HSLU Hochschule Luzern

5G Mobile Networks, Technologies & Security

Kernkonzepte der mobilen Kommunikation

Informatik
12. April 2024

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Agenda

1. **Grundbegriffe und –konzepte - Einheit 3**
   (...)
   4. Zugriffsarten
   5. Power Control und Cell Breathing
   6. GSM-FDMA/TDMA-Übertragungsverfahren
   7. UMTS-CDMA-Übertragungsverfahren
   8. Mobility in GSM, LTE und UMTS

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Grundbegriffe und –konzepte – Einheit 3

Zielsetzung

- Kennenlernen von ausgewählten Konzepten des Mobilfunks
- Definition von Mobilität und Unterstützung von mobilen Nutzern im Mobilfunk
- Eigenschaften einer drahtlosen Verbindung: Signal-Ausbreitung, Pfadverlust und Interferenz
- Mehrbenutzerzugriff im Mobilfunk bei verschiedenen Generationen

Praktische Übung

- Wissensfragen

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Mobility (Wiederholung)

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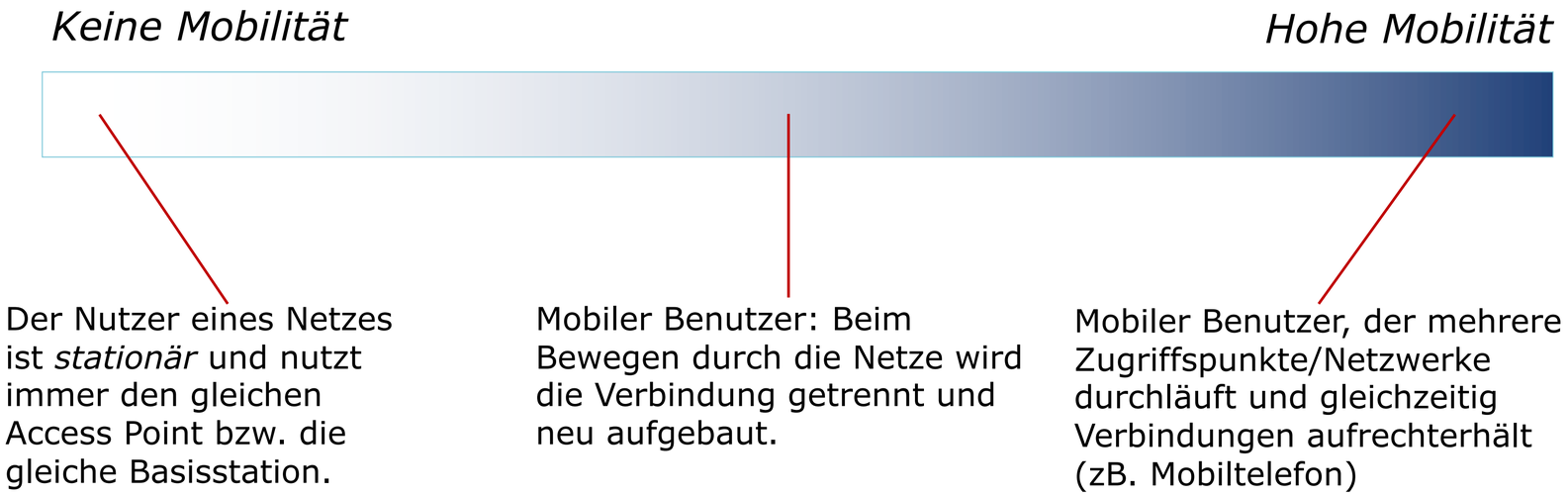
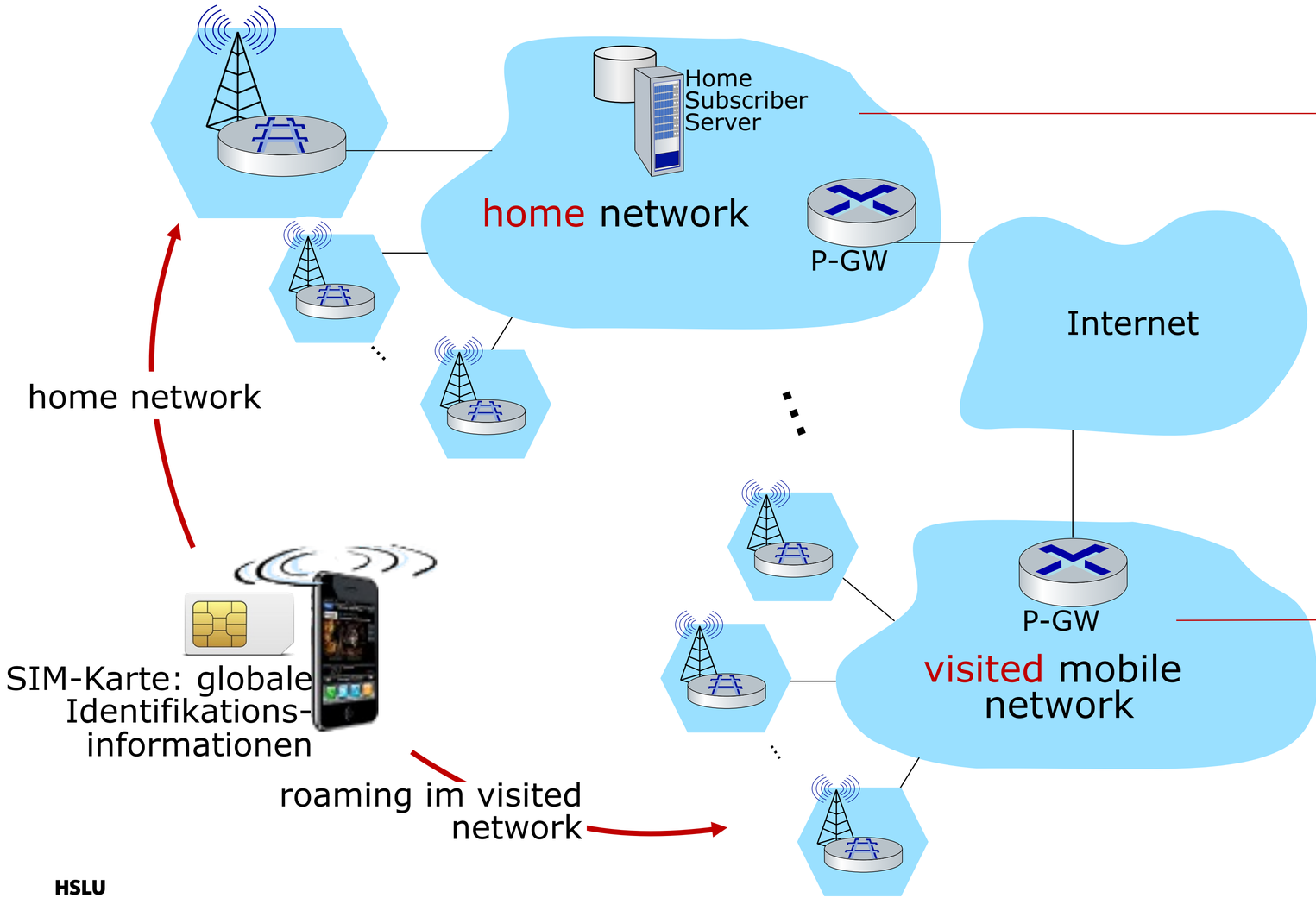
Wiederholung: Was ist Mobilität?

- Prinzipielle Überlegungen: Mobilität aus der Netzwerkperspektive
- Mobilität ist eine Herausforderungen der mobile Kommunikation: Geräte wechseln ihren Standort



- Steigender Aufwand für das Netzwerk → benötigt Funktionalität
- Steigender Komfort für den Nutzer (kein Verbindungsabbruch)

Home network & visited network



home network

- Swisscom oder Salt – je nach Vertrag
- Heimnetzwerk HSS speichert Identifikations-, Vertrags- und Dienstinformationen

visited network

- Visited network ist jedes andere Netzwerk als das Heimnetzwerk
- Provider hält Verträge und Servicevereinbarungen mit anderen Netzwerken: um Zugriff bei Besuchen zu ermöglichen

