6. Cellular phone network: GSM, HSCSD, EDGE, GPRS

6.1. Overview of GSM

6.2. GSM Network: Architecture and Concepts

6.3. Data Services in GSM: CSD and HSCSD

6.4. Packet-oriented Data Service: GPRS

6.5. Mobility Management Internet vs. GSM/GPRS

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6.1. Overview of GSM

GSM

- formerly: Groupe Spéciale Mobile (founded 1982)
- now: Global System for Mobile Communication
- Pan-European standard (ETSI, European Telecommunications Standardisation Institute)
- simultaneous introduction of essential services in three phases (1991, 1994, 1996) by the European telecommunication administrations (Germany: D1 and D2)
  ➔ seamless roaming within Europe possible
- today many providers all over the world use GSM (more than 184 countries in Asia, Africa, Europe, Australia, America)
- more than 747 million subscribers
- more than 70% of all digital mobile phones use GSM
- over 10 billion SMS per month in Germany, > 360 billion/year worldwide

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Characteristics of GSM

JS

Communication
- mobile, wireless communication; support for voice and data services

Total mobility
- international access, chip-card enables use of access points of different providers

Worldwide connectivity
- one number, the network handles localization

In Germany **networks A, B, C**
- analogue systems
- restricted functionality (e.g. location, roaming, …)

High capacity
- better frequency efficiency, smaller cells, more customers per cell

High transmission quality
- high audio quality and reliability for wireless, uninterrupted phone calls at higher speeds (e.g., from cars, trains)

Security functions
- access control, authentication via chip-card and PIN

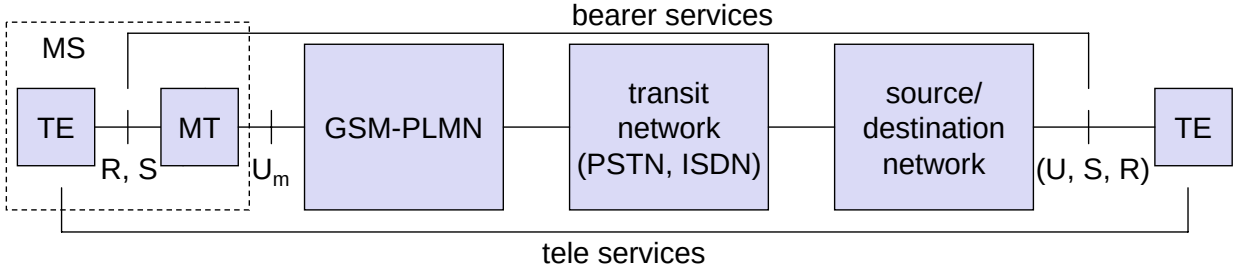
In Germany **GSM networks D, E**
- digital systems
- so called “2nd generation”

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GSM: Mobile Services

JS

- **GSM offers**
  - several types of connections
    - voice connections, data connections, short message service
  - multi-service options (combination of basic services)
- **Three service domains**
  - Bearer Services
  - Telematic Services
  - Supplementary Services



TE = Terminal Equipment
MT = Mobile Termination

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6.2. Architecture of the GSM system *JS*

- **GSM is a PLMN (Public Land Mobile Network)**
  - several providers setup mobile networks following the GSM standard within each country
  - components
    - MS (mobile station)
    - BS (base station)
    - MSC (mobile switching center)
    - LR (location register)
  - subsystems
    - RSS (radio subsystem): covers all radio aspects
    - NSS (network and switching subsystem): call forwarding, handover, switching
    - OSS (operation subsystem): management of the network

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Ingredients 1: Mobile Phones, PDAs & Co. *JS*



The visible but smallest part of the network!

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Ingredients 2: Antennas

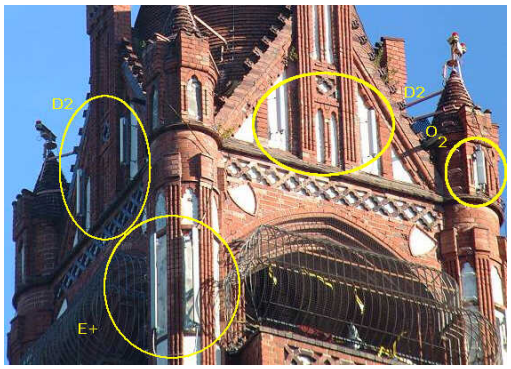
JS













Still visible – cause many discussions…

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Ingredients 3: Infrastructure 1

JS



Base Stations



Cabling



Microwave links



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Ingredients 3: Infrastructure 2 JS



