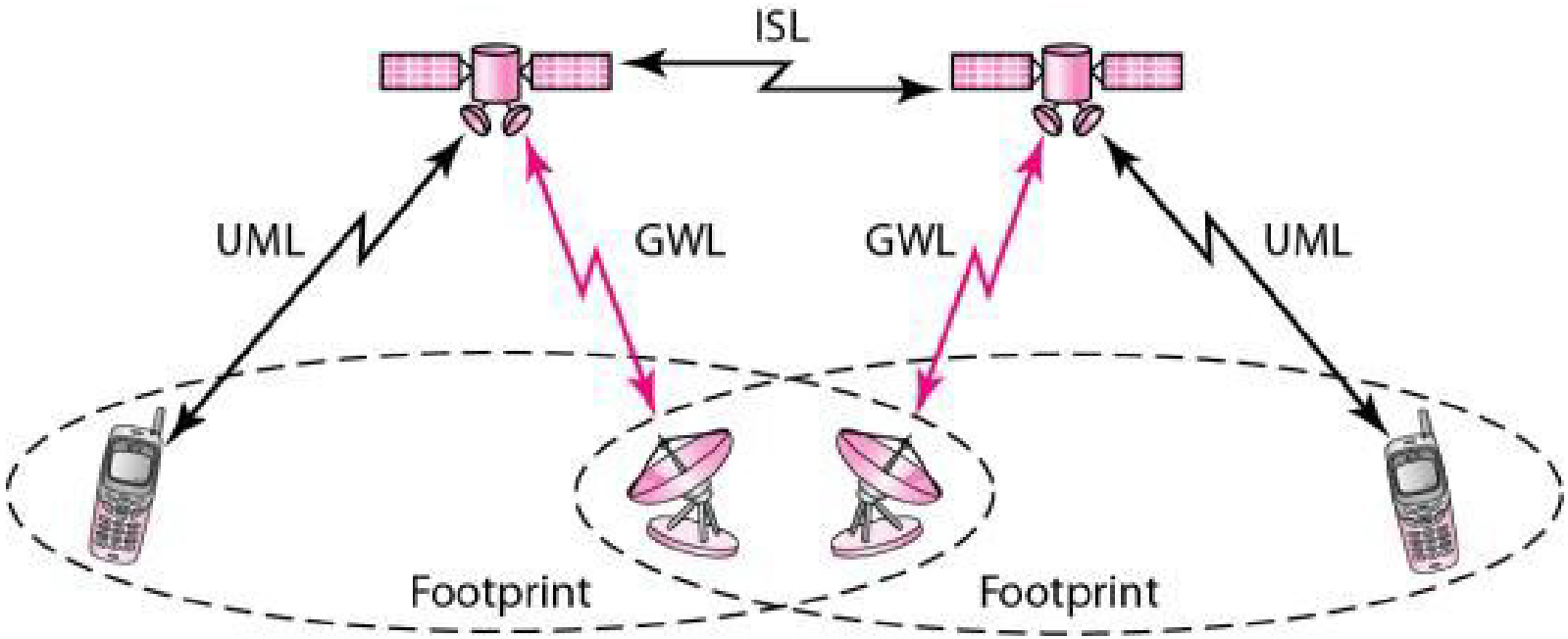


a. Two-dimensional trilateration


b. Three-dimensional trilateration

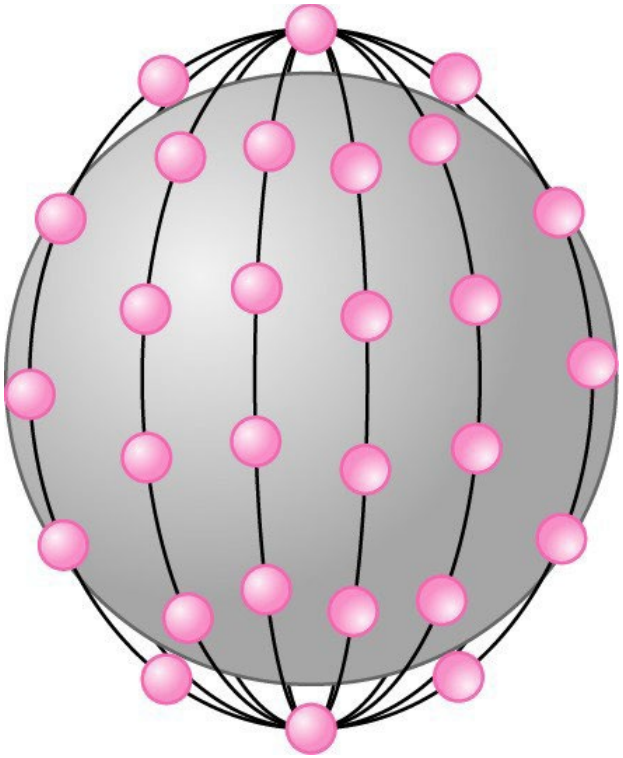
Satellitnät

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



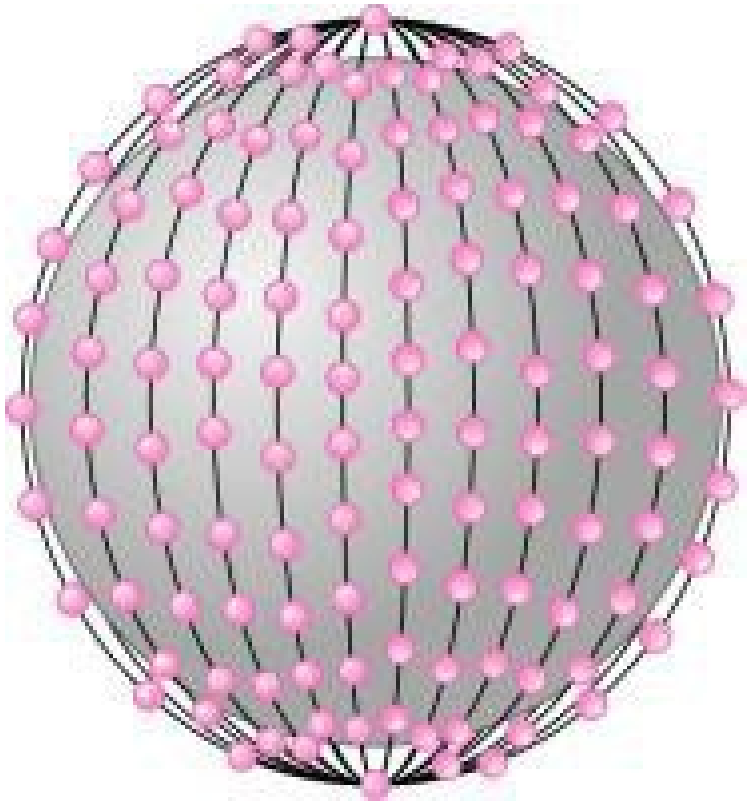
Satellitnät

- 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.