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Mobility in GSM

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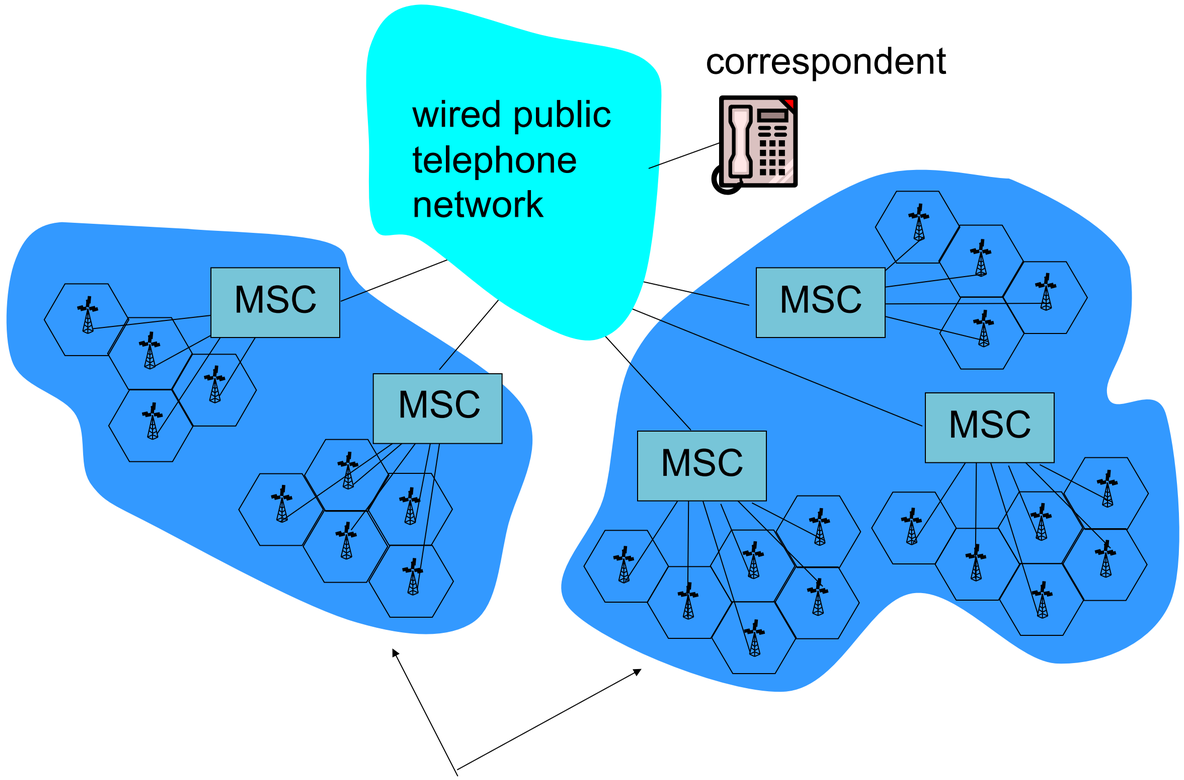
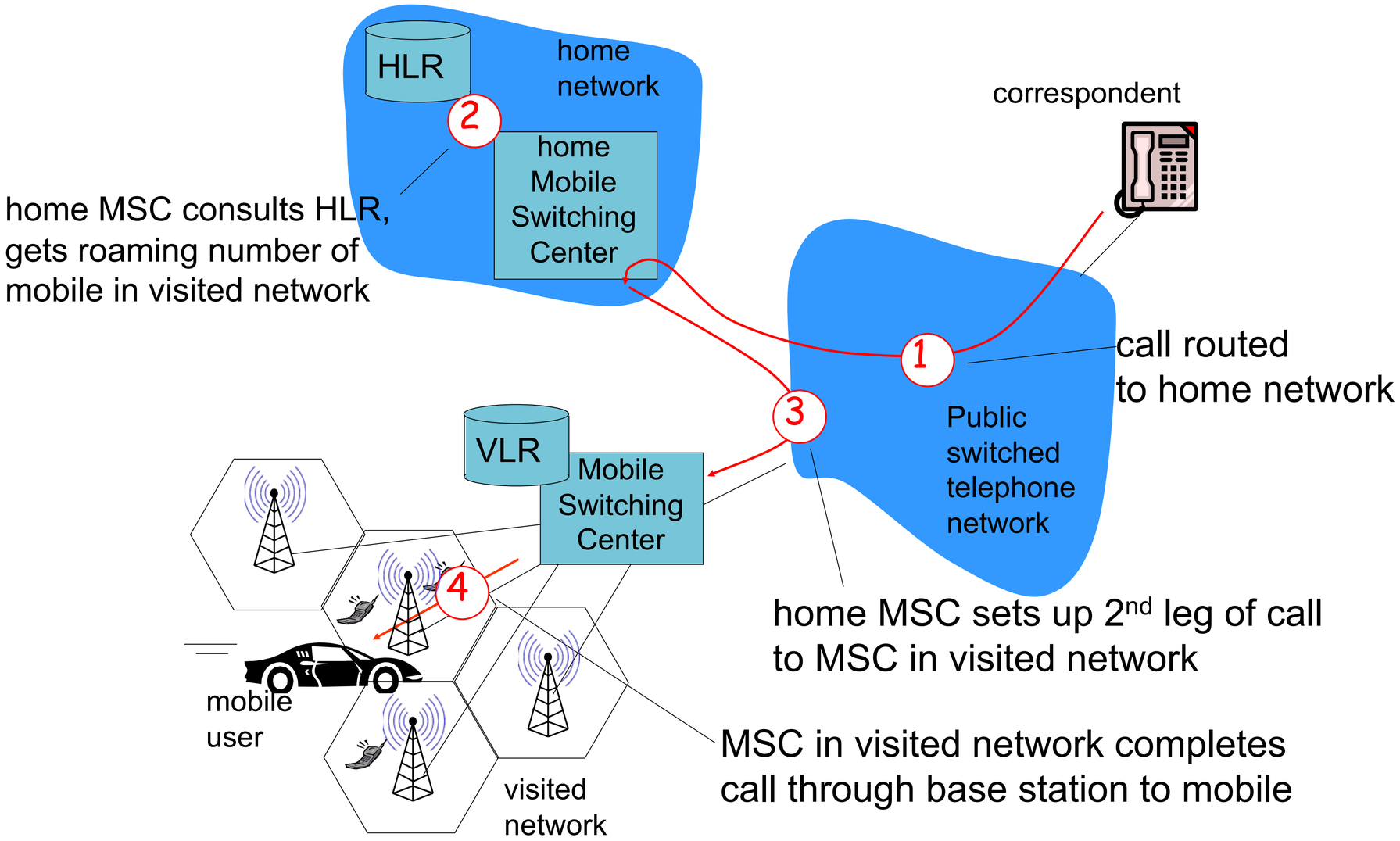
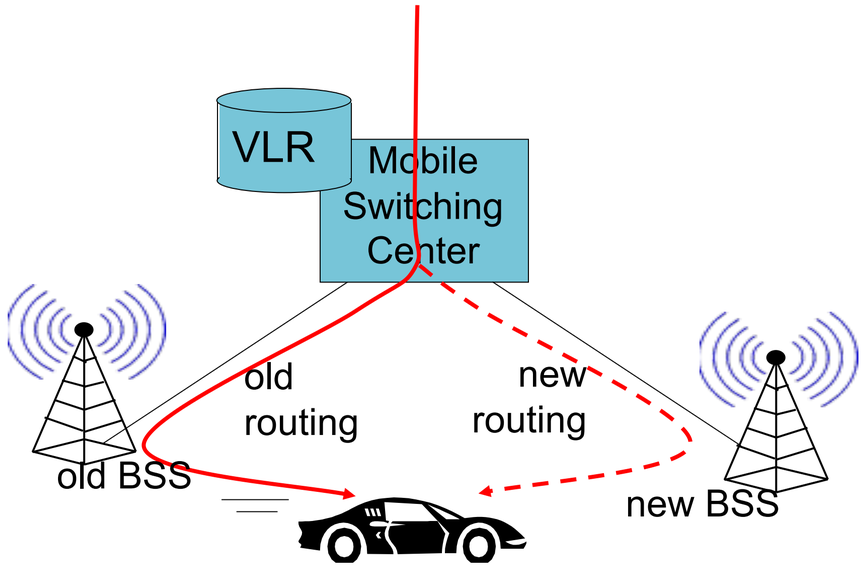
Komponenten der Architektur von Mobilfunknetzen



GSM: indirect routing to mobile



GSM: handoff with common MSC



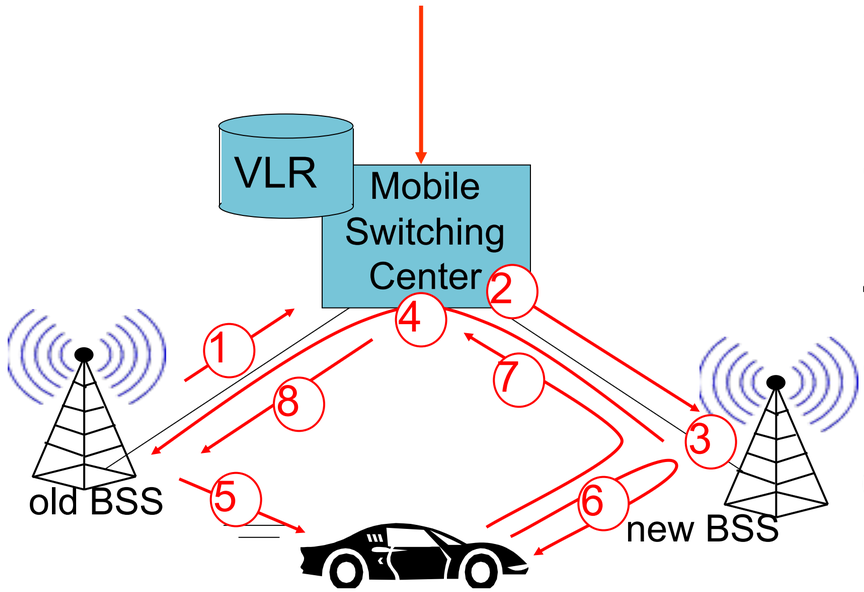
handoff goal: route call via new base station (without interruption)

