

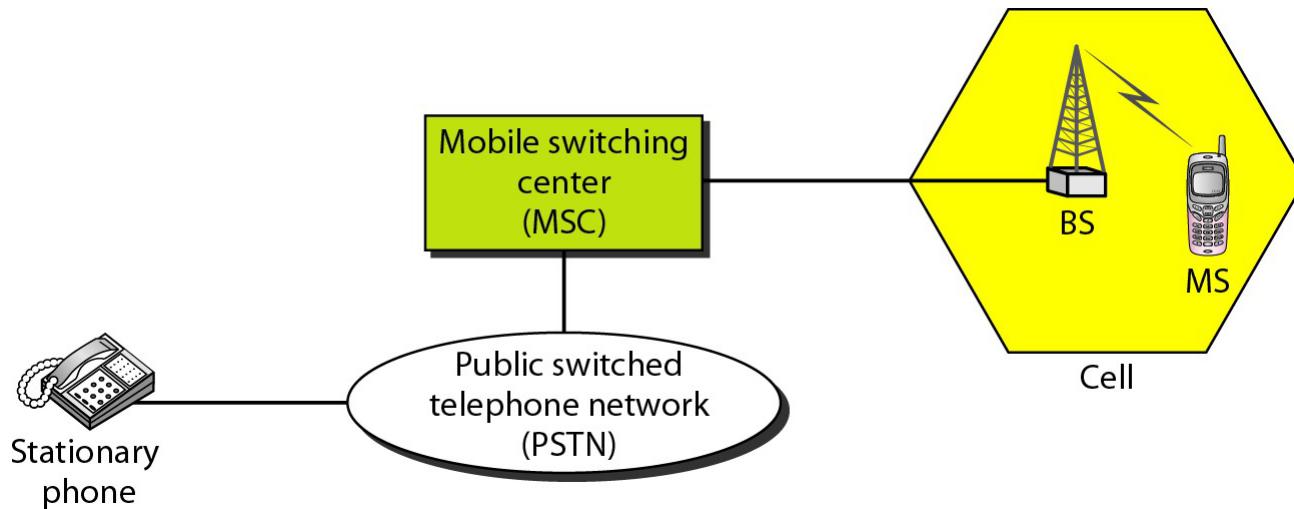
Mobilnät och satellitnät

Multipel access och kanalisingering

- Kanalisingering: 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

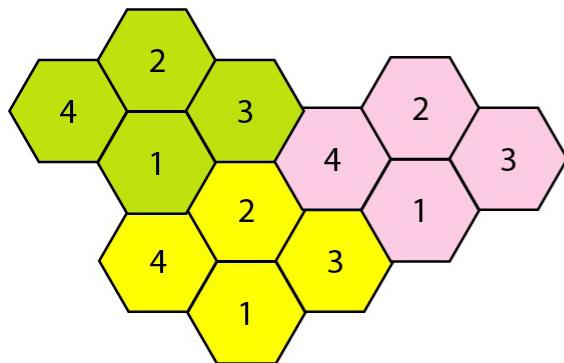
Mobilnät

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

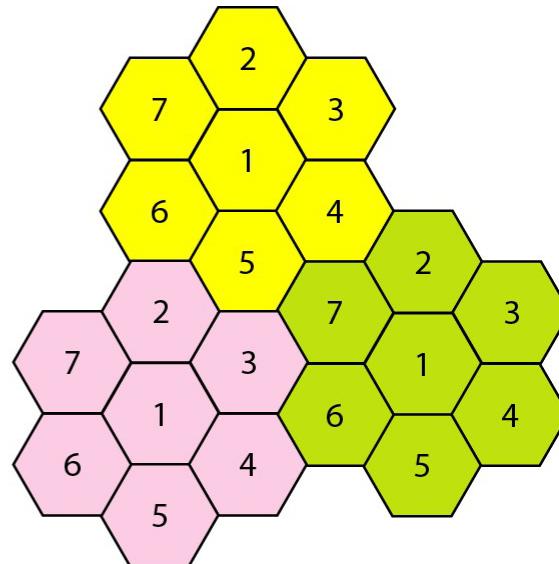


Mobilnät

- Återanvändning av frekvenser



a. Reuse factor of 4



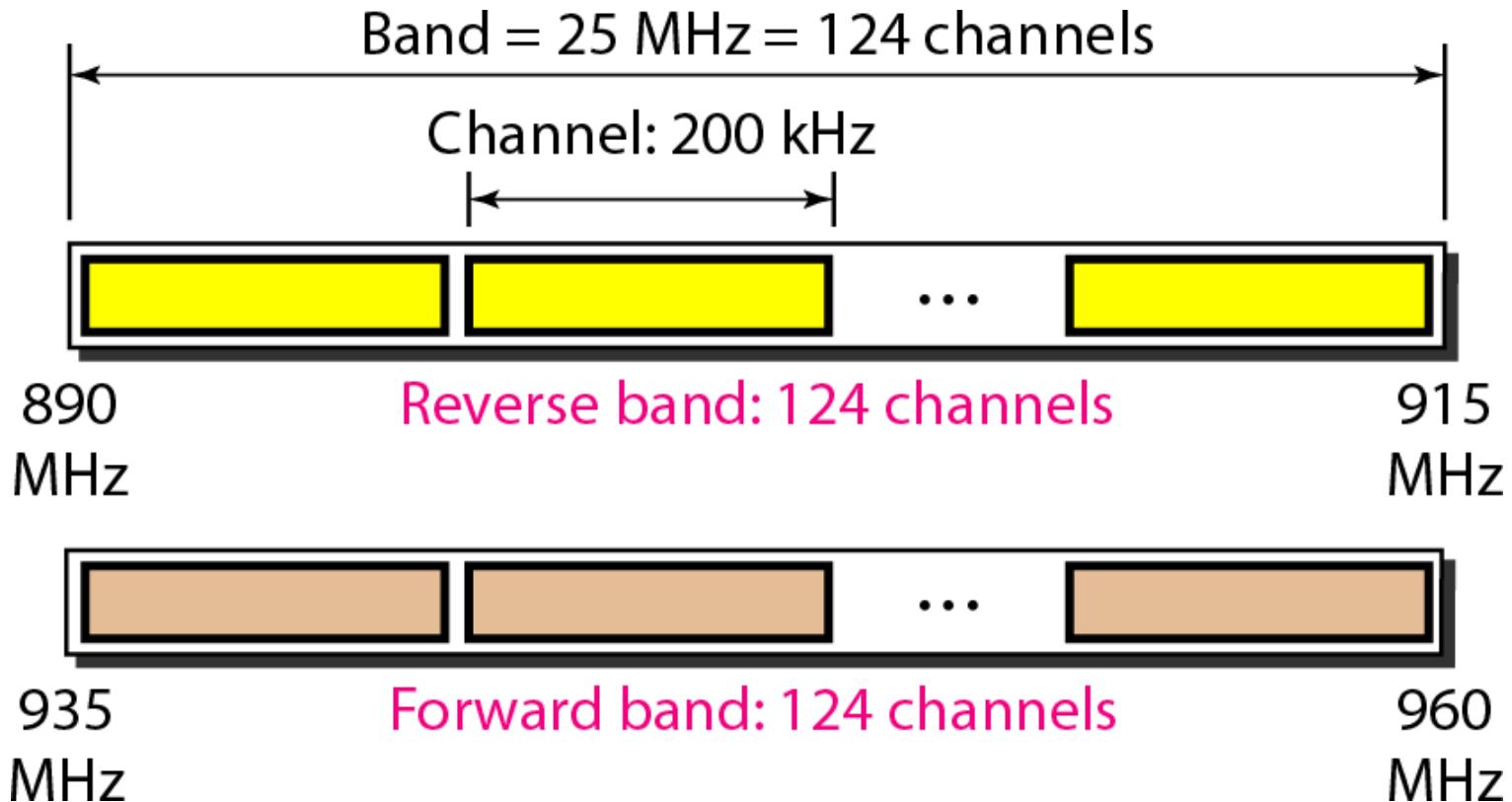
b. Reuse factor of 7

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

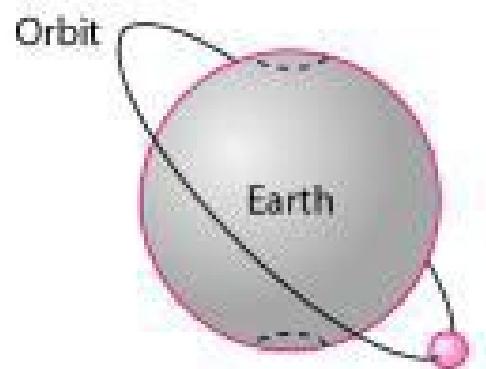
- Hastigheter på 150-250 Mbit/s
- Kortare fördröjningar
- IoT, självkörande bilar
- Inte täckning i hela landet,
antennerna har inte så lång räckvidd
- Kom marknadsmässigt 2020 i Sverige