Switching units



Management

Data bases

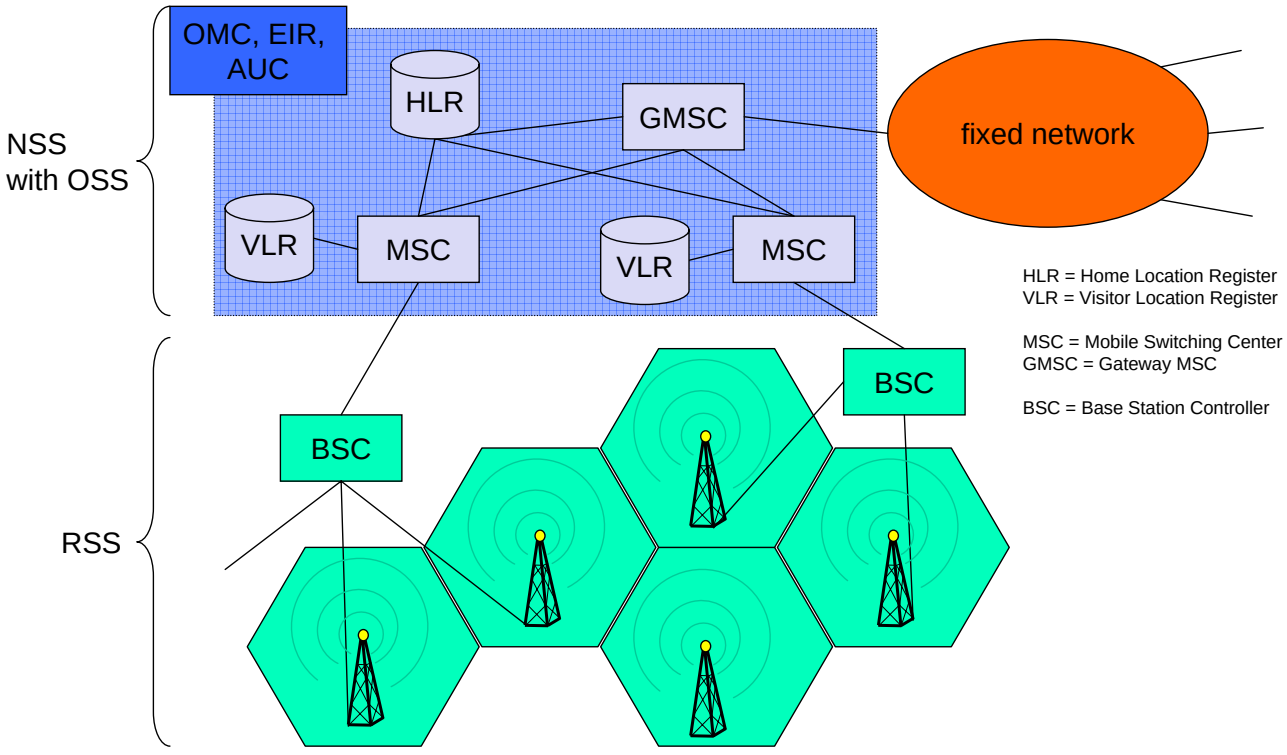
Monitoring

Not „visible“, but comprise the major part of the network (also from an investment point of view…)



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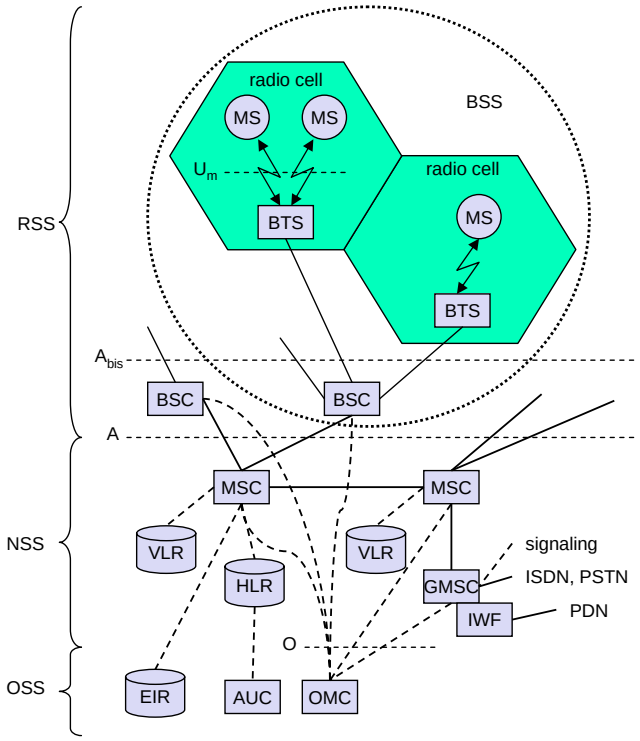
GSM Overview JS