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

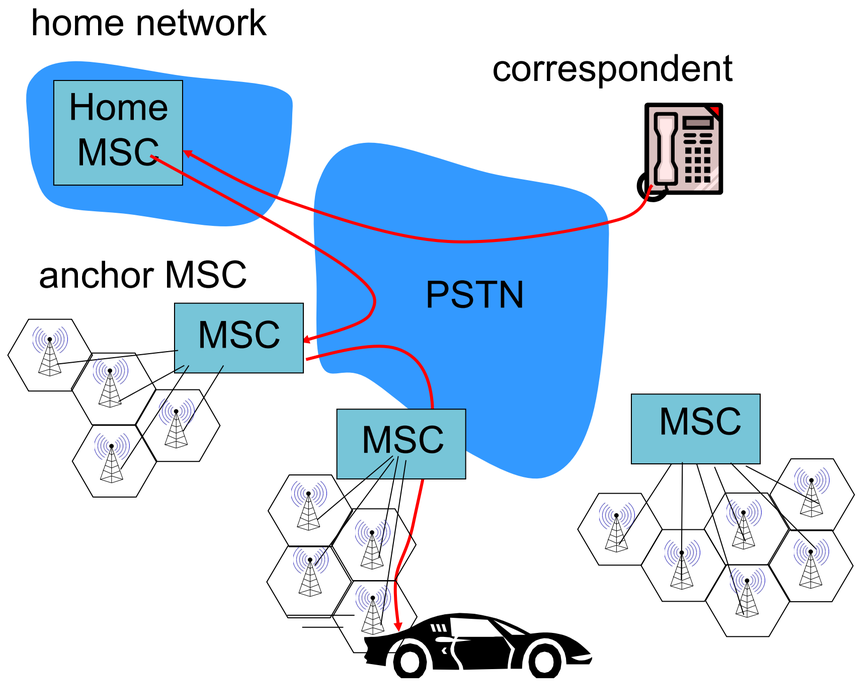
GSM: handoff with common MSC



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



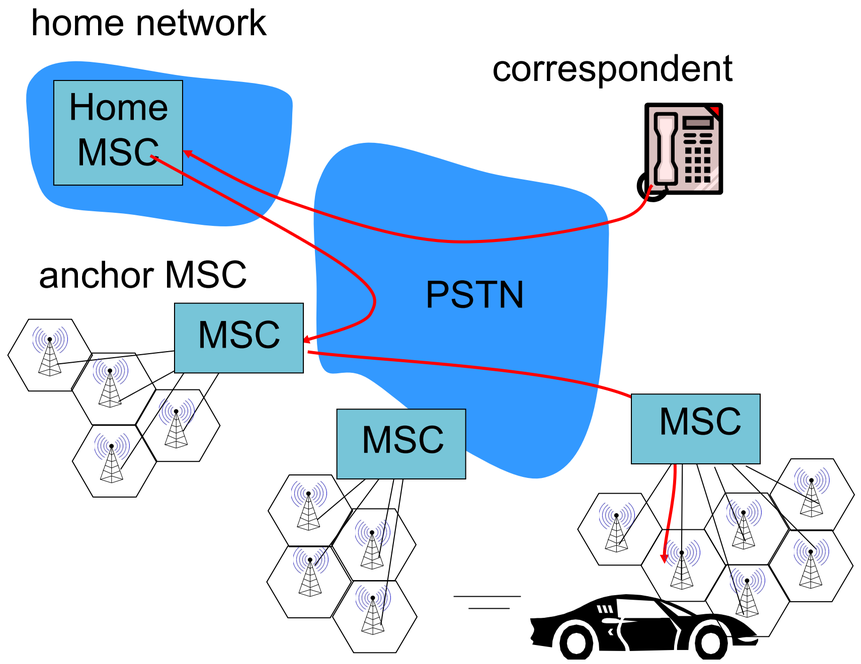
(a) before handoff

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

optional path minimization step to shorten multi-MSC chain

GSM: handoff between MSCs



(b) after handoff

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Mobility in UMTS

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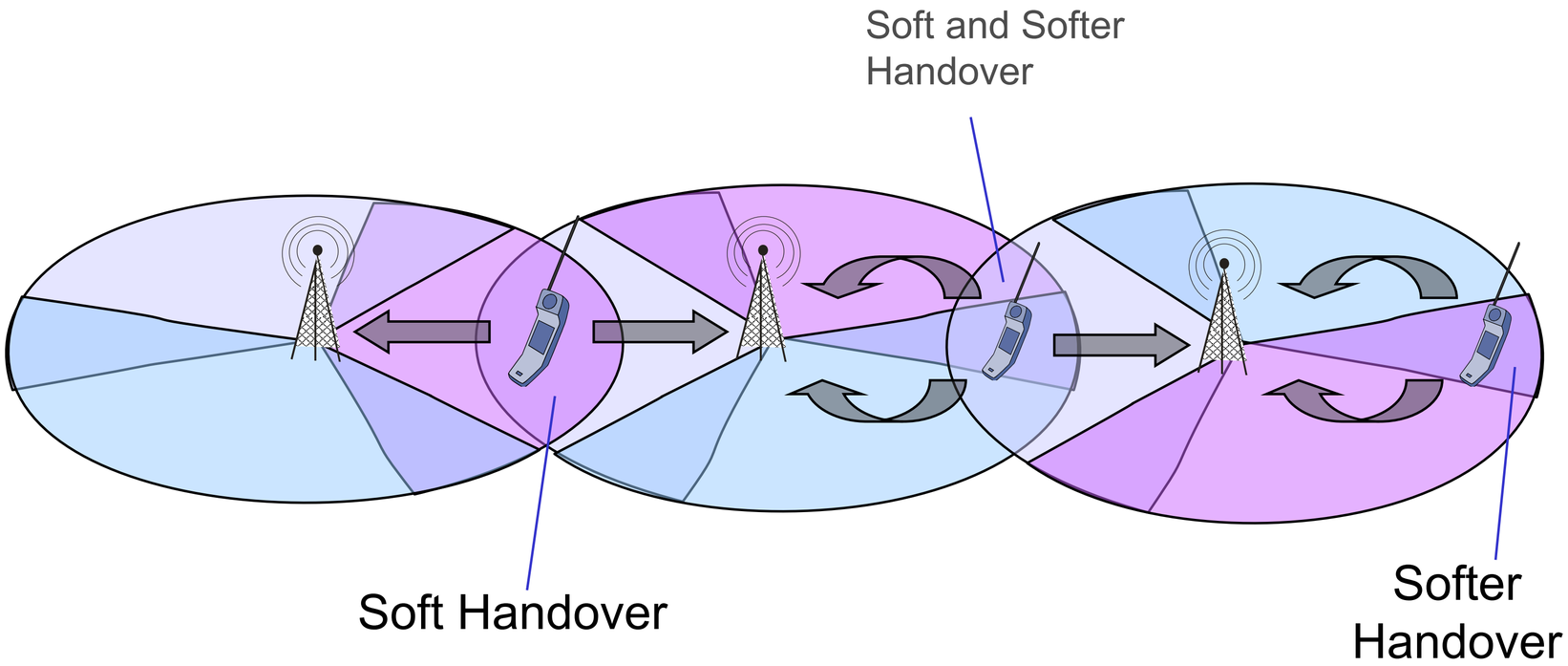
UMTS: Soft-Handover and Softer-Handover

- **Hard Handover**: Break Before Make, link between NodeB & UE is broken, network decides handover to new NodeB
- **Soft Handover**: a mobile station is connected to several NodeBs
- **Softer Handover**: a mobile station is connected to several sectors of one NodeB