Satellitnät

- Olika orienteringar hos satellitbanor



a. Equatorial-orbit satellite



b. Inclined-orbit satellite



c. Polar-orbit satellite

Satellitnät

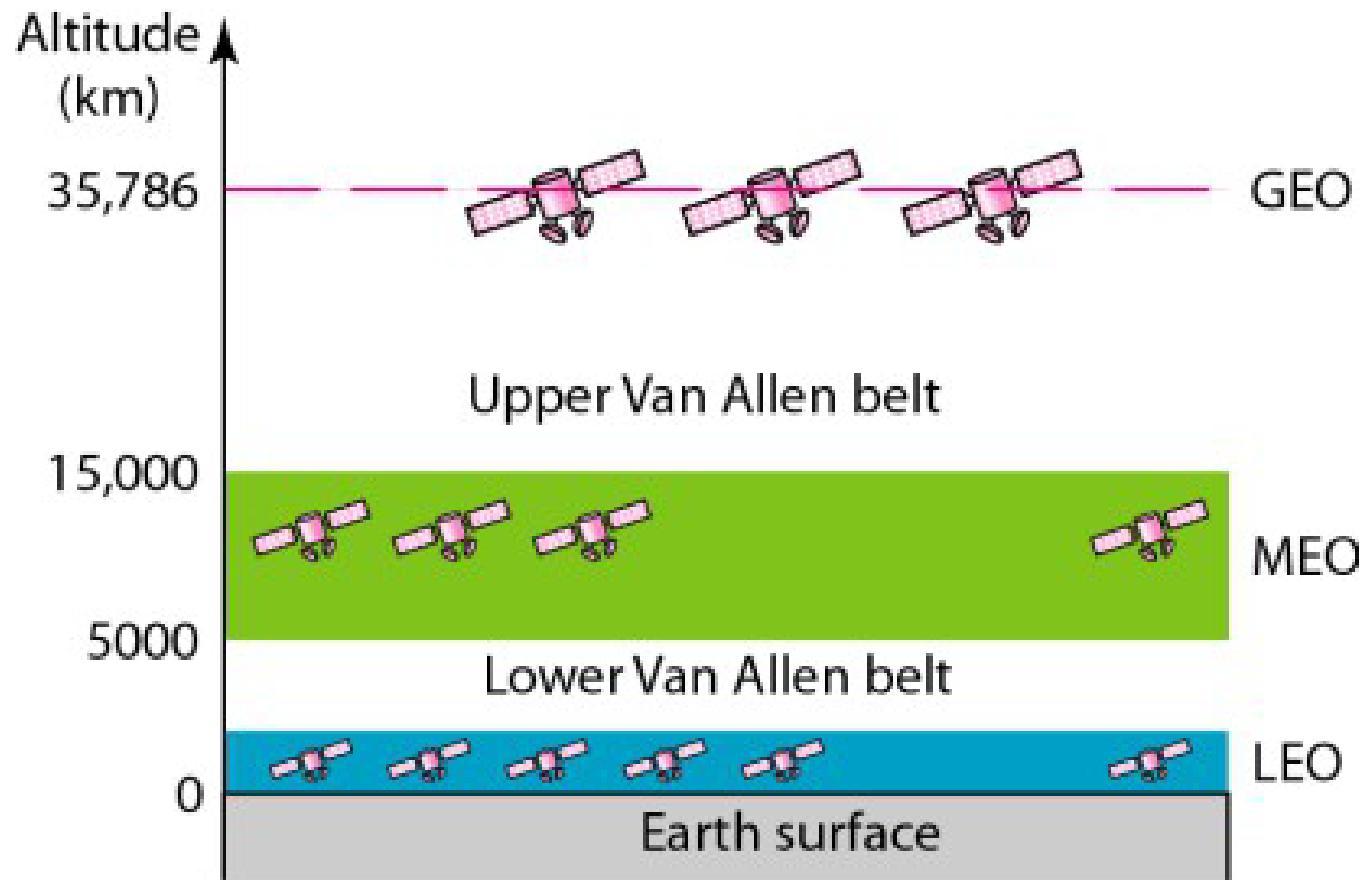
- Keplers 3:e lag gäller även för satelliter i bana runt jorden $T = k * r^{1.5}$
(T = omloppstid, k = "konstant" (g , M , m)
 r = medelavstånd på cirkulerande enhet)
 - *Månens periodtid runt jorden blir 28 dagar dvs ca 1 månad.*
 - *Satellit på höjden 35786 km får en periodtid på 24 timmar dvs ett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