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GSM Elements and Interfaces

JS



Interfaces

- U_m
- A_{bis}
- A
- O

MS = Mobile Station
BTS = Base Transceiver Station

BSC = Base Station Controller

HLR = Home Location Register
VLR = Visitor Location Register

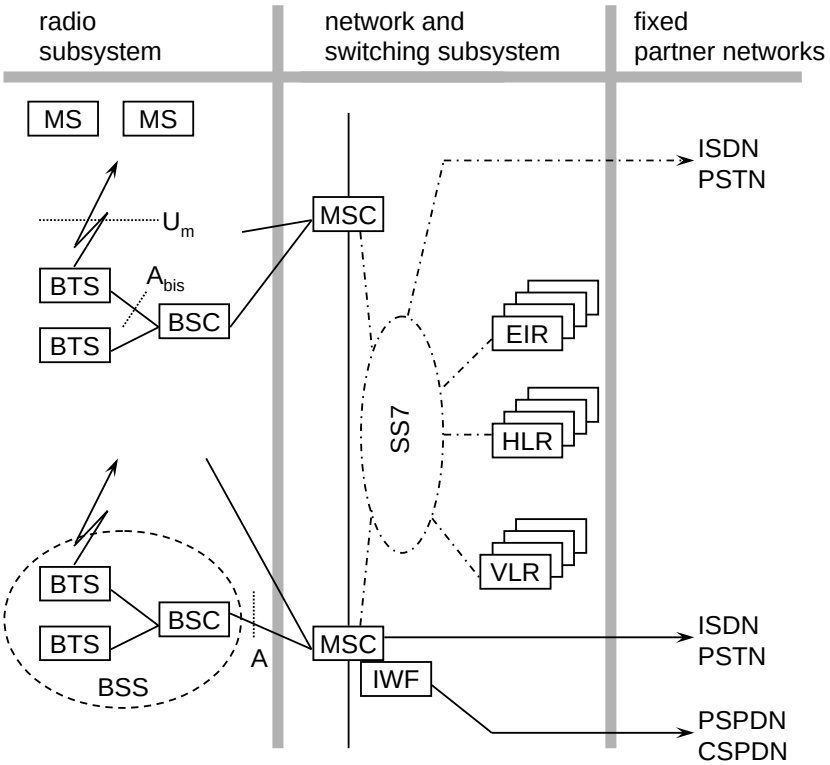
MSC = Mobile Switching Center
GMSC = Gateway MSC
IWF = Interworking Function

details on following slides

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GSM System Architecture

JS



MS = Mobile Station
BTS = Base Transceiver Station

BSC = Base Station Controller

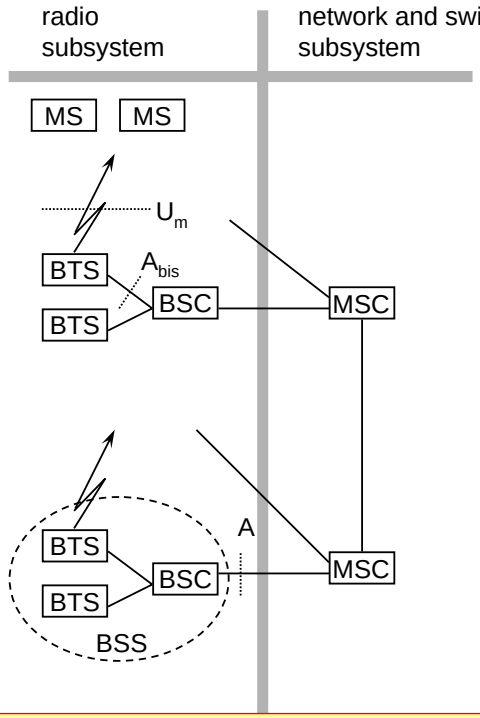
HLR = Home Location Register
VLR = Visitor Location Register

MSC = Mobile Switching Center
GMSC = Gateway MSC
IWF = Interworking Function

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System Architecture – Radio Subsystem JS

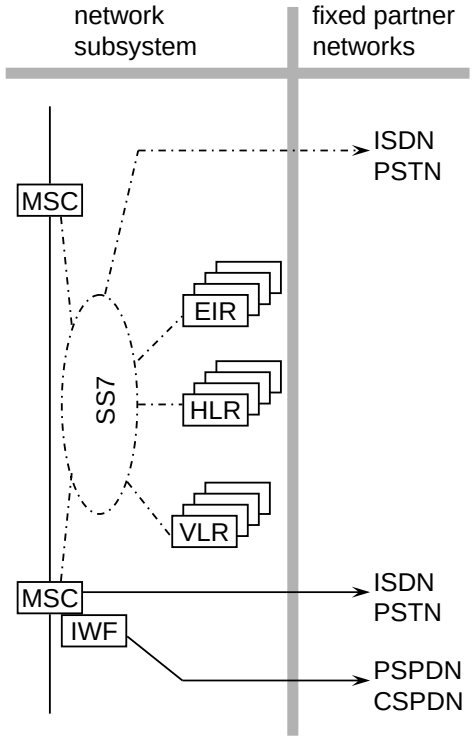


clearly defined interfaces (open system)
compatible to ISDN (wired) telephone system

- **Components**
  - *MS* (Mobile Station)
  - *BSS* (Base Station Subsystem): consisting of
    - *BTS* (Base Transceiver Station): sender and receiver
    - *BSC* (Base Station Controller): controlling several transceivers
- **Interfaces**
  - U_m : radio interface
  - A_{bis} : standardized, open interface with 16 kbit/s user channels
  - *A*: standardized, open interface with 64 kbit/s user channels

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System Architecture – Network and Switching Subsystem JS



Components

- ☐ *MSC* (Mobile Services Switching Center):
- ☐ *IWF* (Interworking Functions)

- ☐ *ISDN* (Integrated Services Digital Network)
- ☐ *PSTN* (Public Switched Telephone Network)
- ☐ *PSPDN* (Packet Switched Public Data Net.)
- ☐ *CSPDN* (Circuit Switched Public Data Net.)