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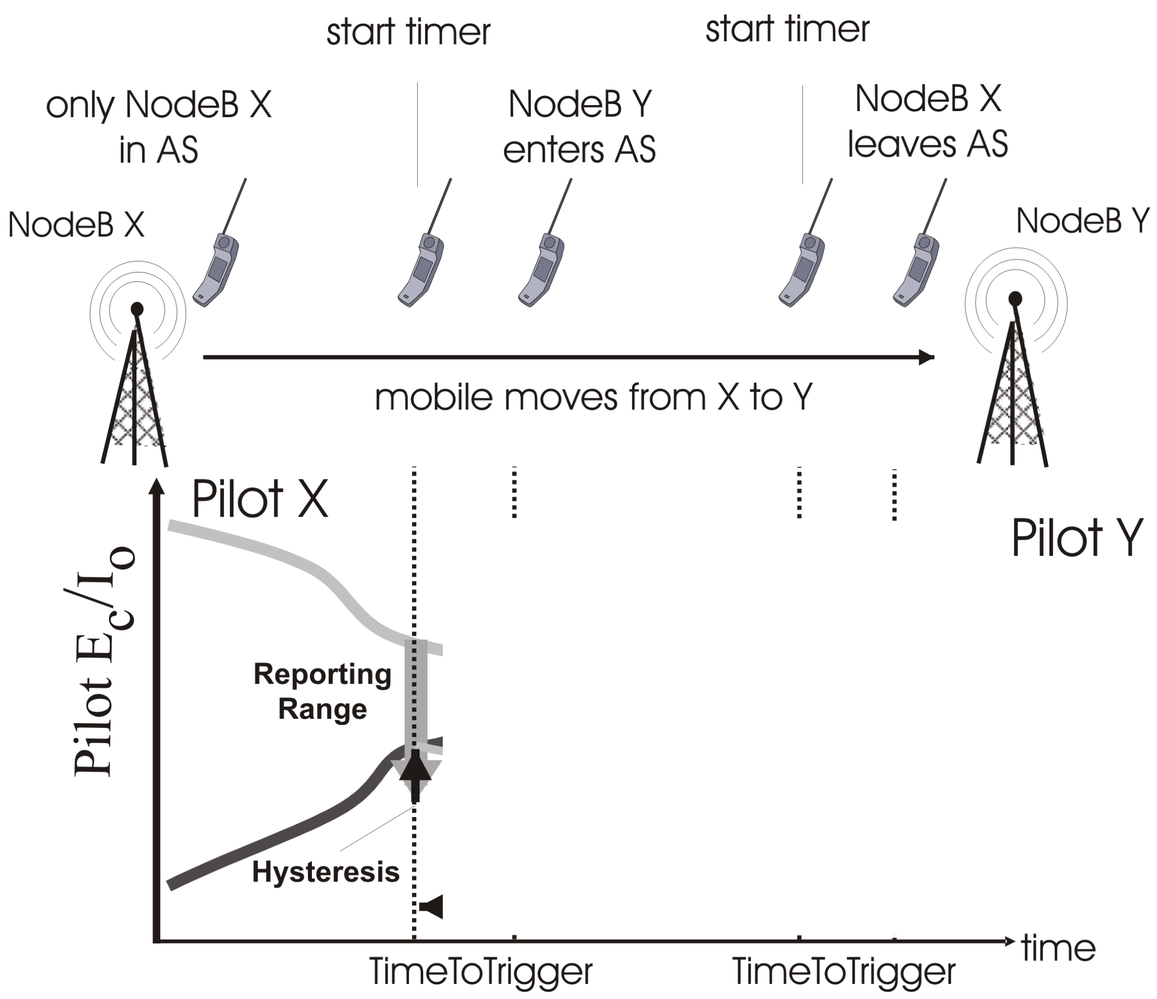


Example: a mobile station moves from NodeB x to NodeB y.

Pilot signal transmitted by every NodeB (30dBm)

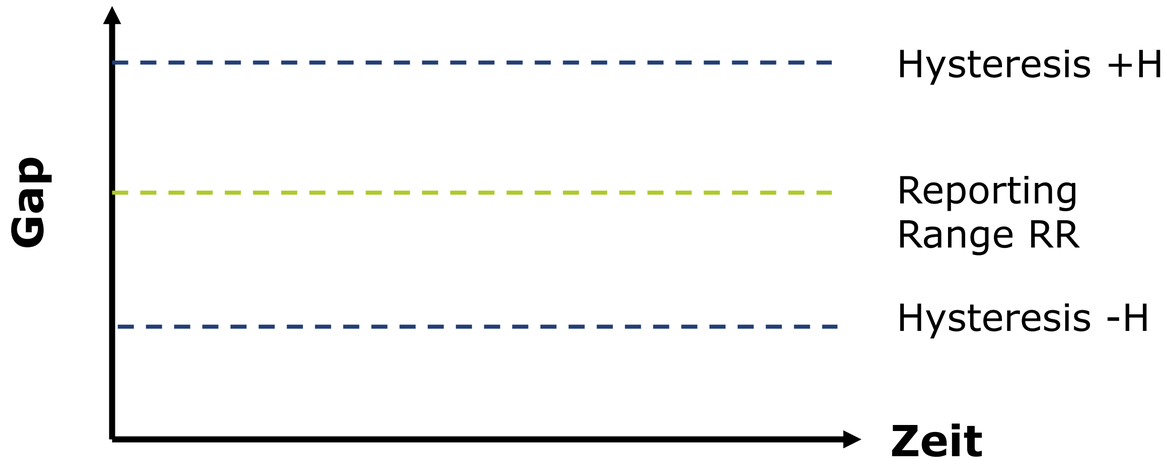
Reporting Range (RR): decides when a new link is considered for handover

Active Set of a mobile station: Set of the NodeBs the mobile station is connected to

Handover control defines the Active Set of a mobile station

Hysteresis

- Gesendetes Pilotsignal von jeder NodeB (30dBm)
- Ablauf
  - Mobiltelefon misst die Signalstärke der stärksten Basisstation NodeB
  - Mobiltelefon misst alle andere Basisstationen, die empfangen werden
  - Gap: Unterschied zum „stärksten“ NodeB



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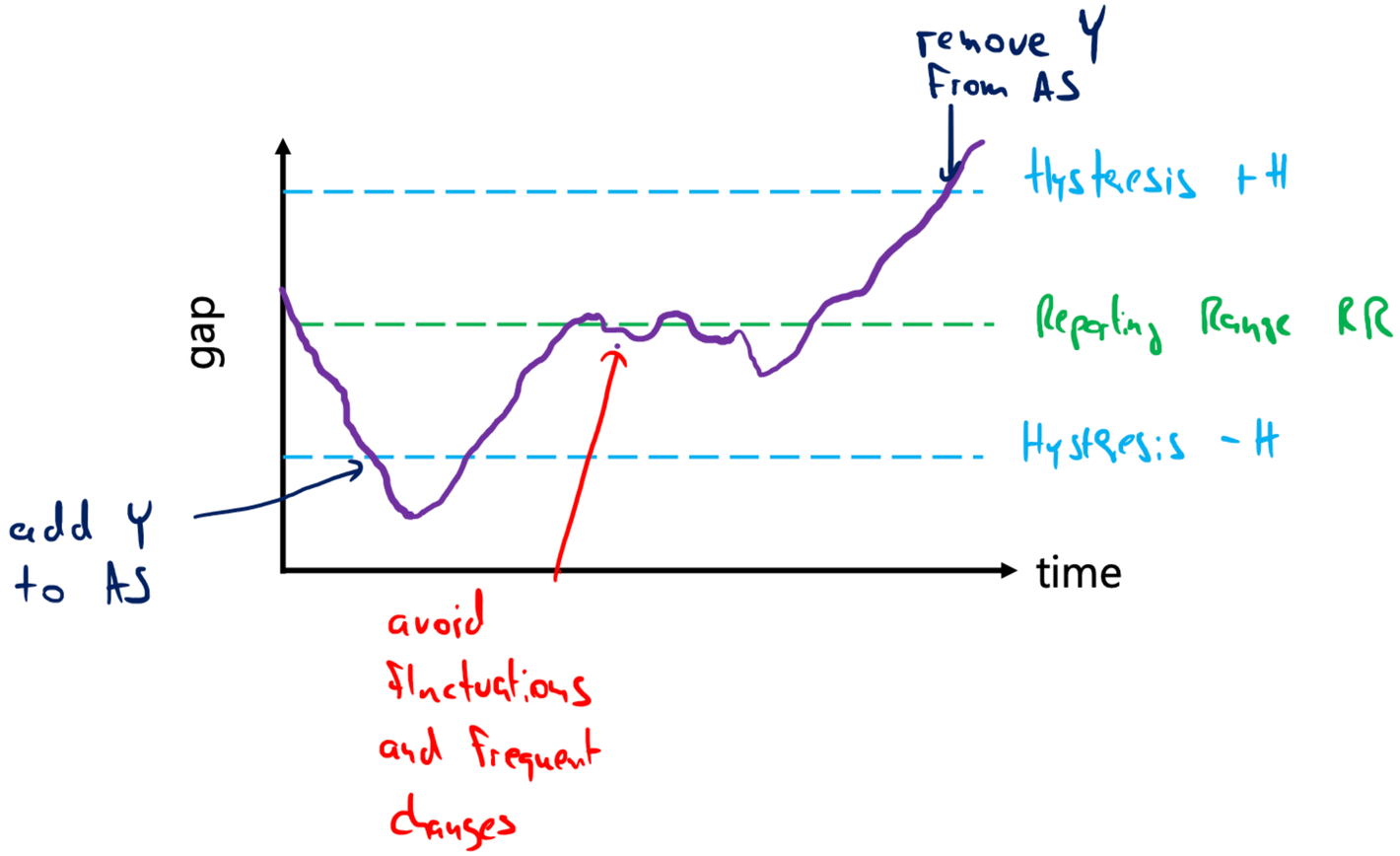