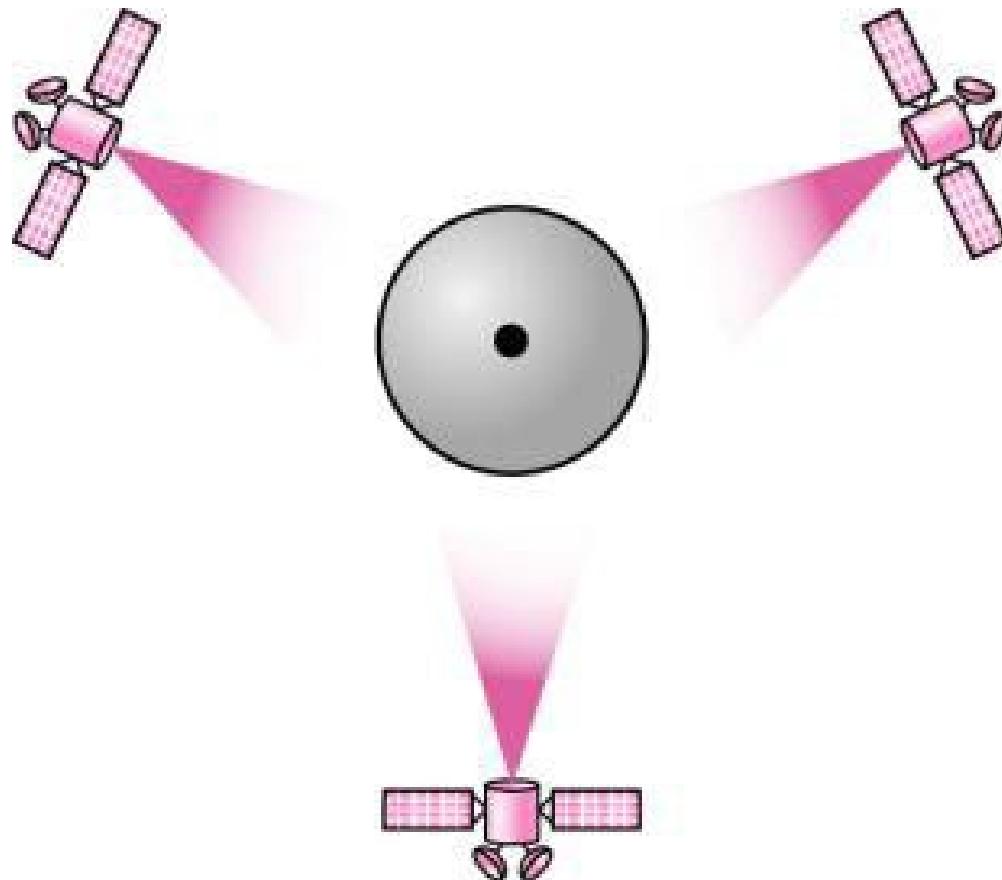
Satellitnät

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



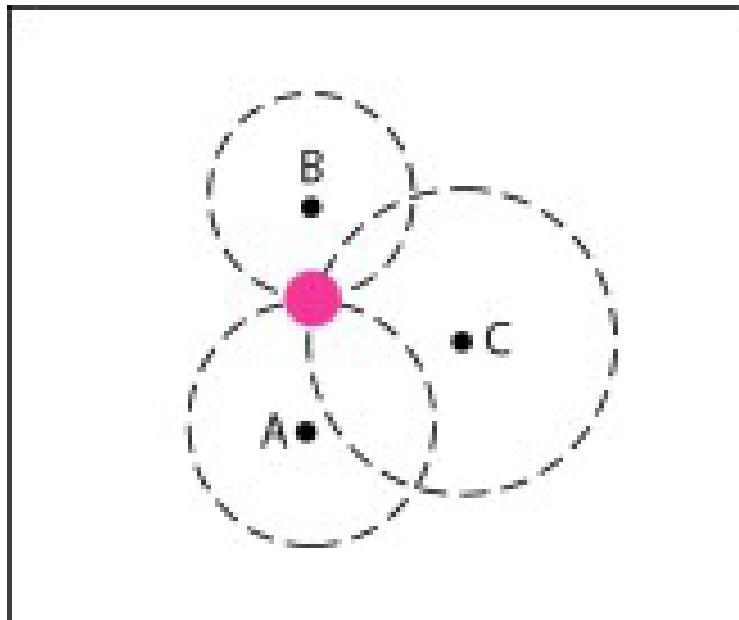
Satellitnät

- Minst tre geostationära satelliter krävs för att täcka hela jorden

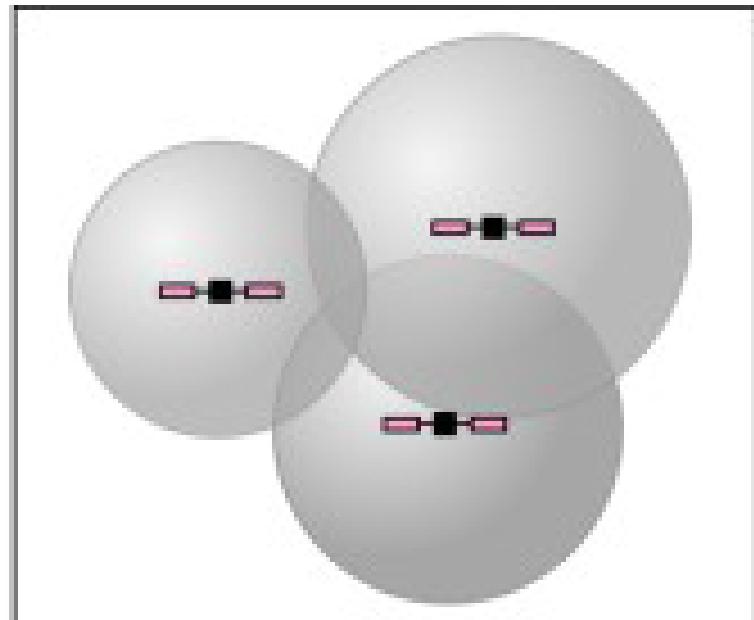


Satellitnät

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



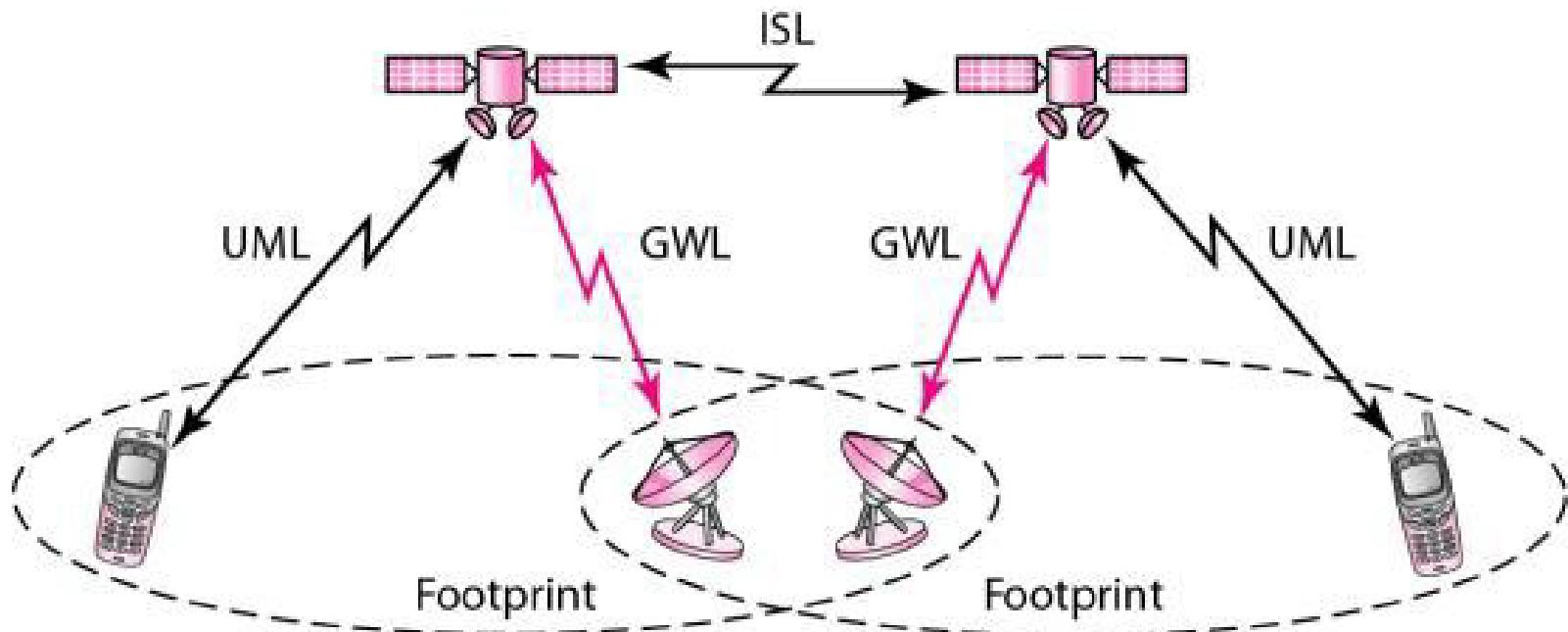
a. Two-dimensional trilateration



b. Three-dimensional trilateration

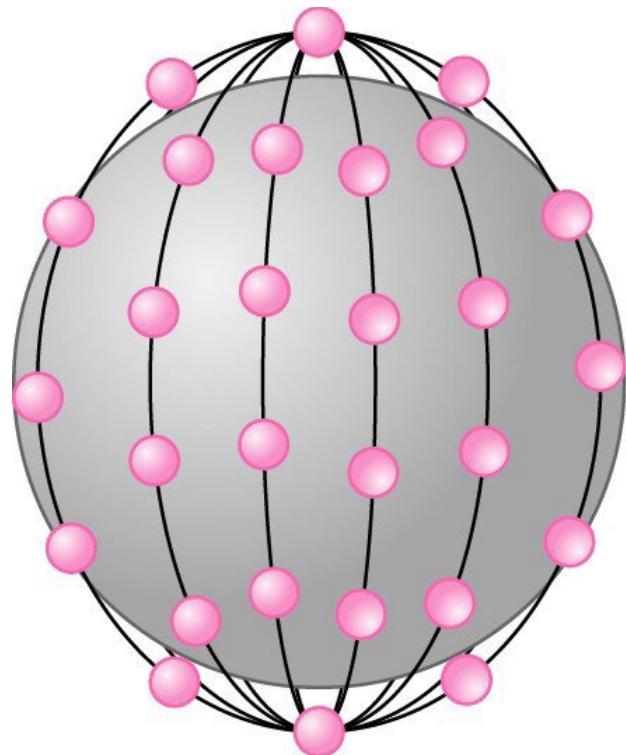
Satellitnät

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



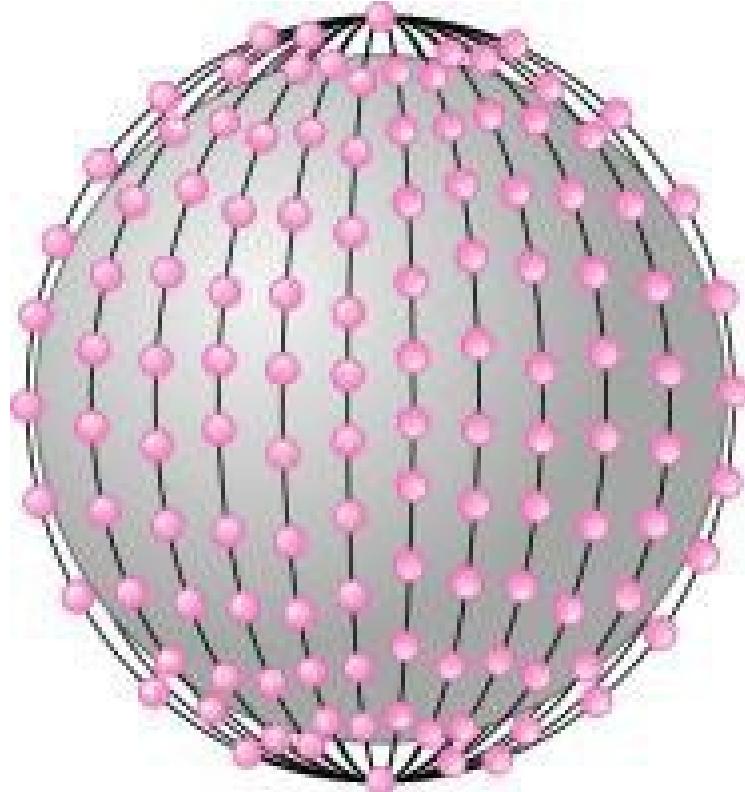
Satellitnät

- 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.



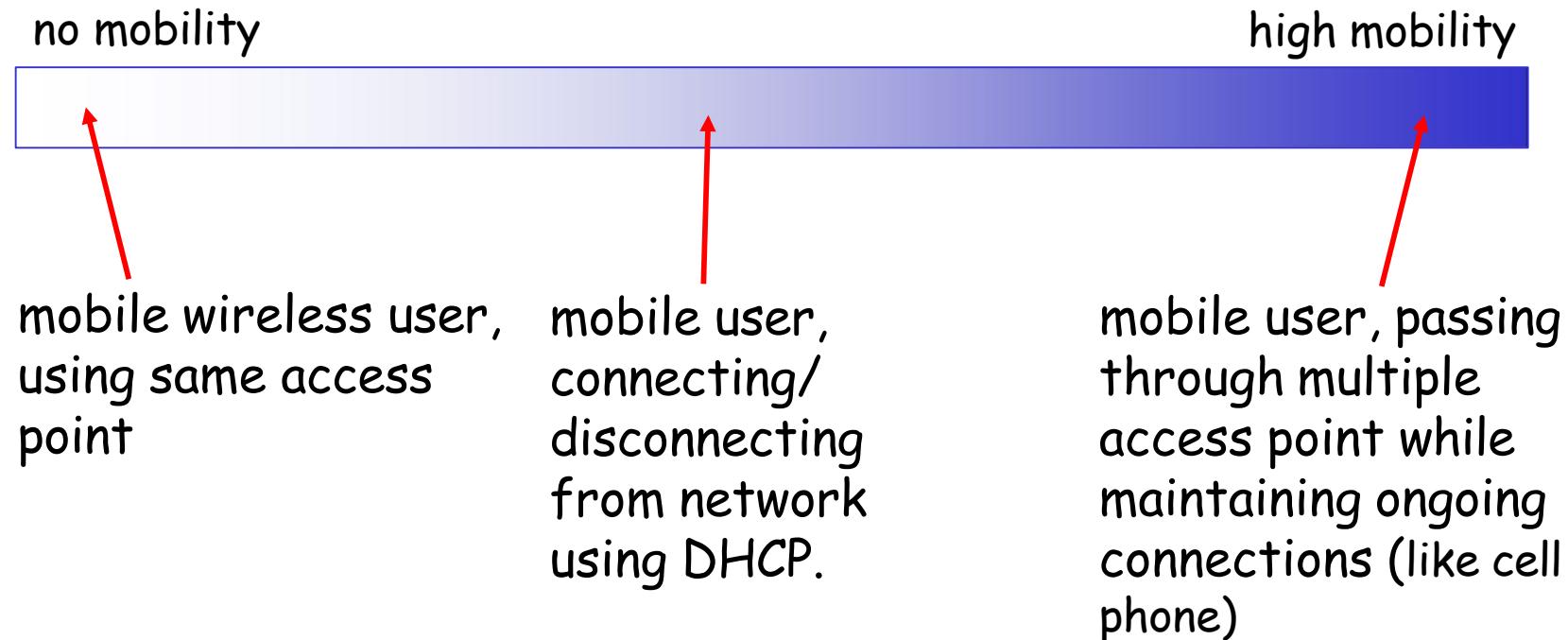
Satellitnät