Databases

- ☐ *HLR* (Home Location *R*egister)
- ☐ *VLR* (Visitor Location *R*egister)
- ☐ *EIR* (Equipment Identity Register)

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Radio subsystem JS

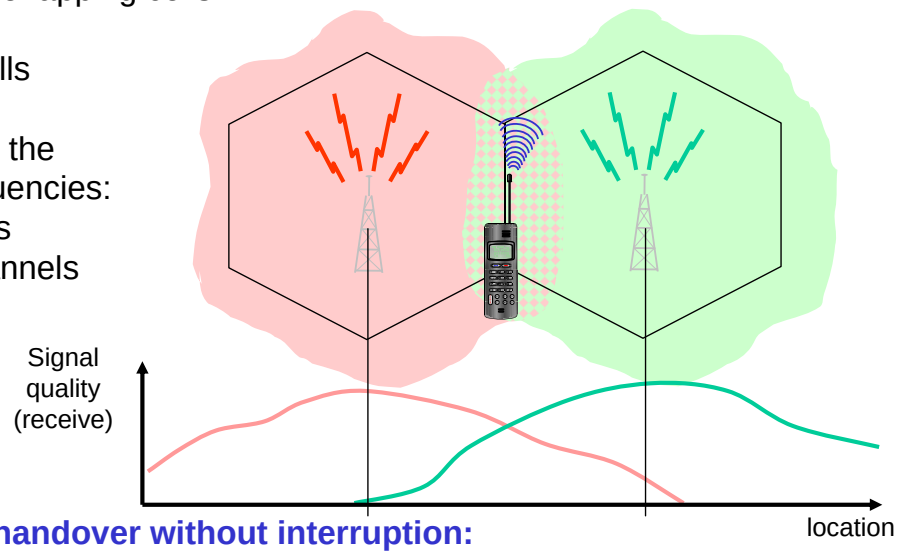
- **The Radio Subsystem** (RSS) comprises the cellular mobile network up to the switching centers
- Components
  - **Base Station Subsystem** (BSS):
    - Base Transceiver Station (BTS): radio components including sender, receiver, antenna - if directed antennas are used one BTS can cover several cells
    - Base Station Controller (BSC): switching between BTSs, controlling BTSs, managing of network resources, mapping of radio channels (U_m) onto terrestrial channels (A interface)
    - BSS = BSC + sum(BTS) + interconnection
  - Mobile Stations **(MS)**

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Cellular network principle

Purpose

- base station (cell) only has limited capacity
- coverage of large areas
  by using small overlapping cells
- use different frequencies
  in neighboring cells
- cellular principle reduces the number of available frequencies:
  < 125 frequencies
  < 1000 phys. channels



Overlap of cells enables handover without interruption:

MS (Mobile Station) is still in contact with old BTS (Base Transceiving Station)

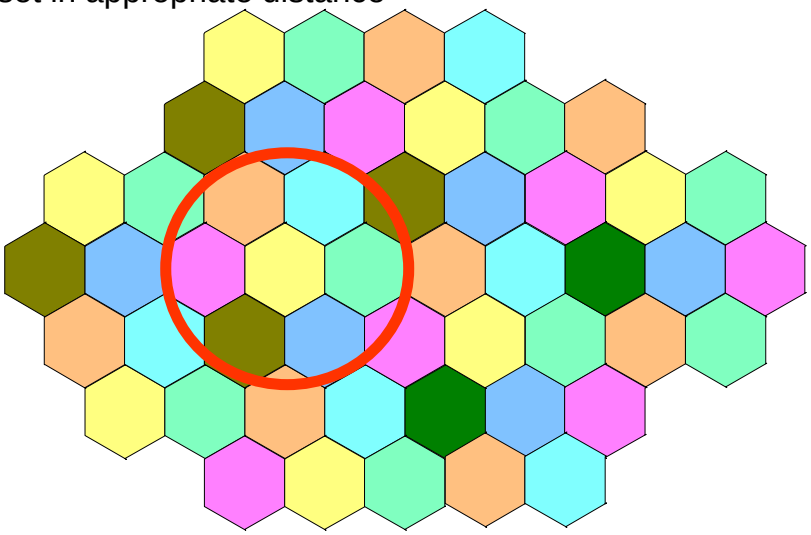
- new BTS receive quality is better than from old BTS
- prepare handover with old BTS
- switch to new BTS (almost no interruption)

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Cellular network (2)

Reuse of frequencies

- Use a subset of all available frequencies in a single cell
- all direct neighbour cells use different subset (to avoid interference)
- reuse of same frequency subset in appropriate distance



Cell clustering

- a typical representation of a cell is a hexagon
- a cluster of cells use different subsets of frequencies
- the same subsets repeat in further clusters

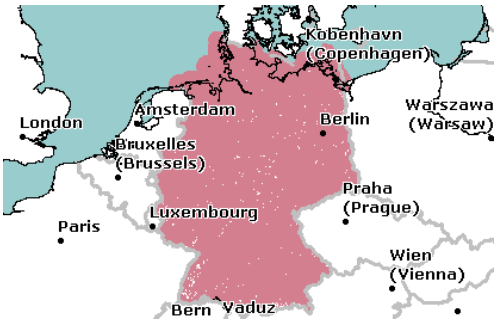
Typical values

- k = 7 (number of cells per cluster)
- D ≈ 4,4 • radius of cell (distance between cells with identical frequency subset)

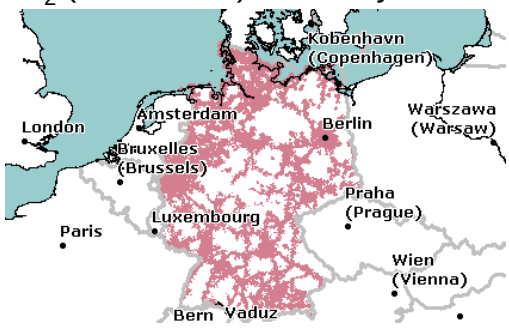
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Example coverage of GSM networks (www.gsmworld.com) *JS*