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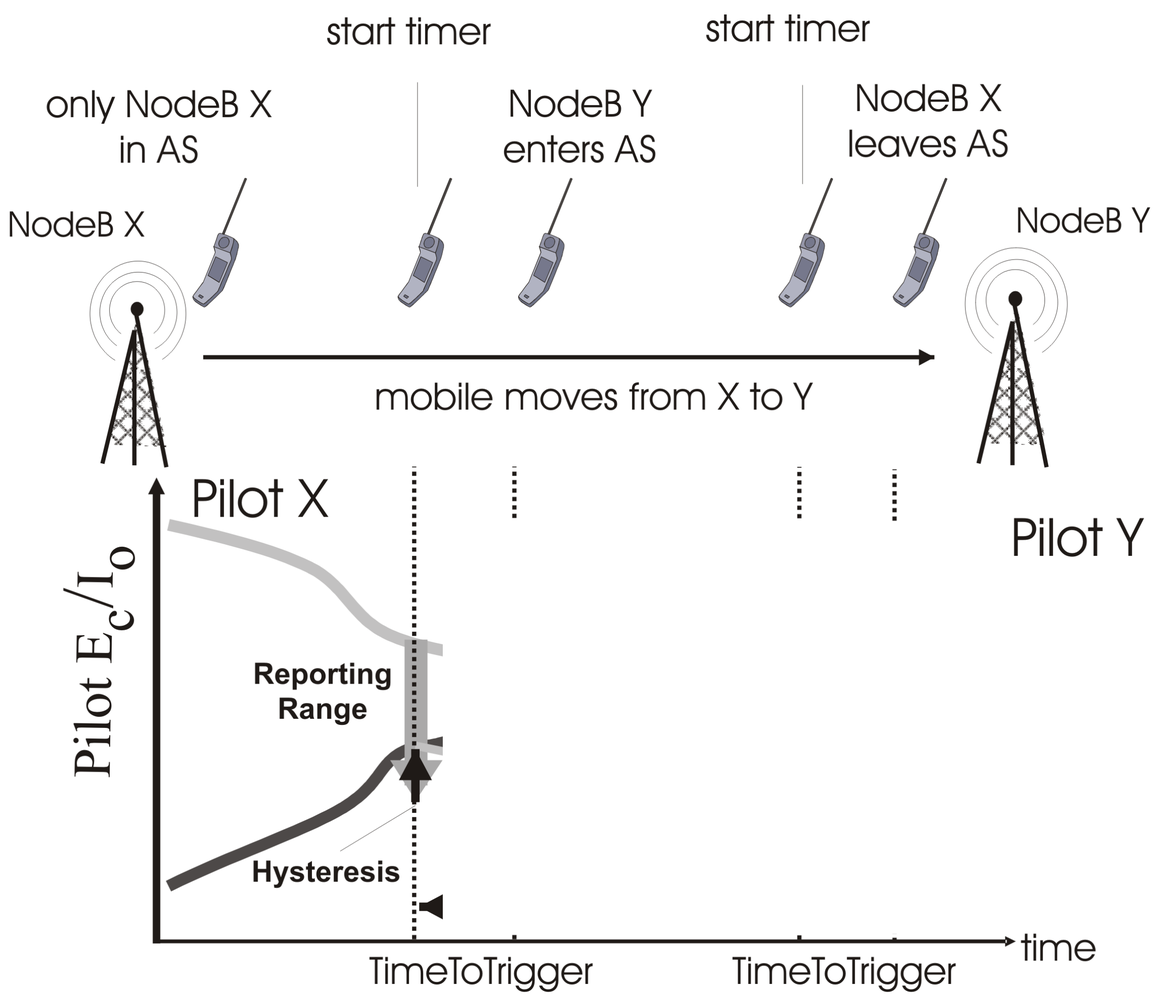

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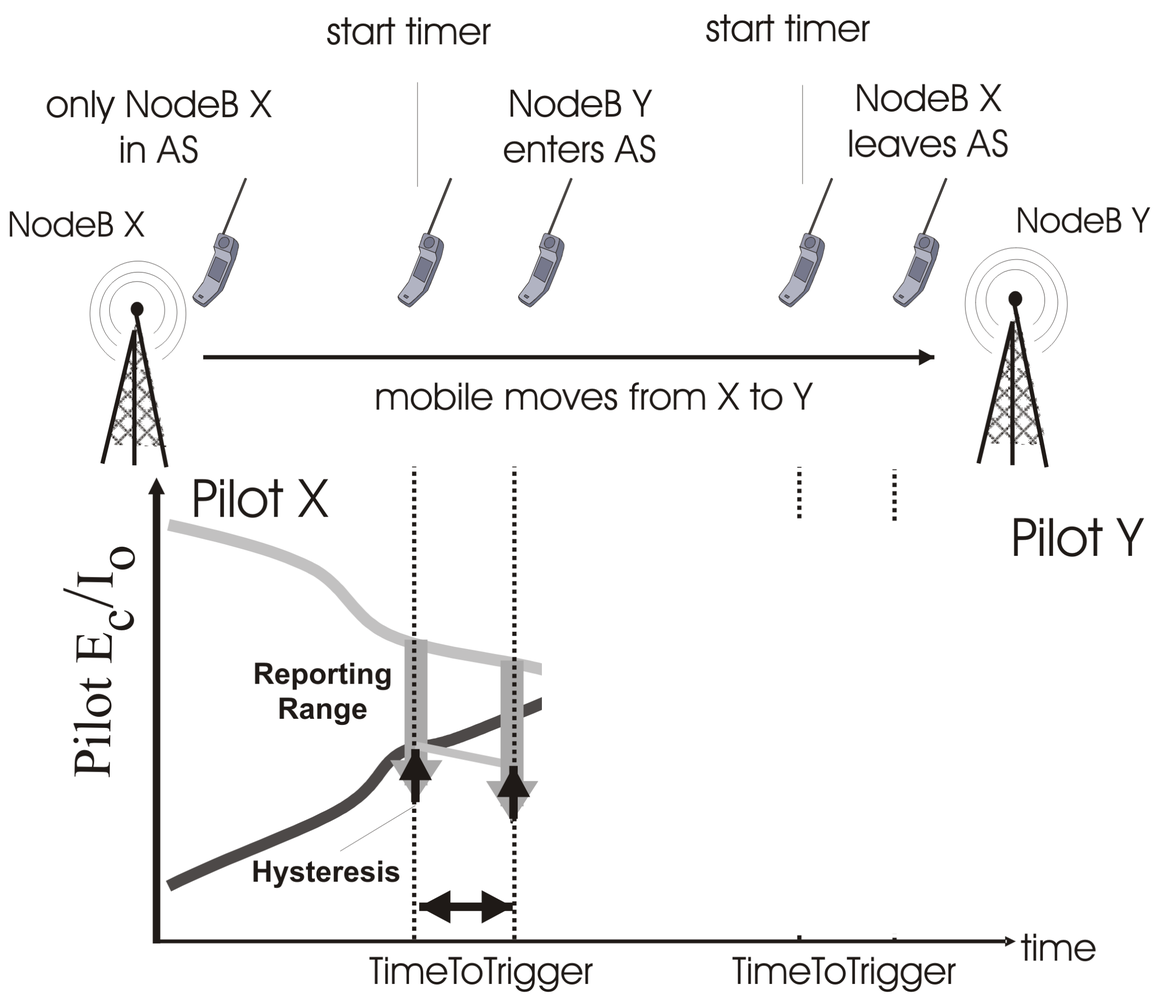