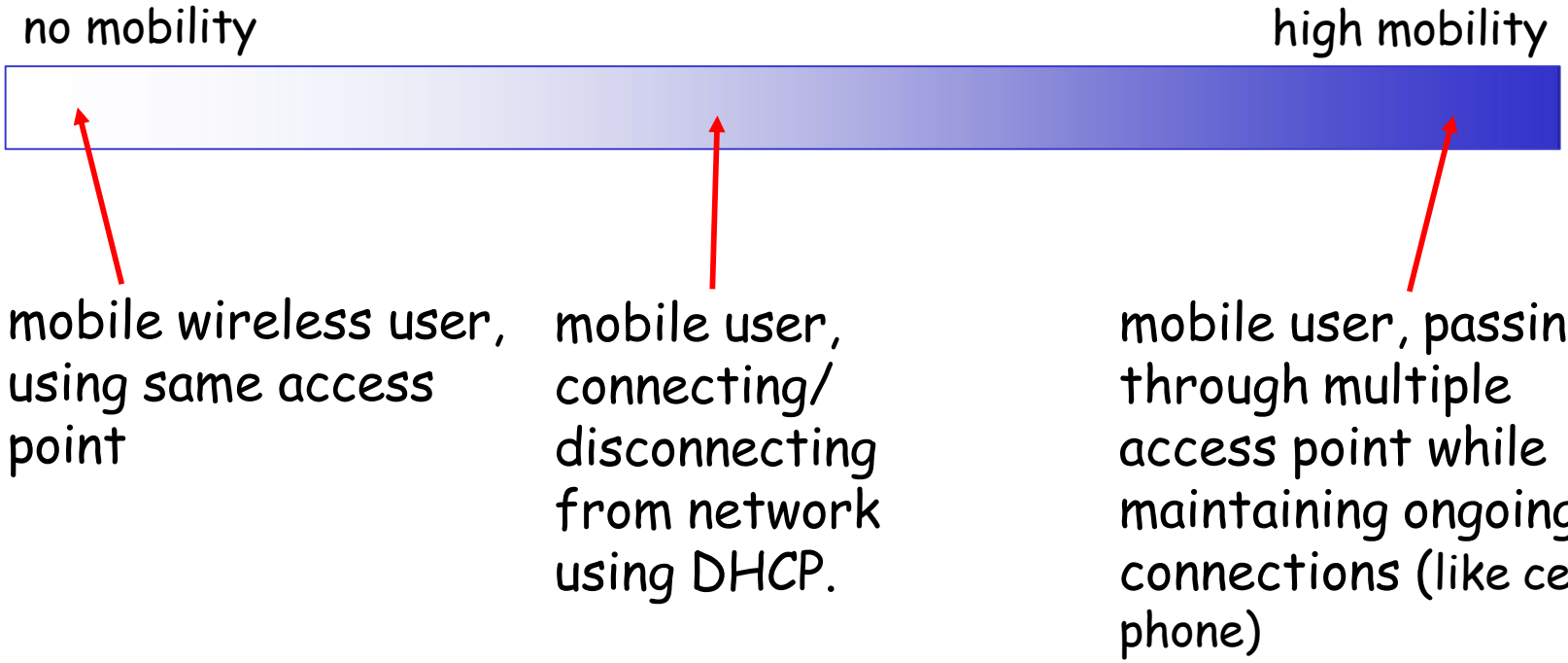


Satellitnät

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

What is mobility?

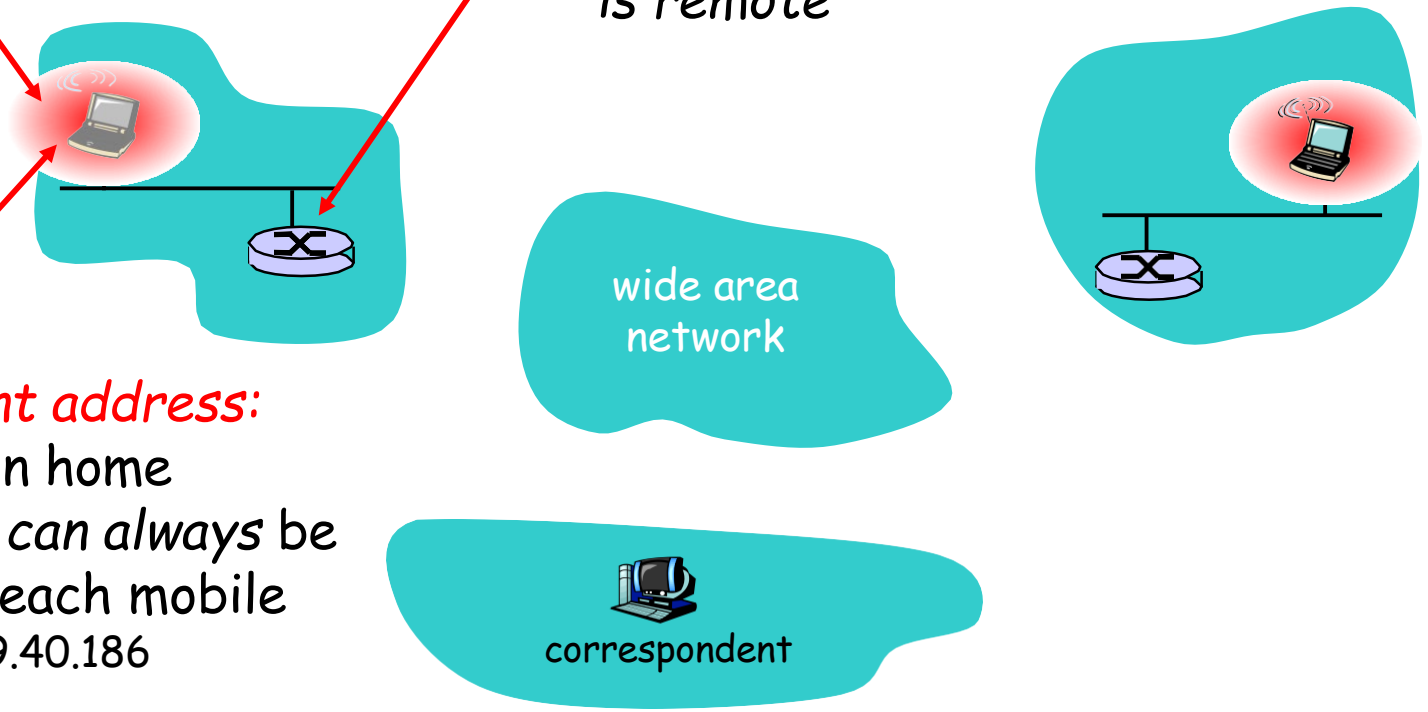
- spectrum of mobility, from the *network* perspective:



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*



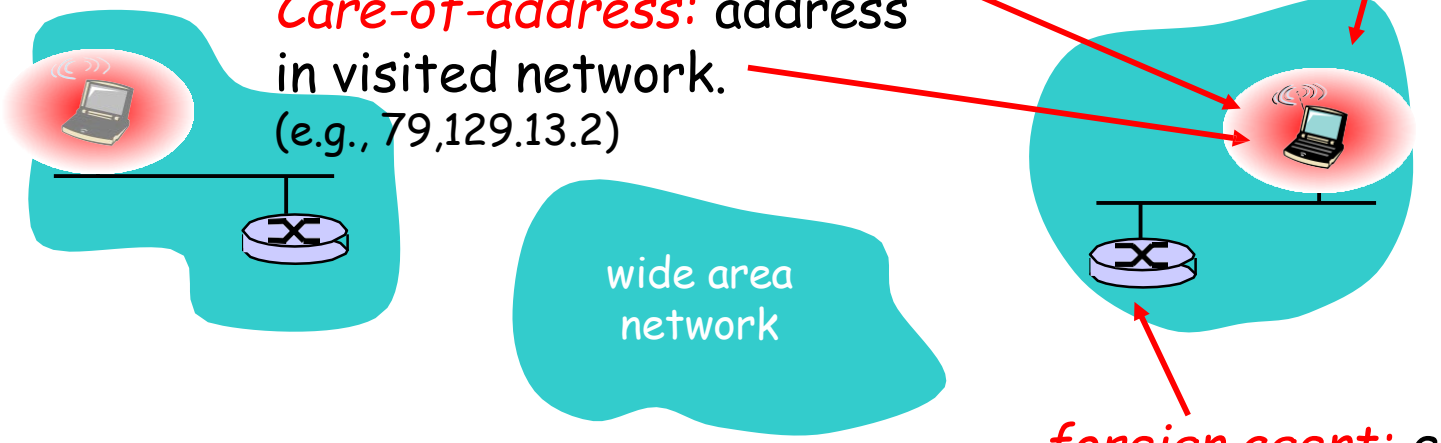
Permanent address: address in home network, *can always* be used to reach mobile e.g., 128.119.40.186

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)



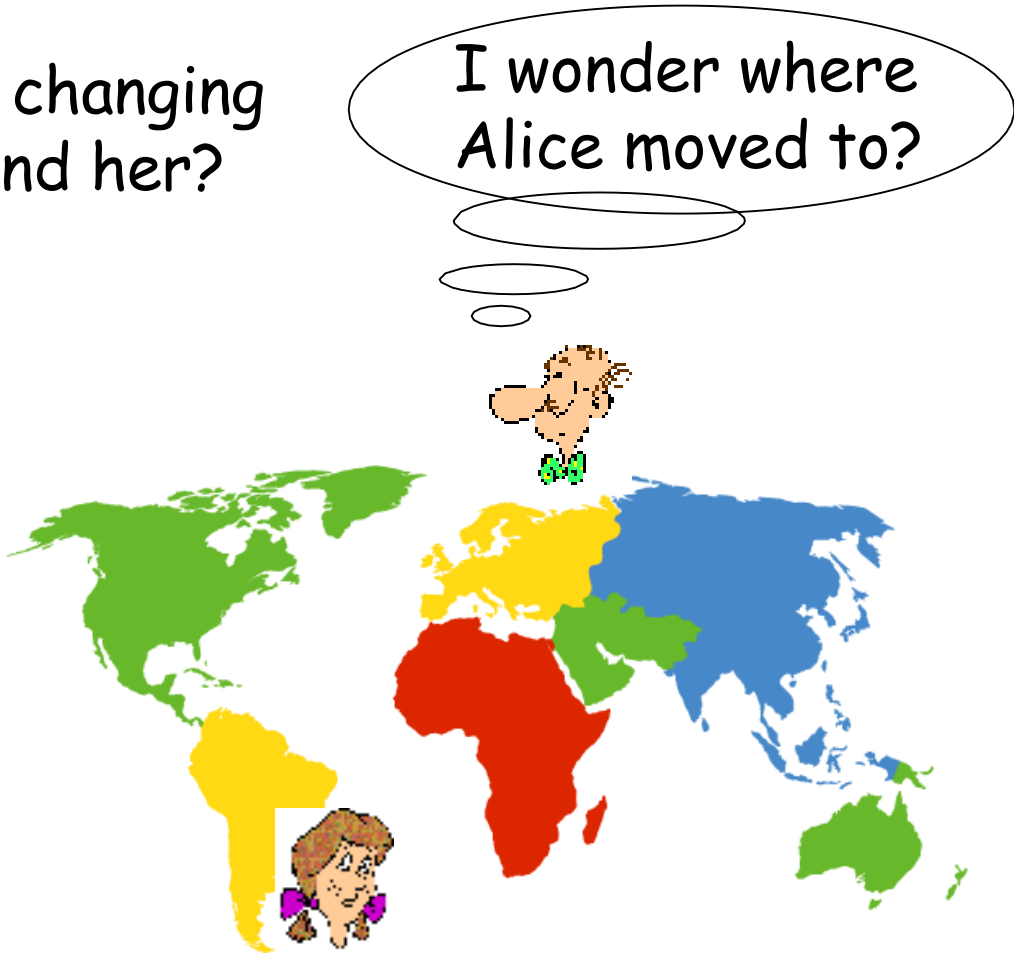
foreign agent: entity in visited network that performs mobility functions on behalf of mobile.