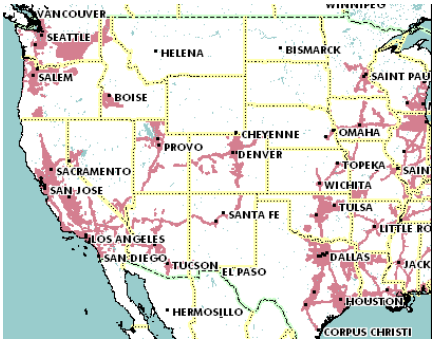
T-Mobile (GSM-900/1800) Germany



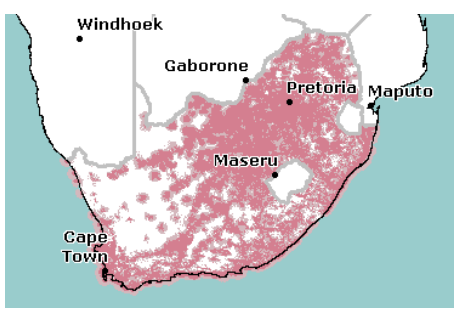
O_2 (GSM-1800) Germany



AT&T (GSM-850/1900) USA



Vodacom (GSM-900) South Africa



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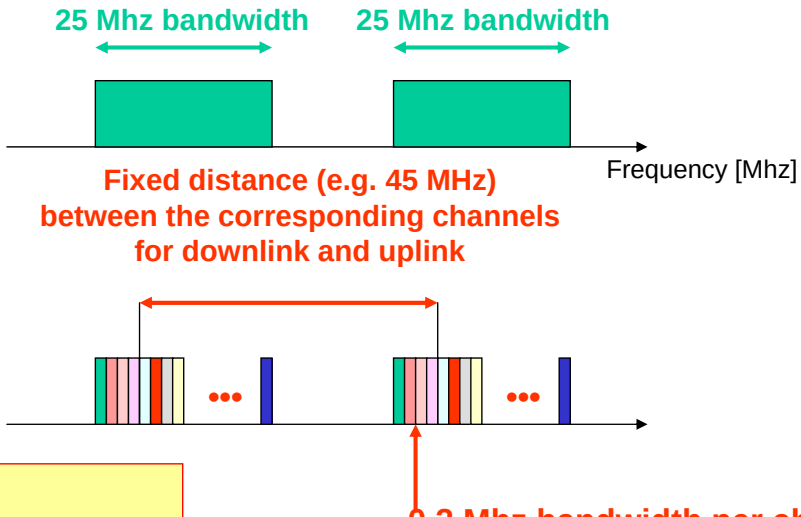
Concepts for Multiple Access: FDMA in GSM

Goal of Multiple Access: Several mobile stations intend to communicate „in parallel“ with the same base station.

The access to the shared medium „air“ (the radio frequencies) has to be coordinated in a deterministic manner (provide QoS for voice transmission, i.e. no collisions allowed)

Frequency Division Multiple Access (FDMA) in GSM:

- two bands of 25 MHz (each for uplink and downlink = Frequency Division Duplex) are divided into 125 channels of 200 kHz bandwidth



=> cf. chapter
3. Wireless Communication Basics

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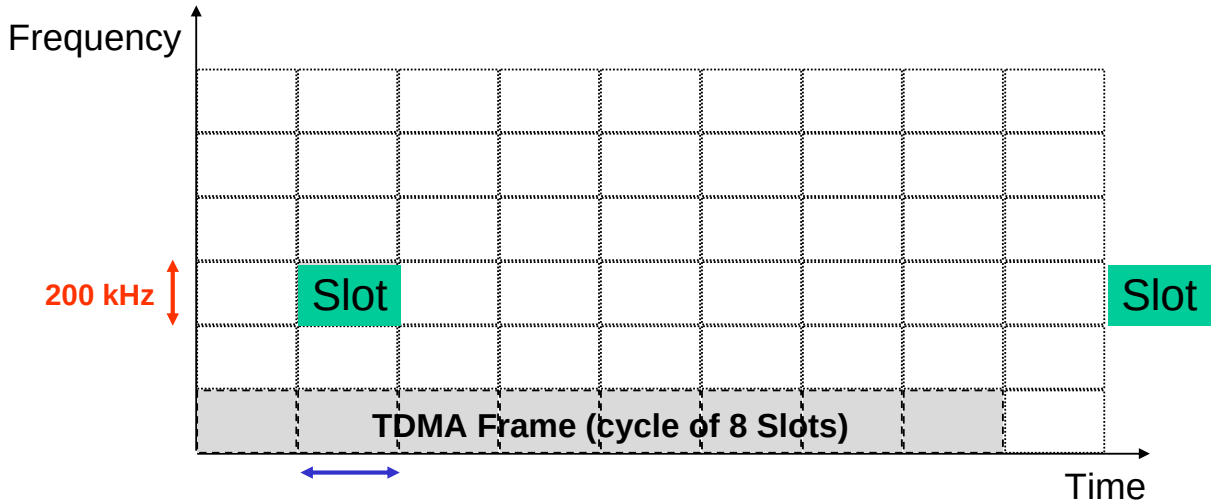
TDMA in GSM