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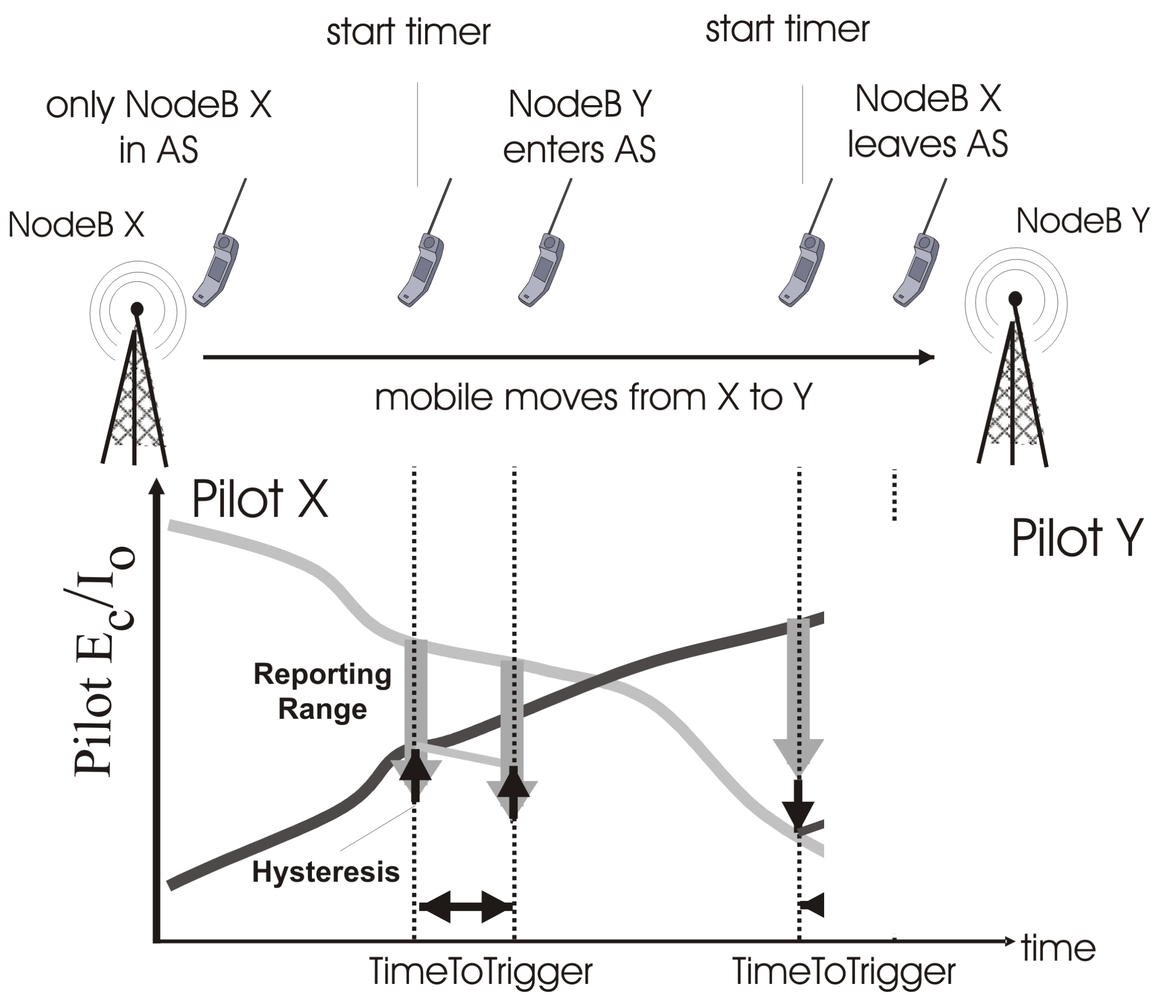

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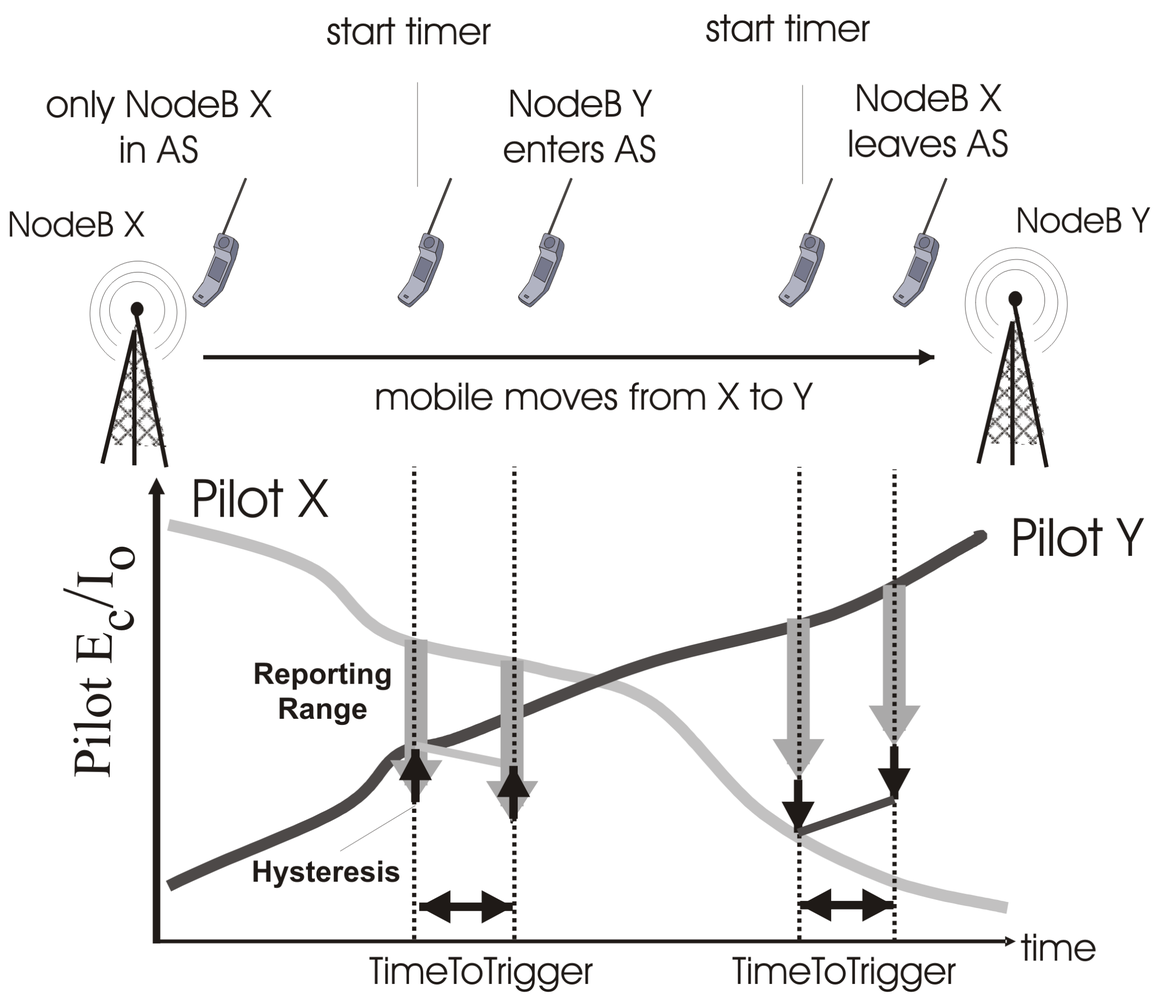