correspondent: wants to communicate with 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

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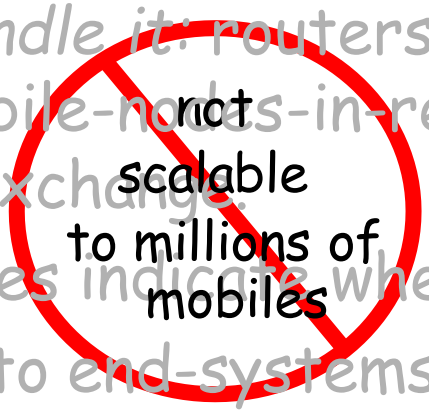
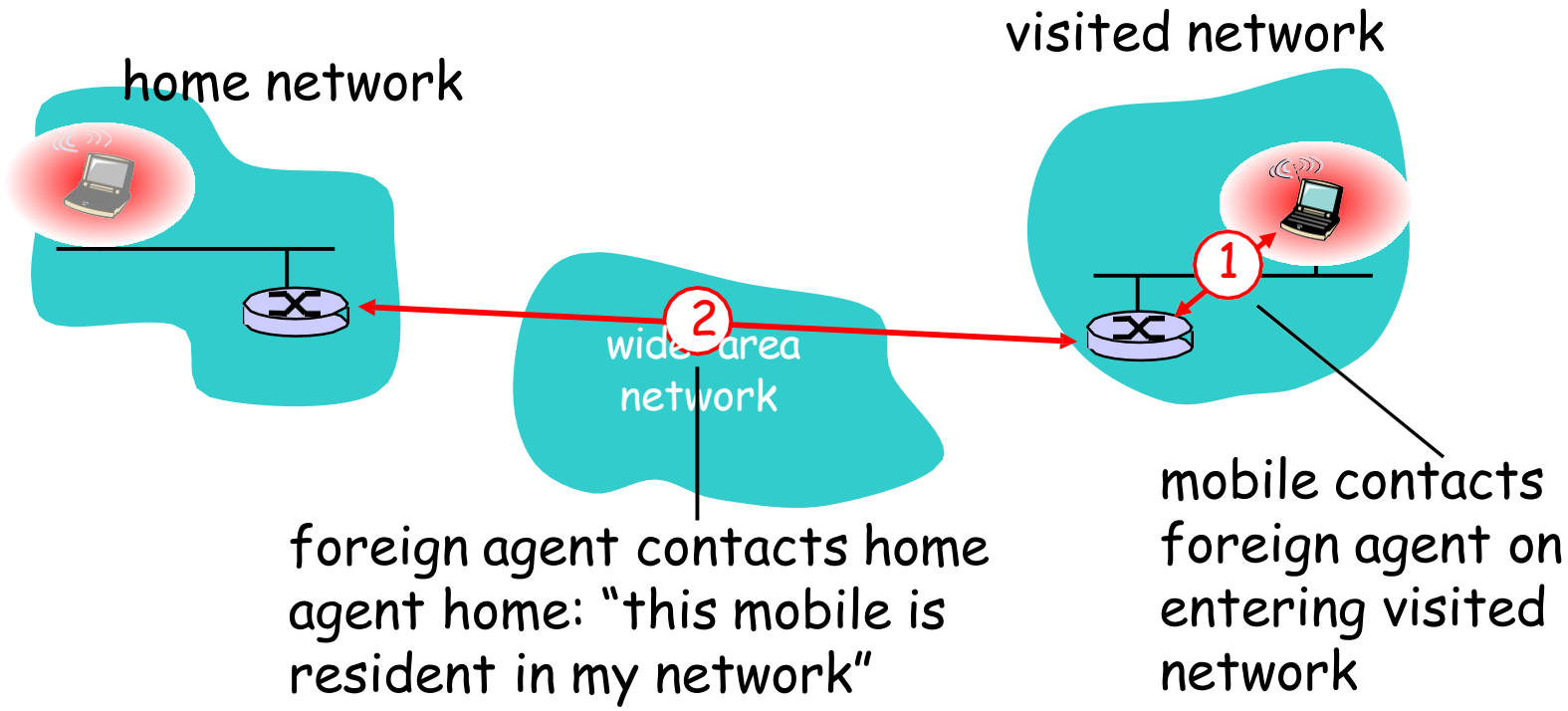