=> cf. chapter
3. Wireless Communication Basics

Time Division Multiple Access (TDMA):

- each channel (of FDMA) is divided into 8 time slots (= 1 cycle)
- the raw datarate in a 200 kHz channel amounts to 271 kbit/s
- the raw datarate per time-slot (TDMA channel) is 33,875 kbit/s

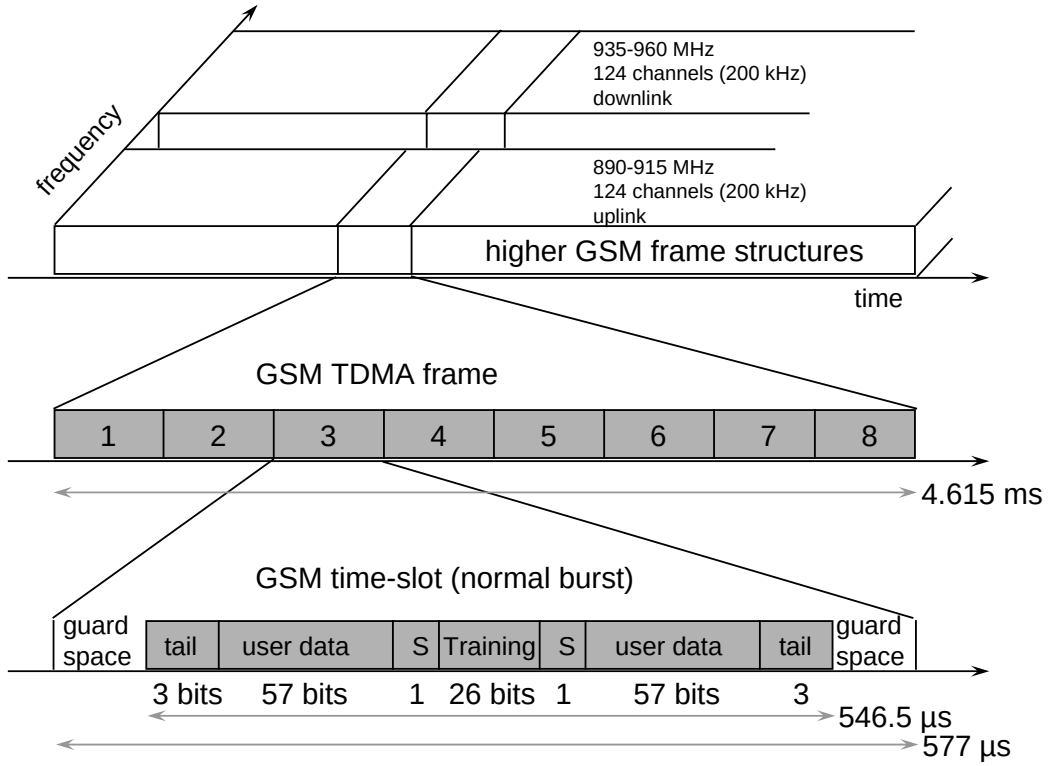
Result: **8 physical channels** (33,875 kbit/s each) **per frequency channel**,
Altogether 125 • 8 = **1000 physical channels** in 25 Mhz



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GSM – TDMA/FDMA

JS



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Network and Switching Subsystem

JS

- **NSS** is the **main component** of the public mobile network GSM
  - switching, mobility management, interconnection to other networks, system control
- Components
  - **Mobile Services Switching Center** (MSC)
    controls all connections via a separated network to/from a mobile terminal within the domain of the MSC - several BSC can belong to a MSC
  - Databases (important: scalability, high capacity, low delay)
    - **Home Location Register** (HLR)
      central master database containing user data, permanent and semi-permanent data of all subscribers assigned to the HLR (one provider can have several HLRs)
    - **Visitor Location Register** (VLR)
      local database for a subset of user data, including data about all user currently in the domain of the VLR

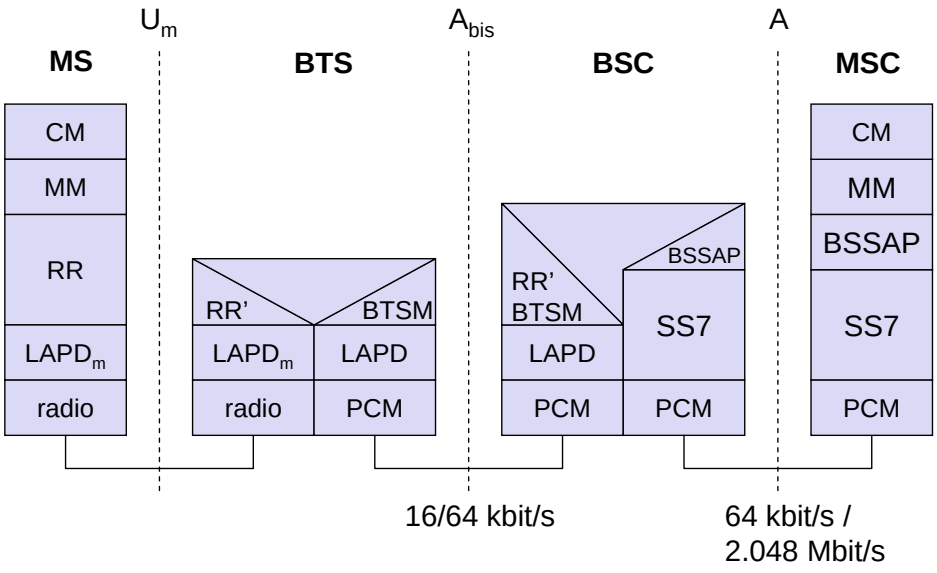
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Mobile Service Switching Center *JS*