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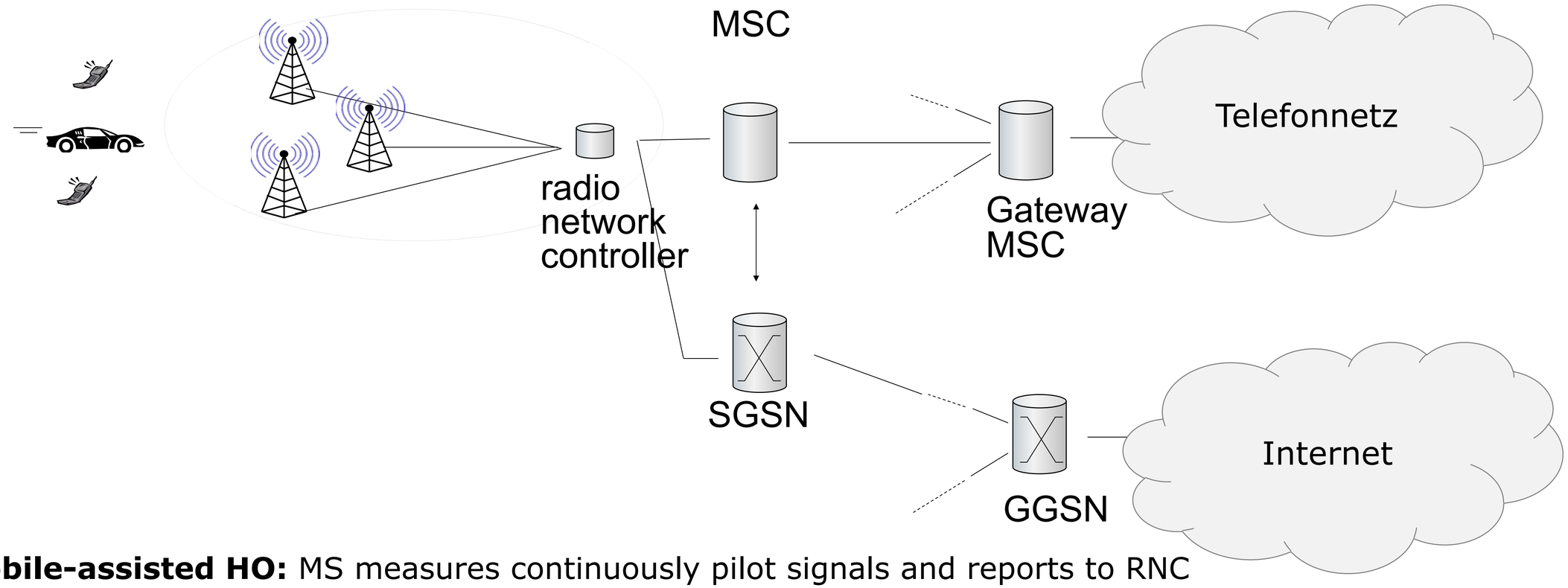
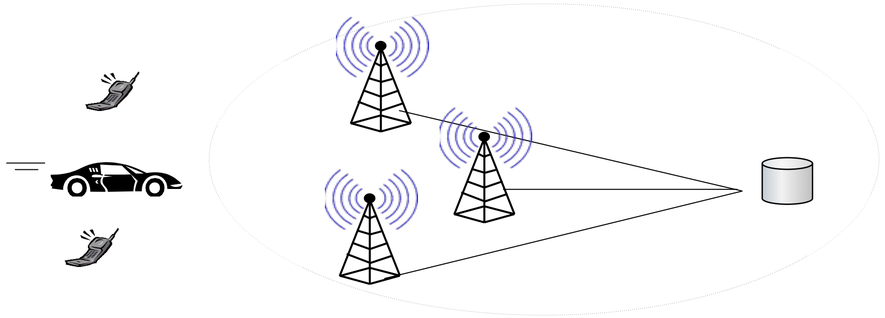
Mobile-assisted & Network-based Handover



- **Mobile-assisted HO:** MS measures continuously pilot signals and reports to RNC
- **Network-based HO:** RNC decides handover actions
  - radio link addition, radio link removal → AS with separate channels from each NodeB in AS to the mobile
  - call admission control, e.g. overload in cell

Soft and Softer Handover: Signal Combination

- Mobile maintains active radio links to more than one NodeB
- Combination of the signals from multiple active radio links
- Soft Handover
  - Mobile connected to (at least) two different NodeBs
  - Uplink: signals are combined in the RNC
- Softer Handover
  - Mobile is connected to two sectors within one NodeB
  - Uplink: signals are combined in the NodeB instead of RNC
- Uplink: no additional signal is transmitted by mobile
  - HO general increase performance
- Downlink: each new link causes interference to other users
  - Trade-off: interference vs. performance



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Mobility in LTE

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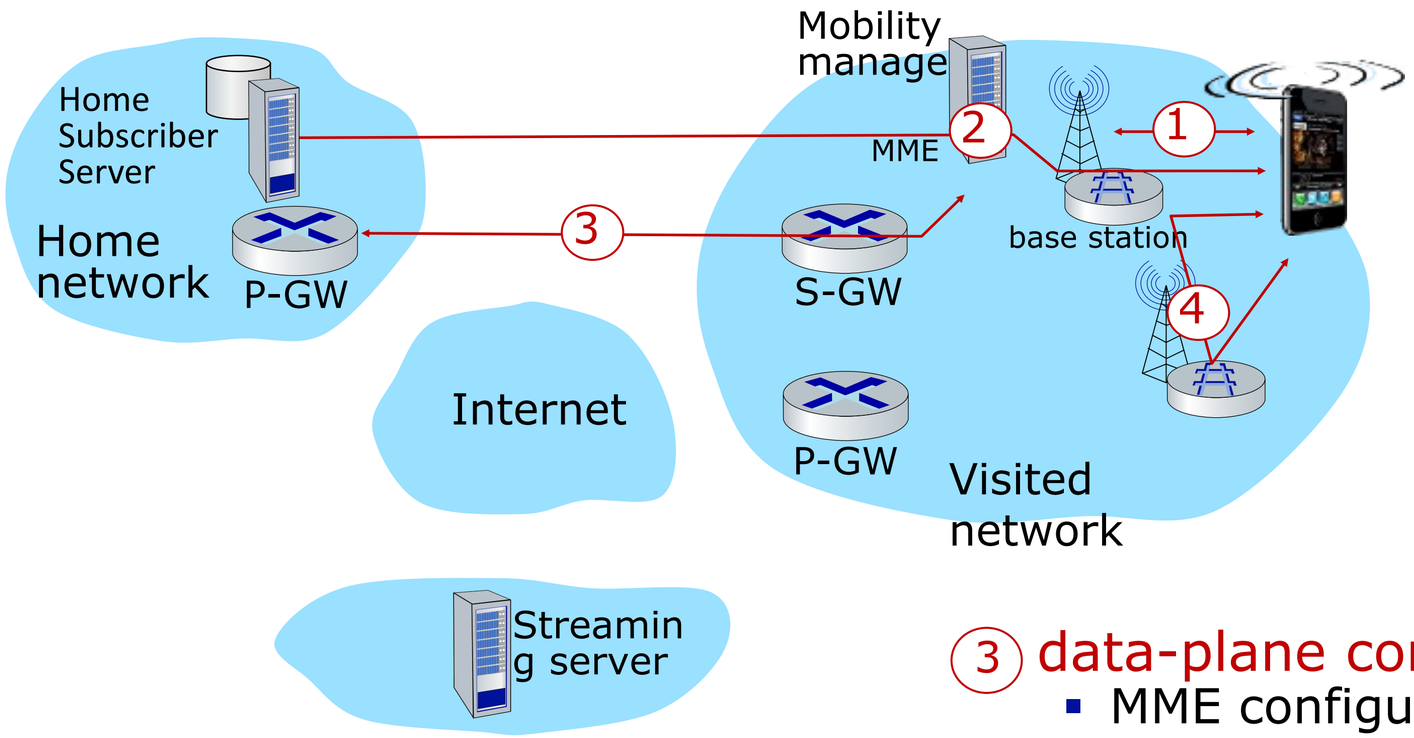
Mobility in 4G networks: major mobility tasks