- "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.



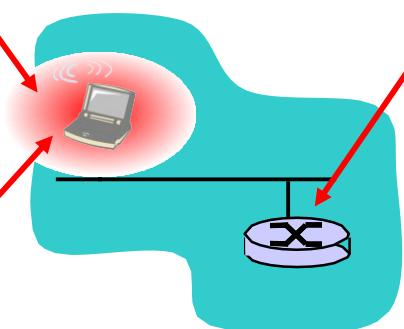
What is mobility?

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



Mobility: Vocabulary

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



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

home agent: entity that will
perform mobility functions on
behalf of mobile, when mobile
is remote



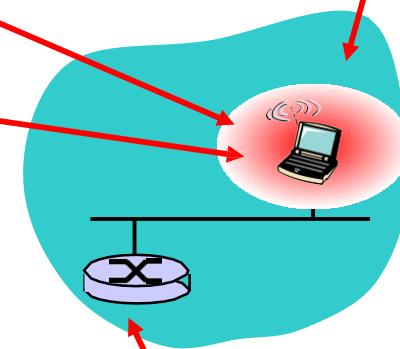
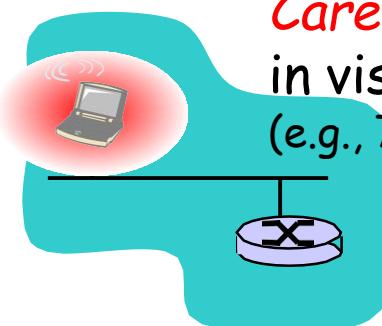
correspondent

Mobility: more vocabulary

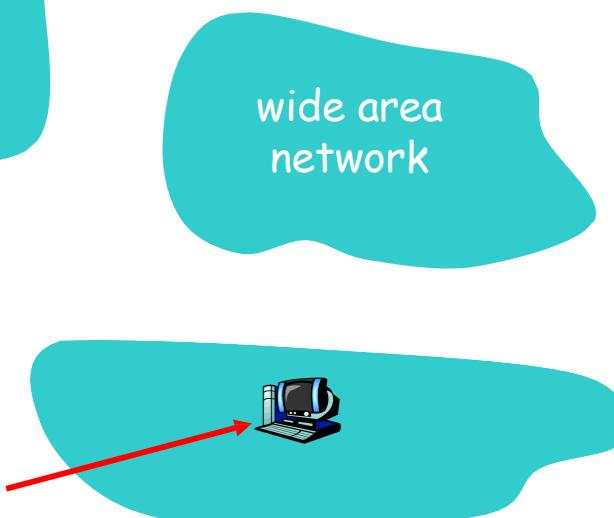
Permanent address: remains constant (e.g., 128.119.40.186)

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)



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?