- The **MSC (mobile switching center)** plays a central role in GSM
  - switching functions
  - additional functions for mobility support
  - management of network resources
  - interworking functions via Gateway MSC (GMSC)
  - integration of several databases
- **Functions of a MSC**
  - specific functions for paging and call forwarding
  - termination of SS7 (signaling system no. 7)
  - mobility specific signaling
  - location registration and forwarding of location information
  - provision of new services (fax, data calls)
  - support of short message service (SMS)
  - generation and forwarding of accounting and billing information

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GSM Protocol Layers for Signaling *JS*

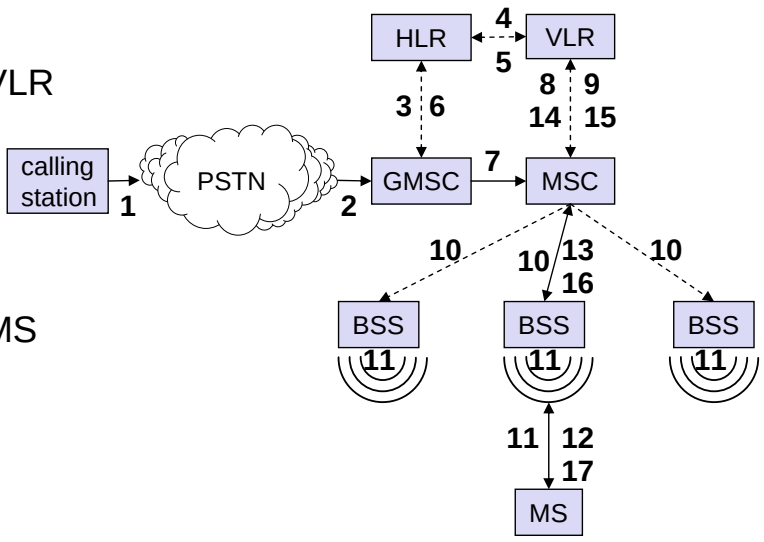


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Example: Mobile Terminated Call

JS

- 1: calling a GSM subscriber
- 2: forwarding call to GMSC
- 3: signal call setup to HLR
- 4, 5: request MSRN from VLR
- 6: forward responsible MSC to GMSC
- 7: forward call to current MSC
- 8, 9: get current status of MS
- 10, 11: paging of MS
- 12, 13: MS answers
- 14, 15: security checks
- 16, 17: set up connection



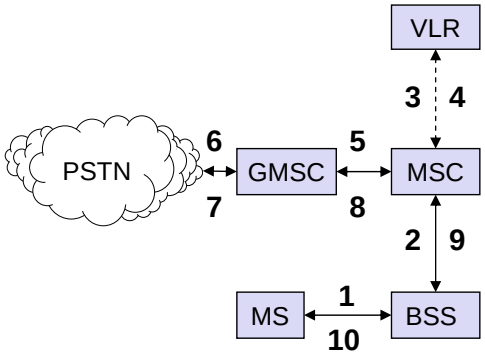
Note step 4,5: MSRN = Mobile Station Roaming Number
similar to Care-of-Address in Mobile IP

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Mobile Originated Call

JS

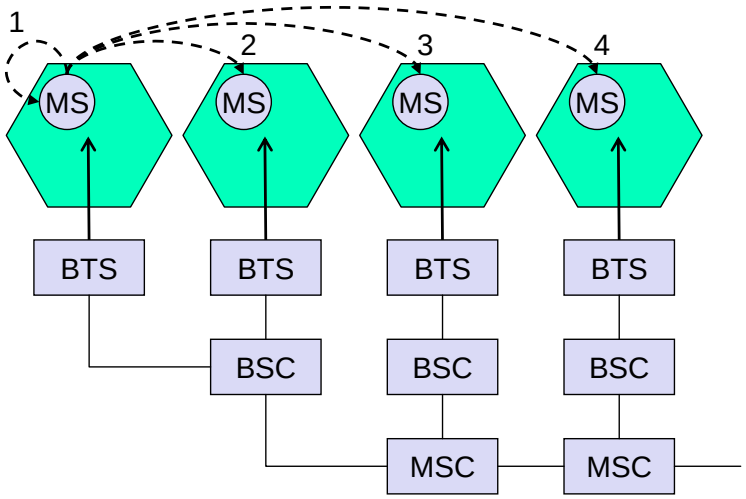
- 1, 2: connection request
- 3, 4: security check
- 5-8: check resources (free circuit)
- 9-10: set up call



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Four Types of Handover

JS



1: Intra-Cell, Intra-BTS

2: Inter-BTS (same BSC)