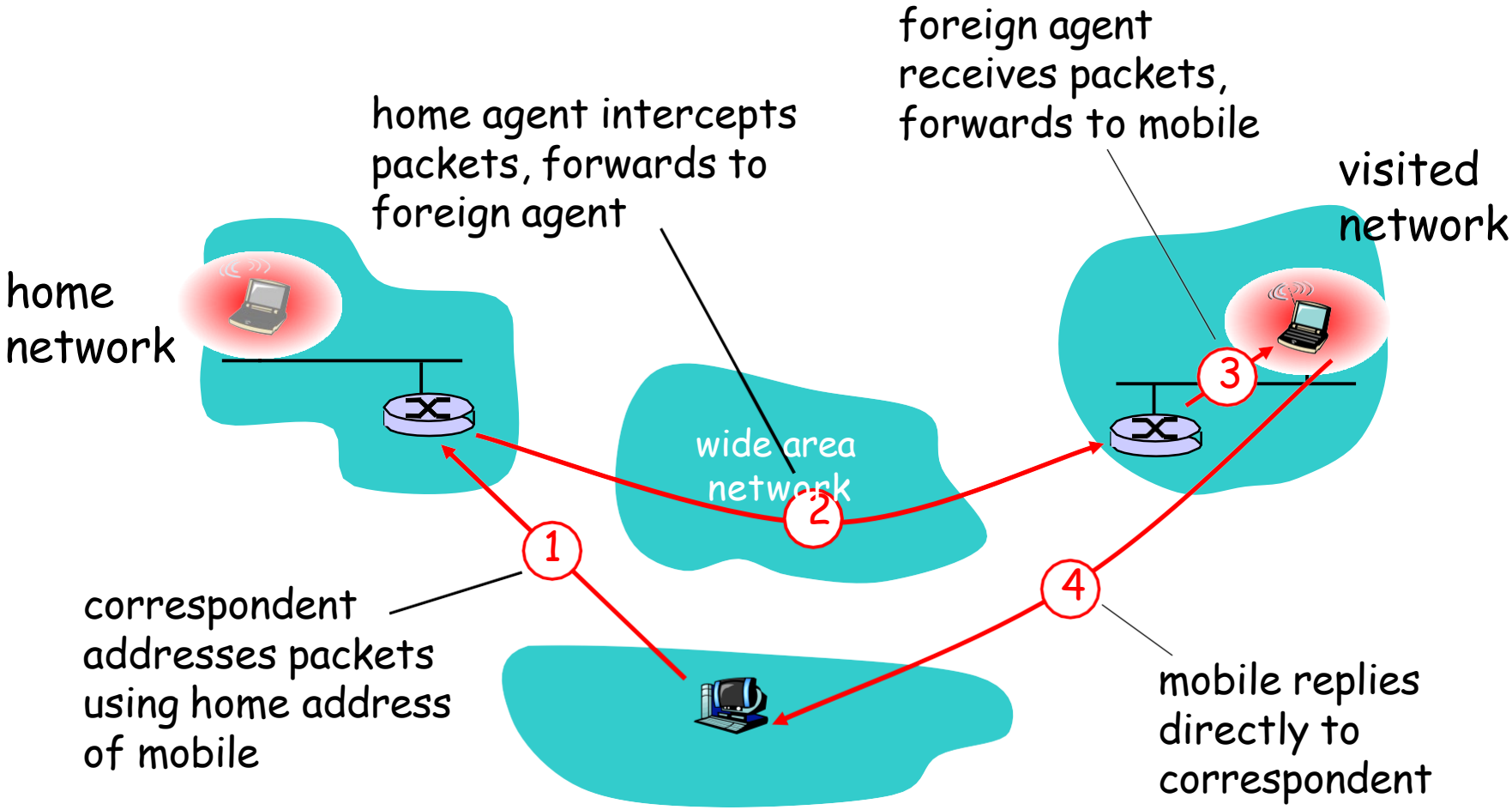
Mobility: registration



End result:

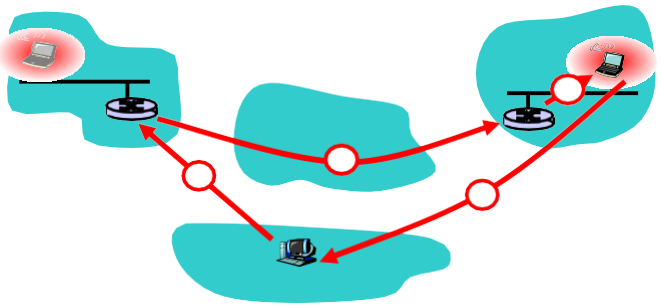
- Foreign agent knows about mobile
- Home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing: comments

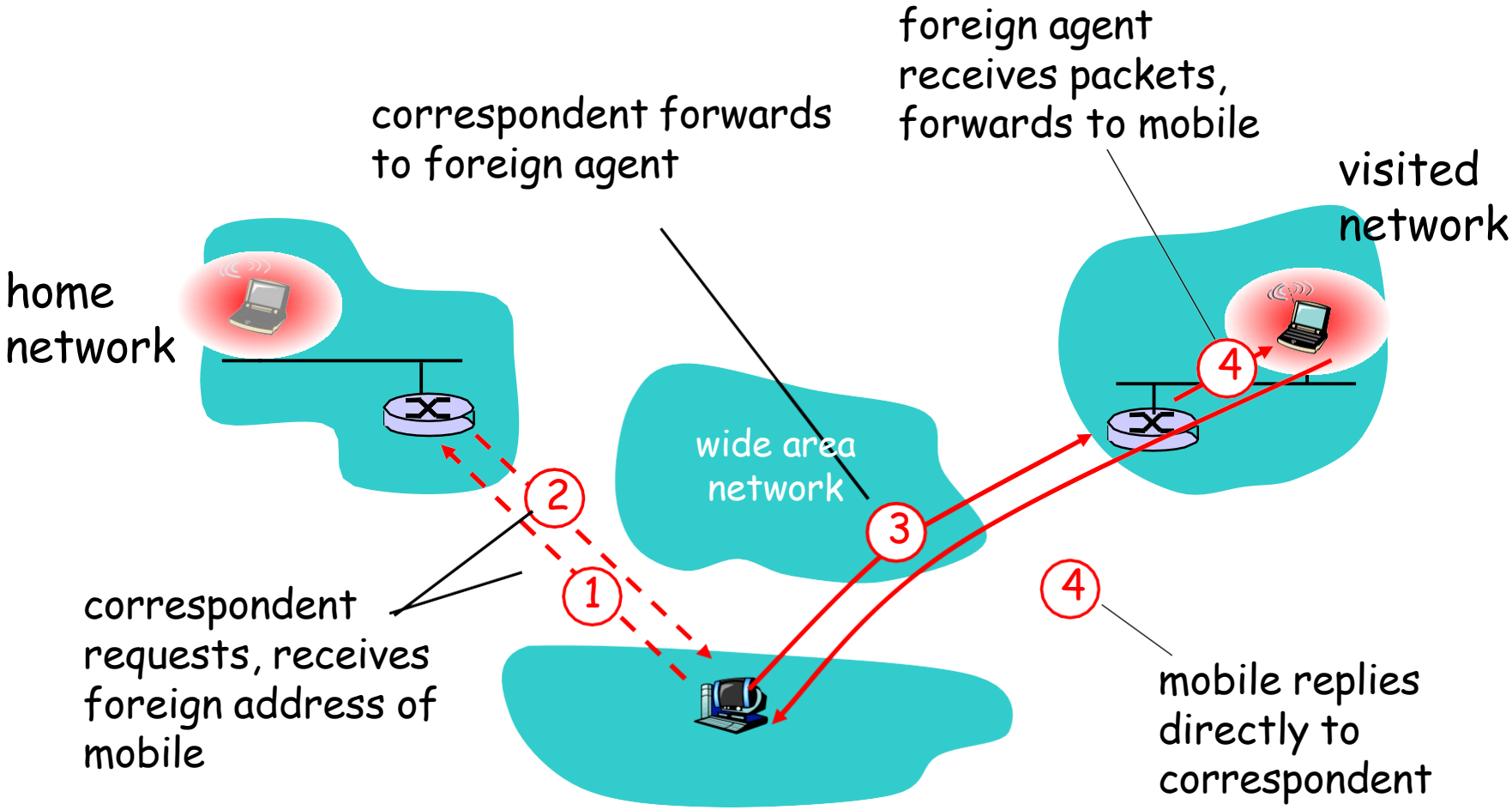
- Mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
  - care-of-address: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile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