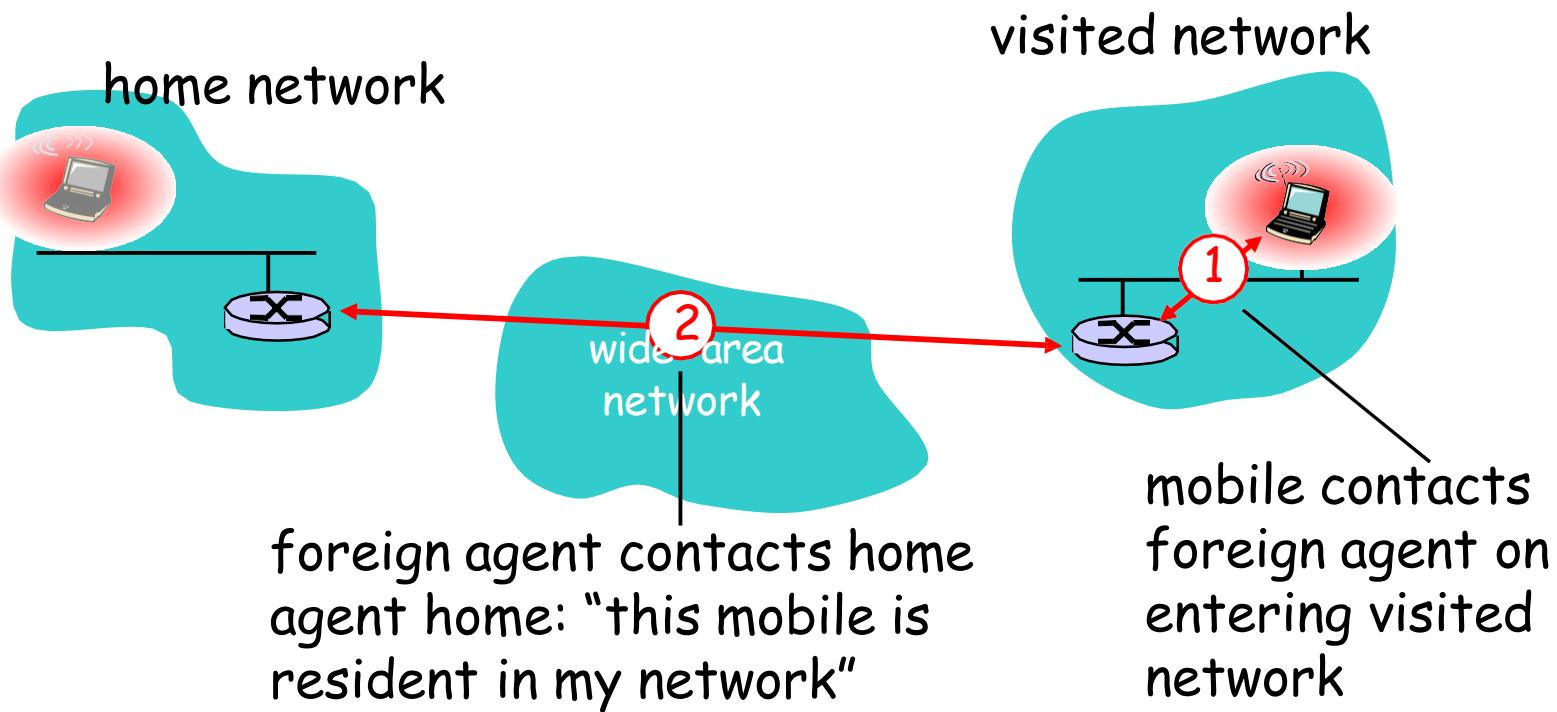
Mobility: approaches

- ❖ *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-nodes-in-residence via usual routing table exchanges.
 - 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

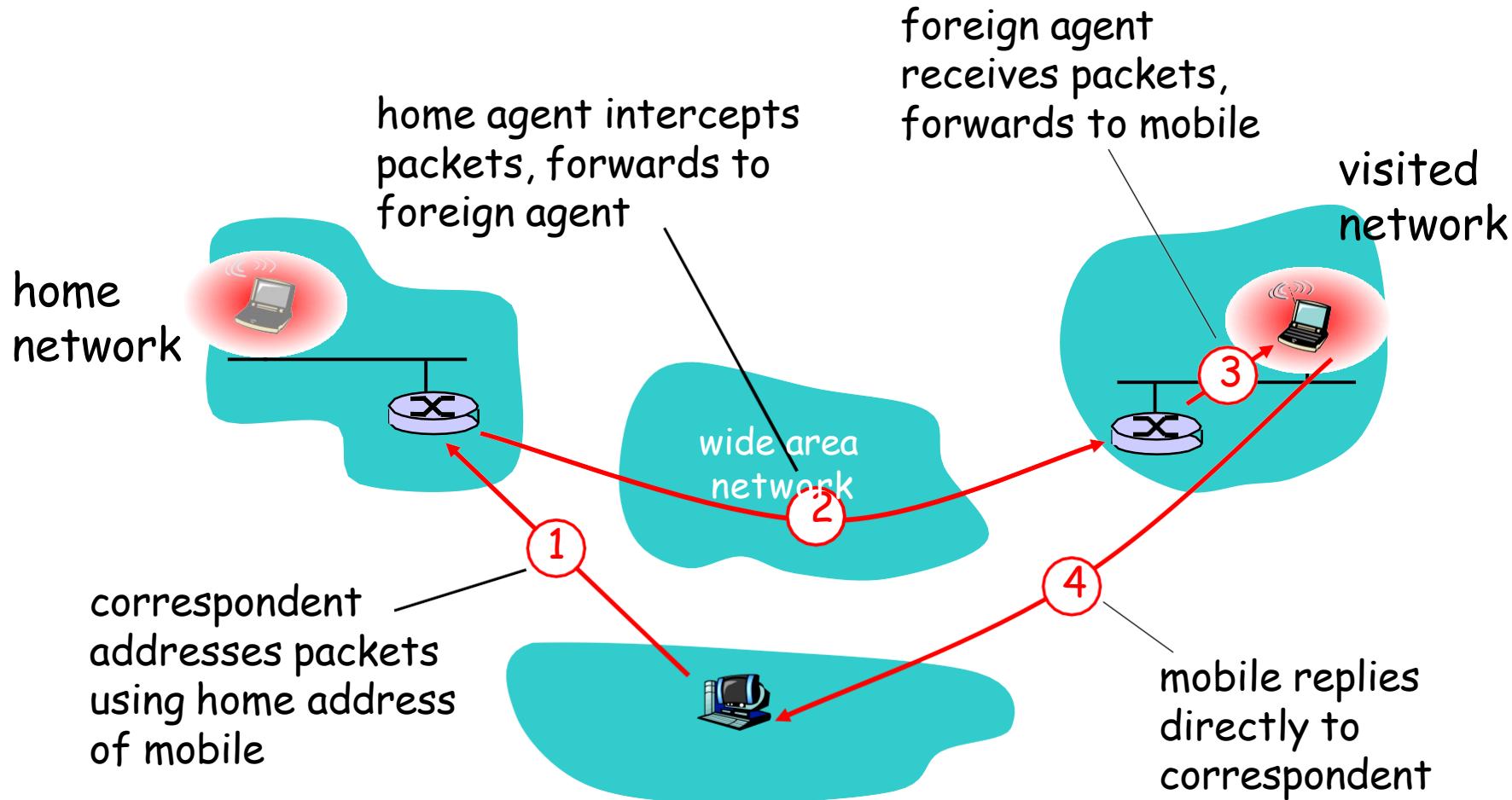
Mobility: registration



End result:

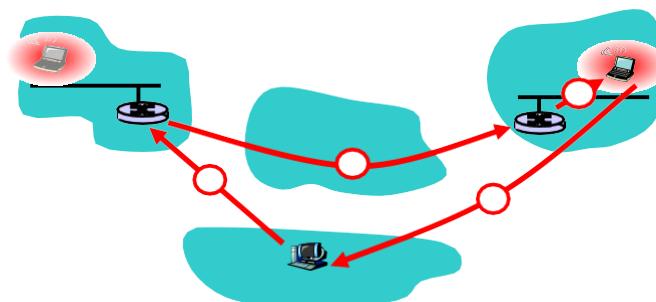
- ❖ Foreign agent knows about mobile
- ❖ Home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing: comments

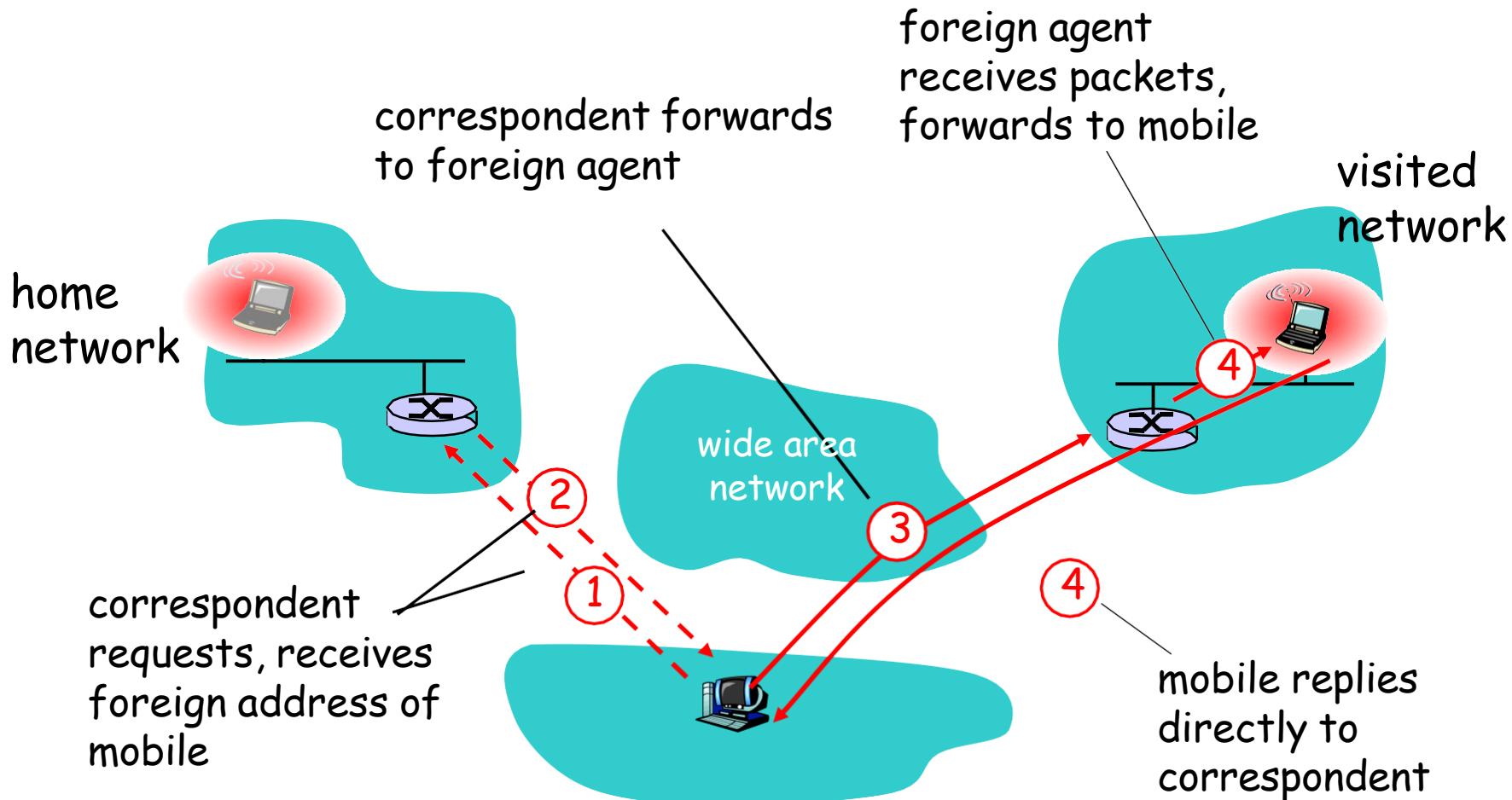
- ❖ Mobile uses two addresses:
 - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
 - care-of-address: used by home agent to forward datagrams to mobile
- ❖ foreign agent functions may be done by mobile itself
- ❖ triangle routing: correspondent-home-network-mobile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



Indirect Routing: moving between networks

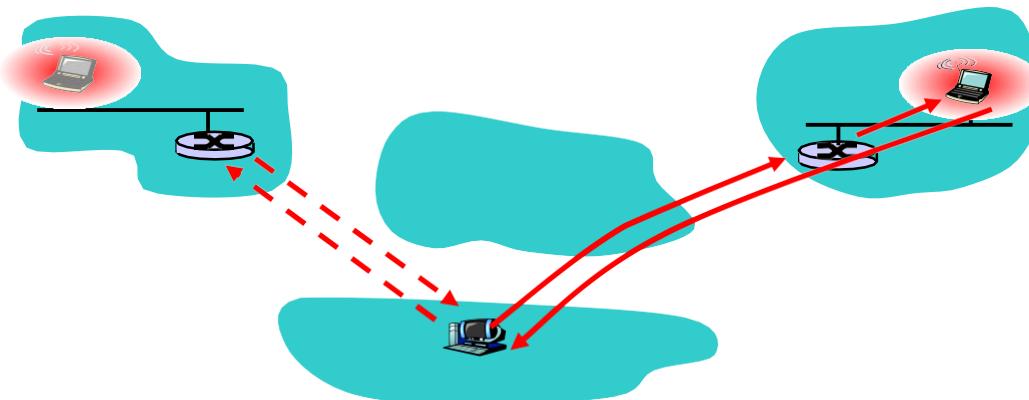
- ❖ suppose mobile user moves to another network
 - registers with new foreign agent
 - new foreign agent registers with home agent
 - home agent update care-of-address for mobile
 - packets continue to be forwarded to mobile (but with new care-of-address)
- ❖ mobility, changing foreign networks
transparent: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