1 **base station association:**

- mobile provides IMSI – identifying itself, home network

2 **control-plane configuration:**

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

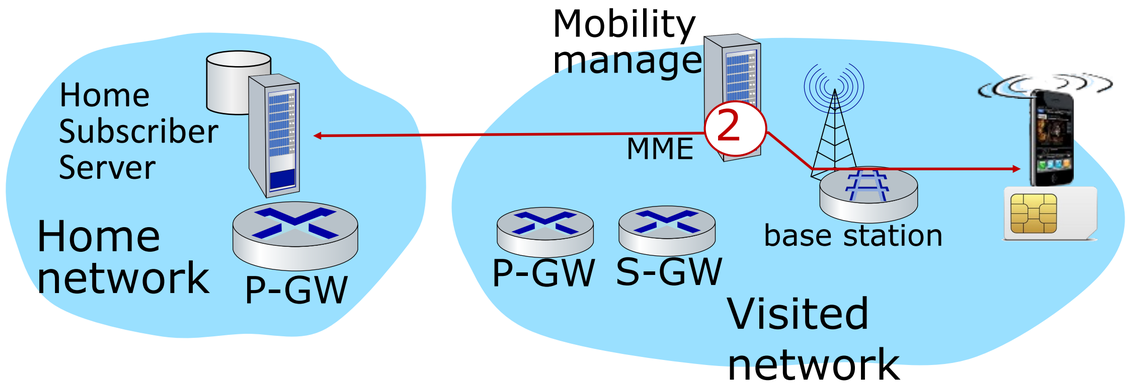
3 **data-plane configuration:**

- 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

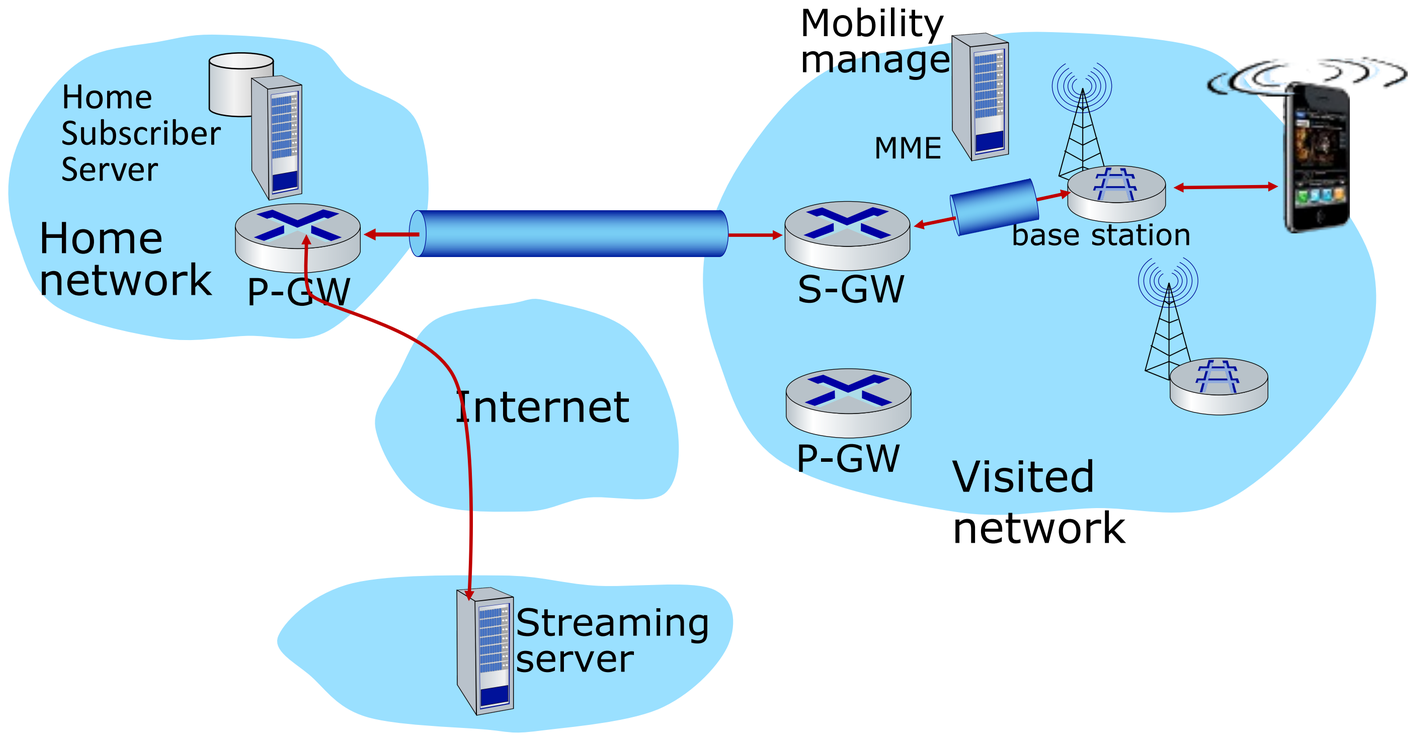
- retrieve authentication, encryption, network service information
- home HHS knows mobile now resident in visited network

BS, mobile select parameters for BS-mobile data-plane radio channel

Configuring data-plane tunnels for mobile

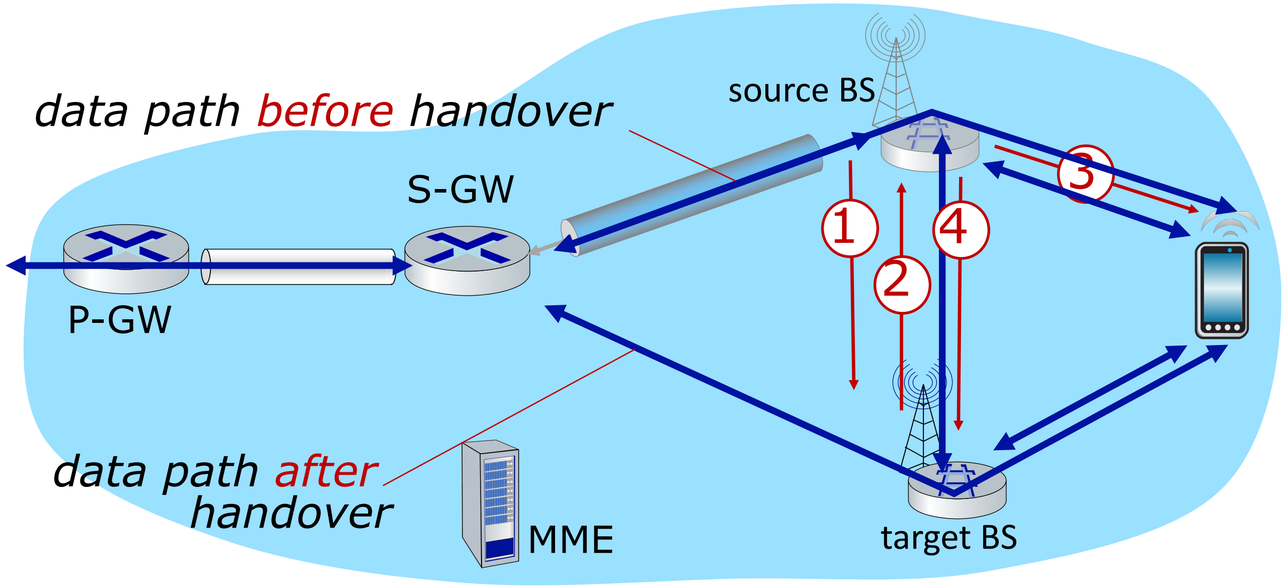
S-GW to BS tunnel: when mobile changes base stations, simply change endpoint IP address of tunnel

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



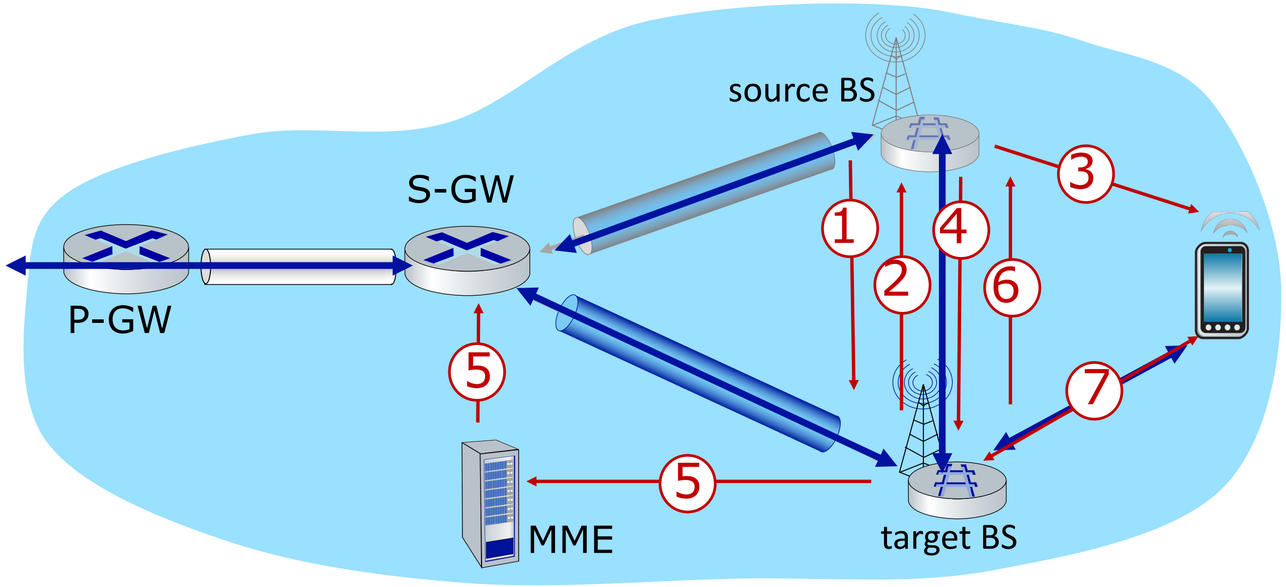
1. current (source) BS selects target BS, sends *Handover Request message* to target BS

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

Arten von Handovers

Unterscheidung nach beteiligten Netzelementen

1. **Intra-Cell Handover:** Es wird auf eine andere Frequenz oder einen anderen Zeitschlitz derselben Zelle gewechselt (GSM, GPRS).

2. **Inter-Cell Handover (Intra-BSC Handover):** Es wird zu einer Nachbarzelle gewechselt, die am selben BSC angeschlossen ist.

3. **Inter-BSC Handover (Intra-MSC Handover):** Beim Handover wird in eine Nachbarzelle gewechselt, die an einen anderen BSC, aber an das gleiche MSC angeschlossen ist.

4. **Inter-MSC Handover:** Beim Handover wird in eine Nachbarzelle gewechselt, die an einen anderen BSC angeschlossen ist, welcher wiederum an ein anderes MSC angeschlossen ist.

5. **Inter-PLMN Handover:** Beim Handover wird in eine Zelle eines anderen Mobilfunknetzes gewechselt.

6. **Inter-System Handover:** Es wird zu einer Zelle gewechselt, die eine andere Mobilfunktechnik benutzt (z. B. Handover zwischen GSM und UMTS).