Indirect Routing: moving between networks

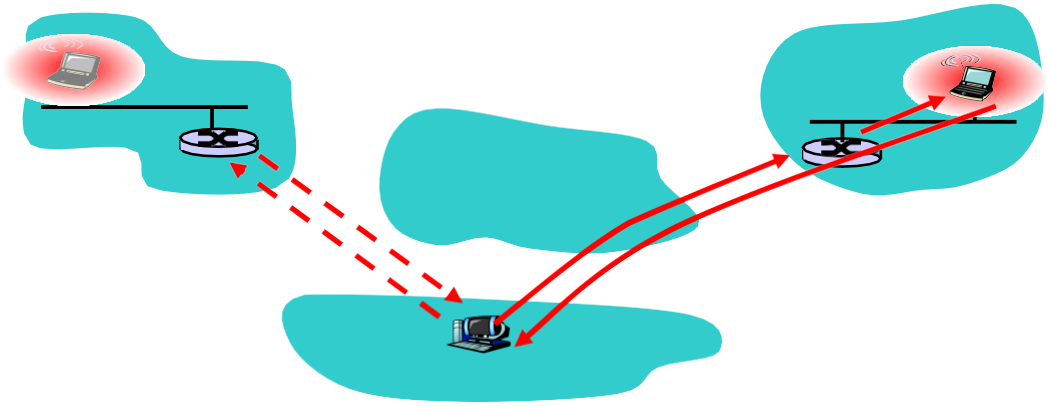
- suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)
- mobility, changing foreign networks transparent: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

Mobility via Direct Routing



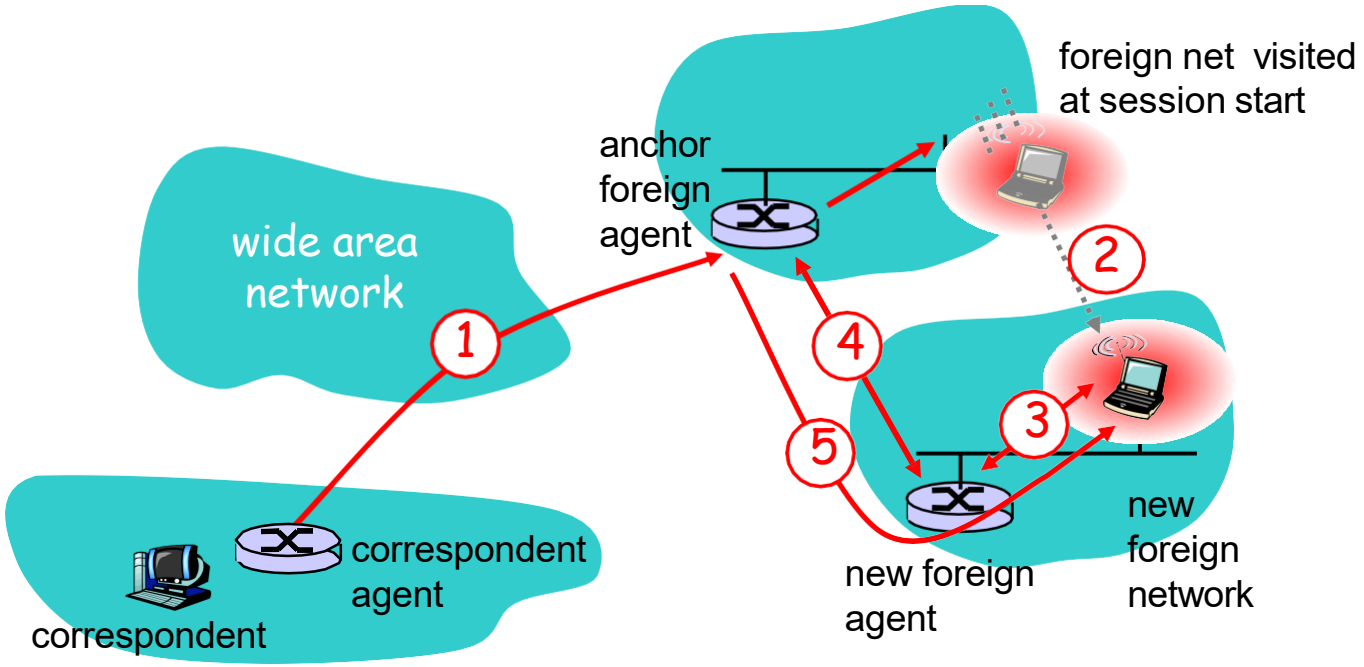
Mobility via Direct Routing: comments

- 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)