Mobility via Direct Routing



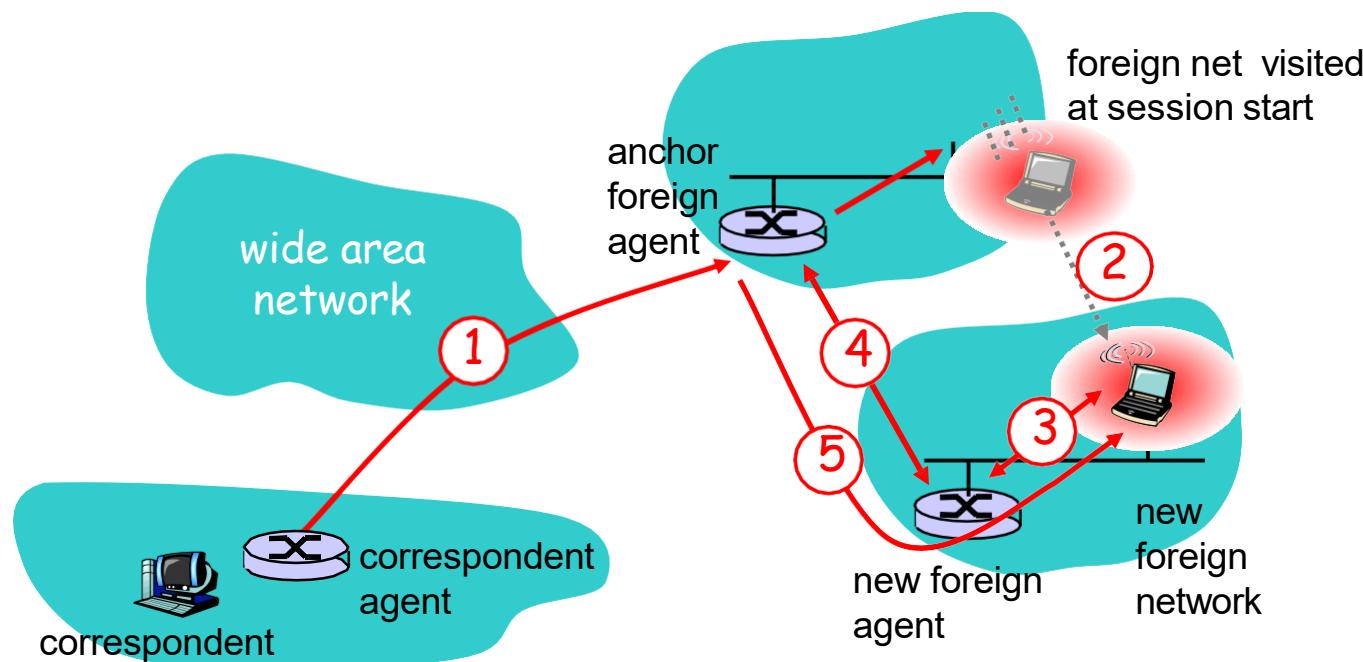
Mobility via Direct Routing: comments

- ❖ 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)

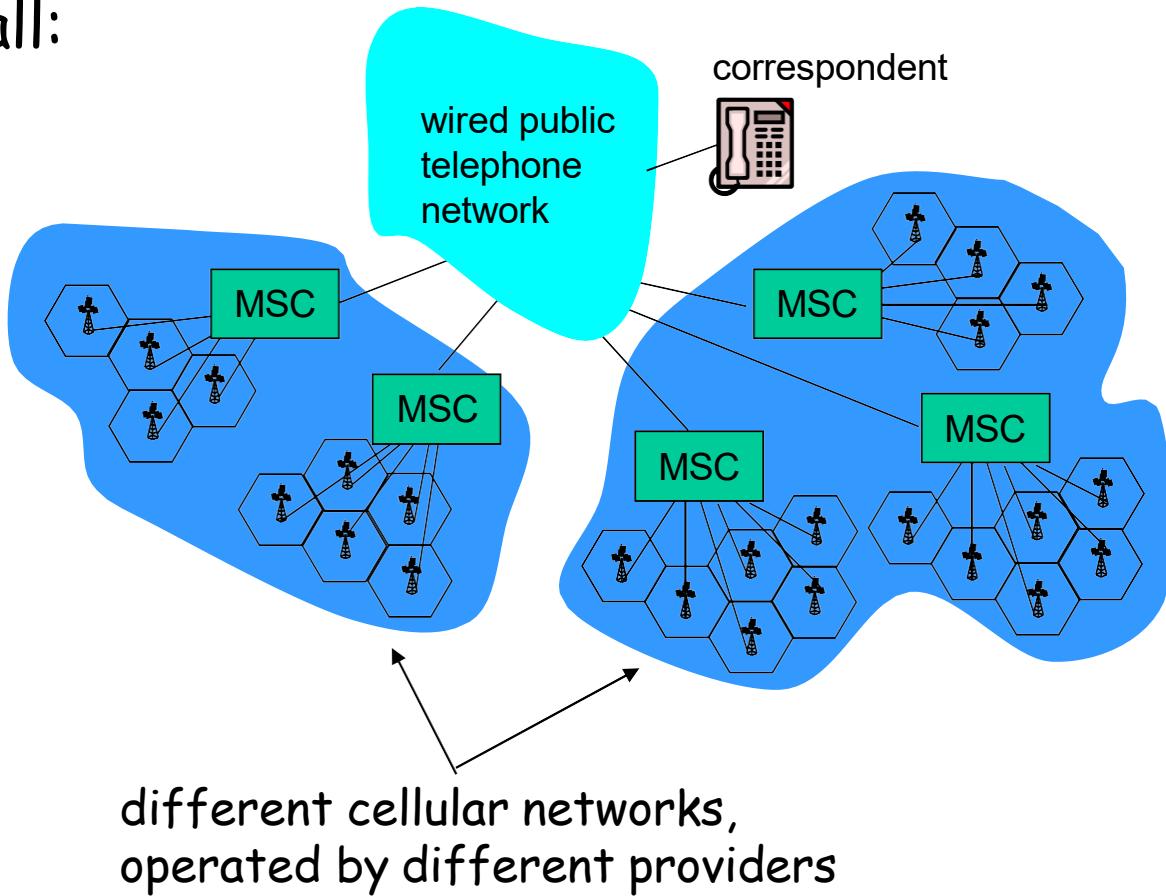


Mobile IP

- ❖ 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

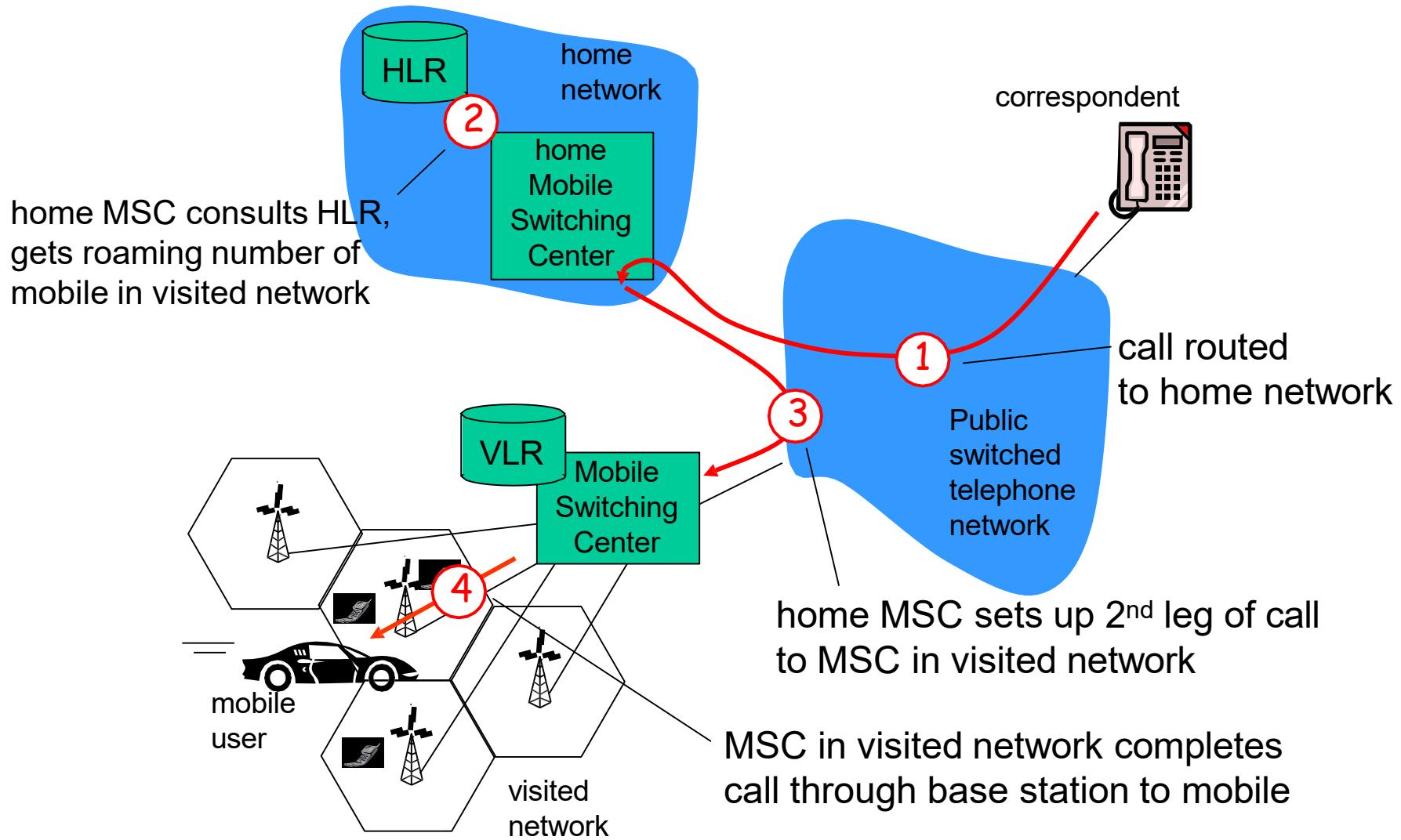
recall:



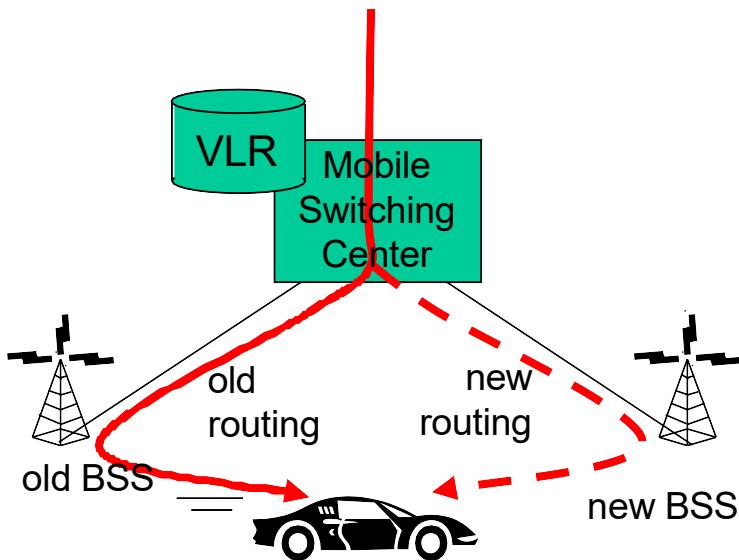
Handling mobility in cellular networks

- ❖ **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

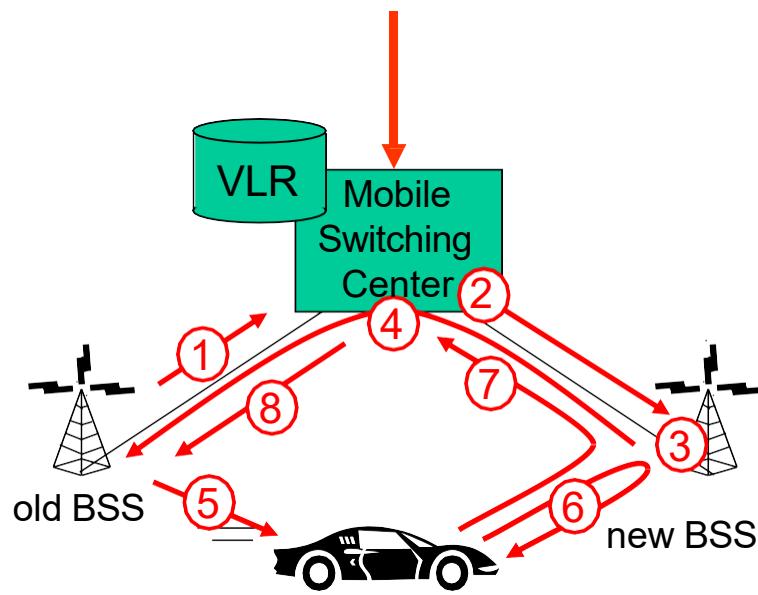


GSM: handoff with common MSC



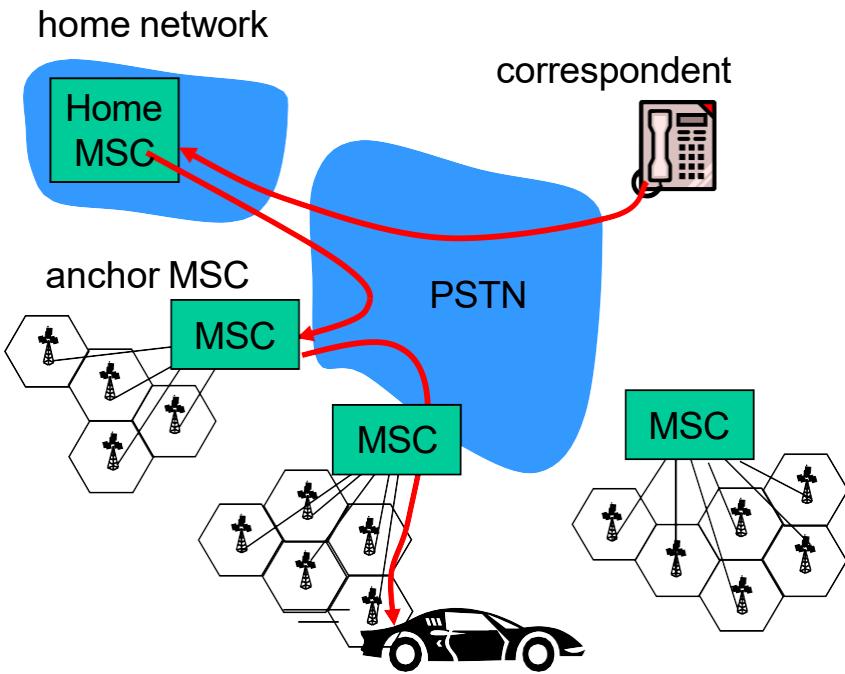
- ❖ Handoff goal: route call via new base station (without interruption)
- ❖ reasons for handoff:
 - stronger signal to/from new BSS (continuing connectivity, less battery drain)
 - load balance: free up channel in current BSS
 - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)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

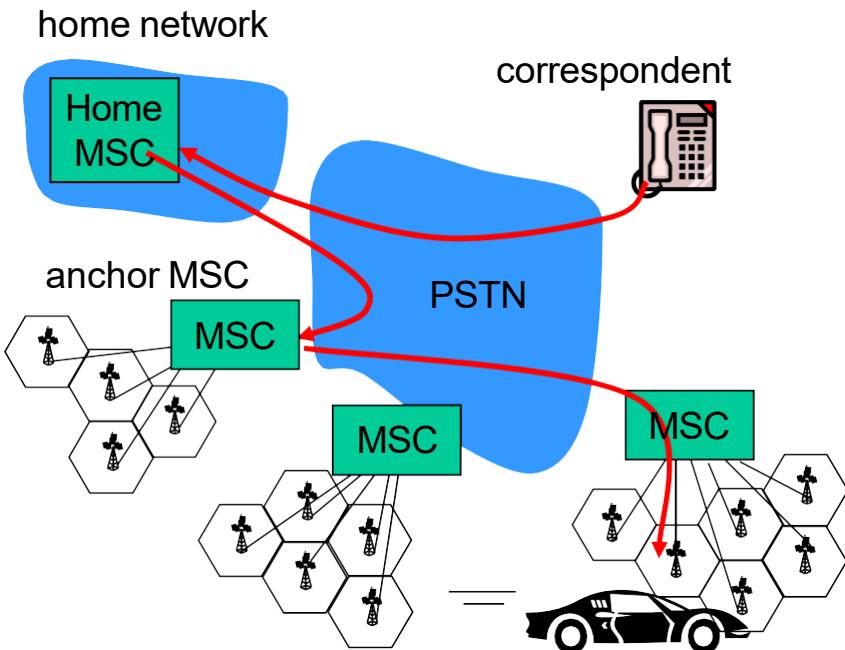
GSM: handoff between MSCs



(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