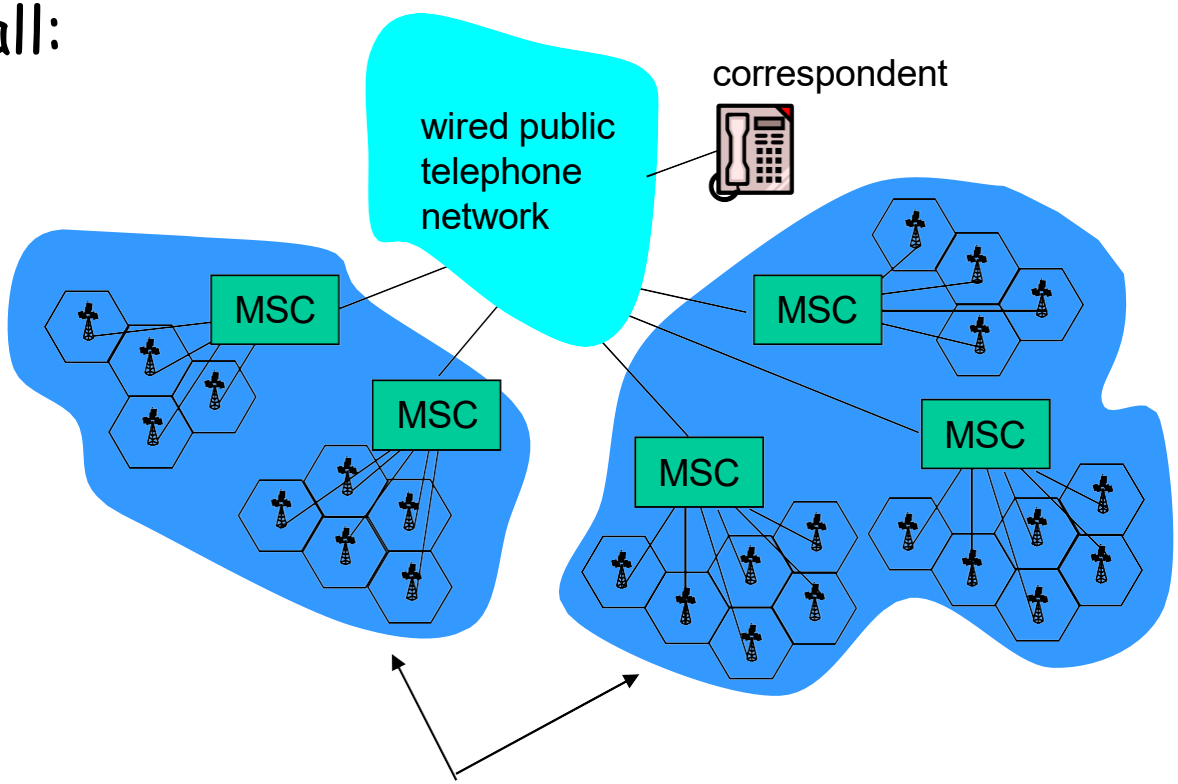


Mobile IP

- 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:

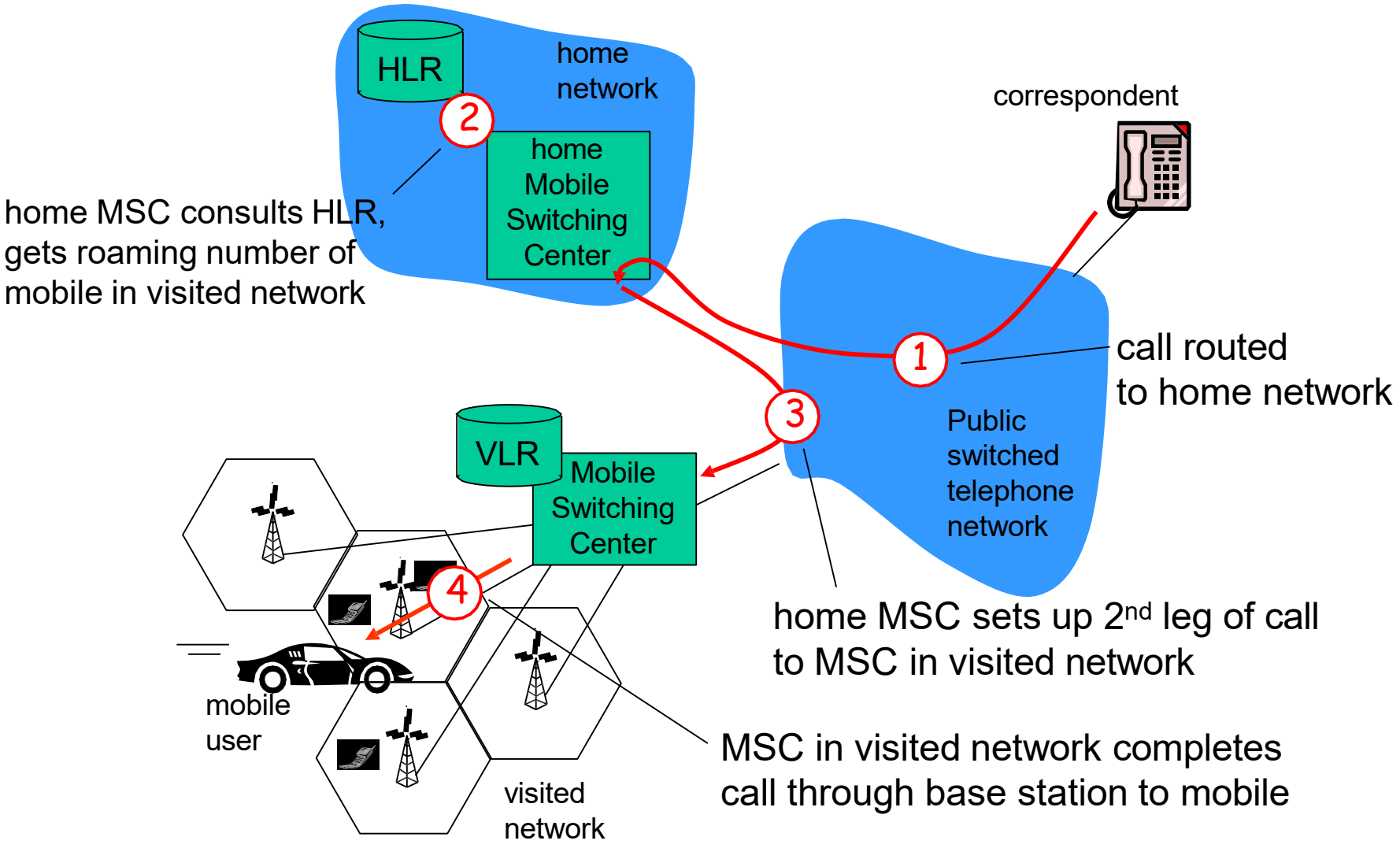


different cellular networks,
operated by different providers

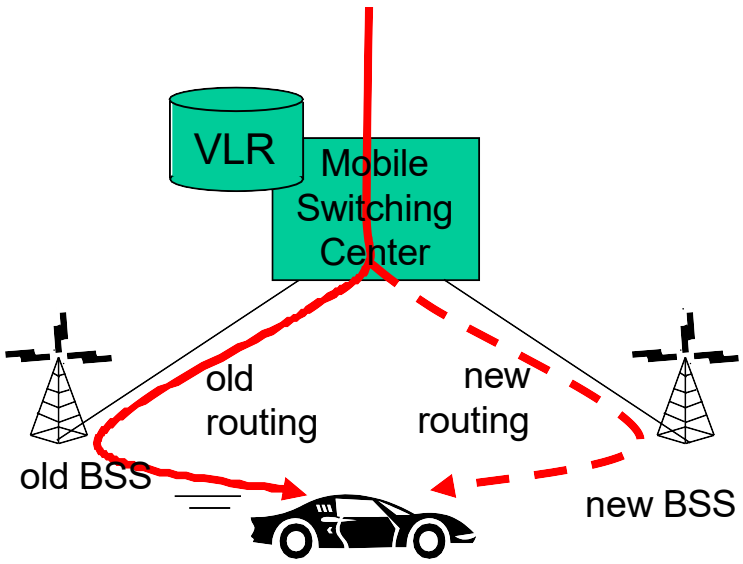
Handling mobility in cellular networks

- *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

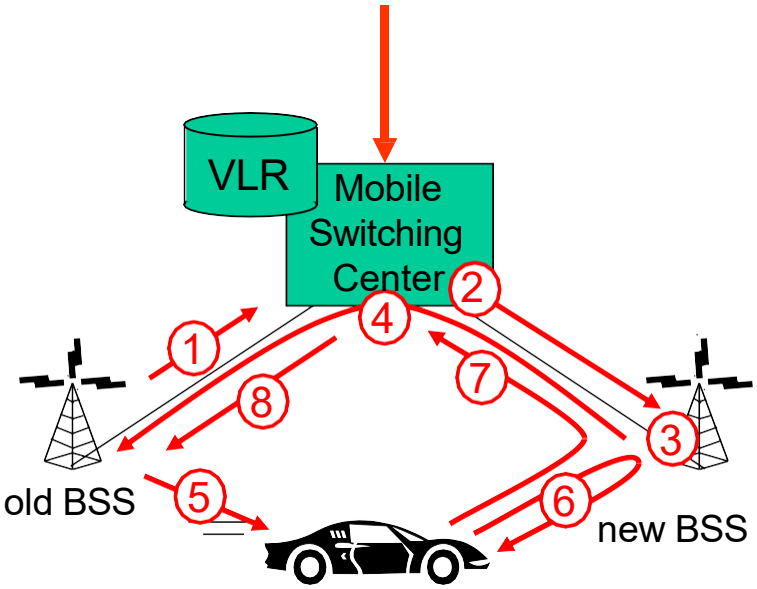


GSM: handoff with common MSC



- 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

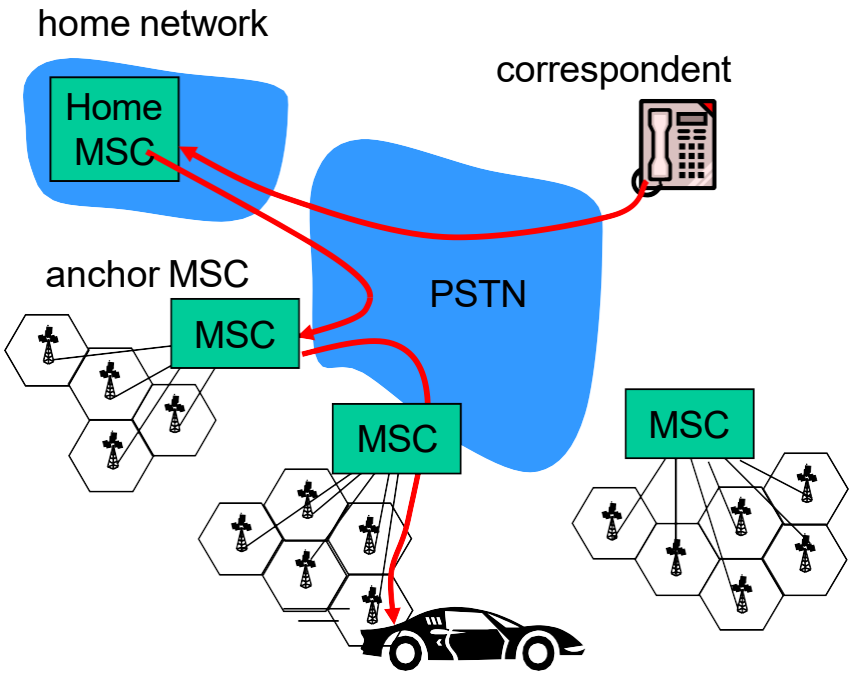
GSM: handoff with common MSC



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

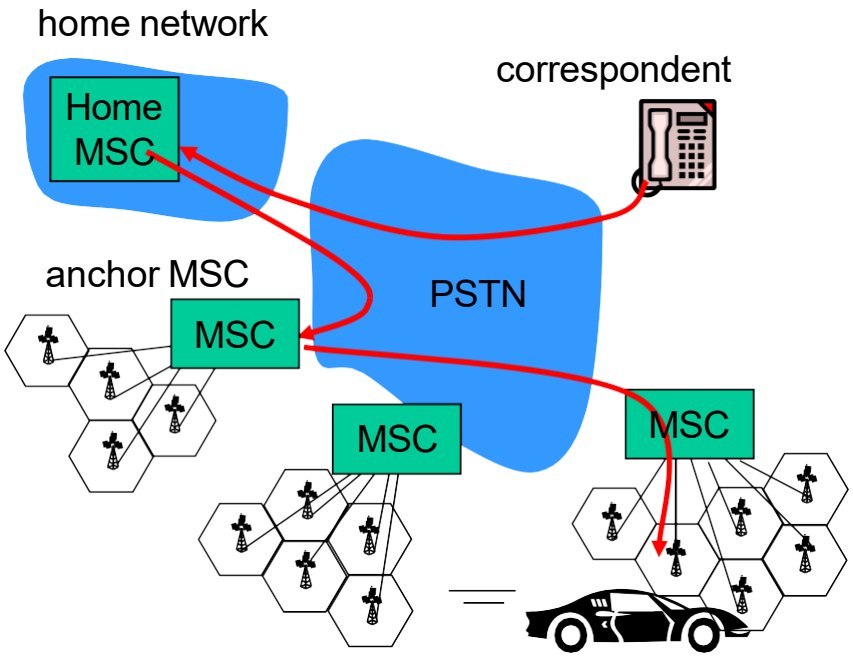
GSM: handoff between MSCs



(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

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