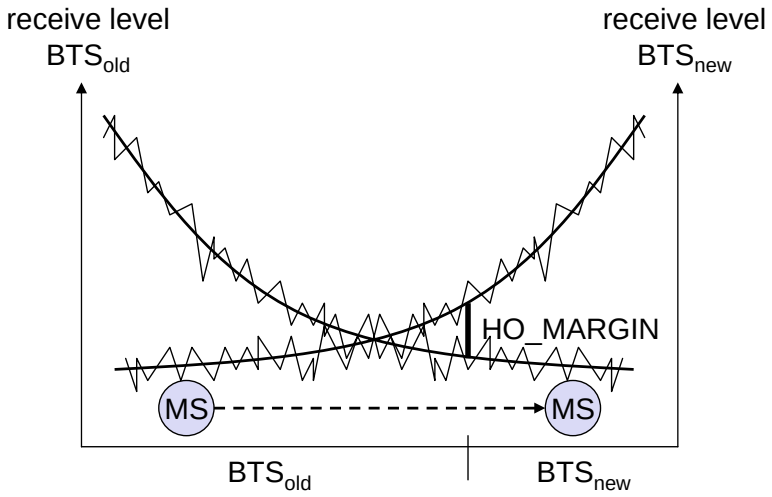
3: Inter-BSC (same MSC)

4: Inter-MSC

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Handover decision

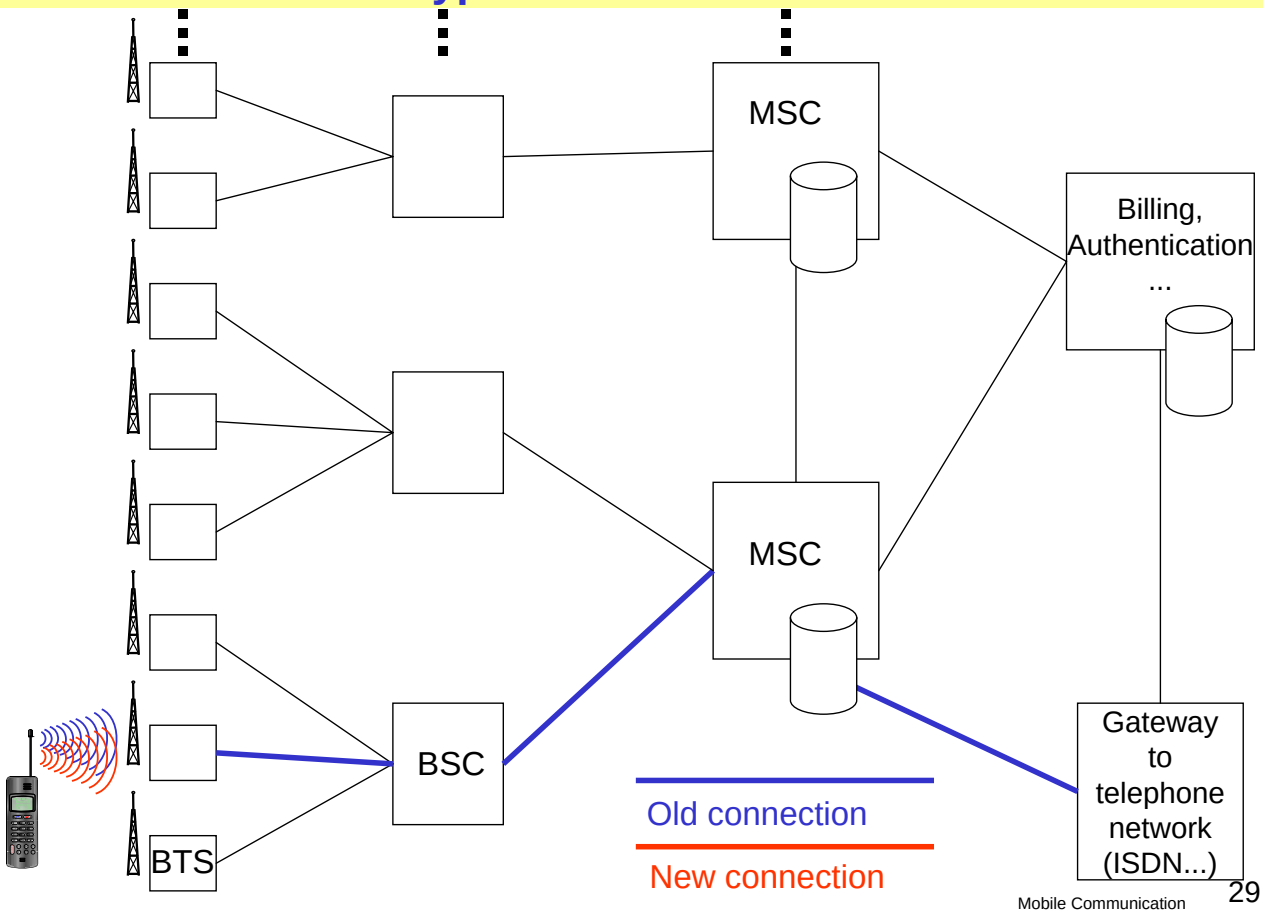
JS



- when moving (slowly) between BTS old and new, a **"ping pong" effect** may occur
- "ping pong" = **switching back and forth** between new and old BTS (several times)
- may be prevented (or reduced) by defining a **hysteresis for handover decision** (HO_MARGIN)

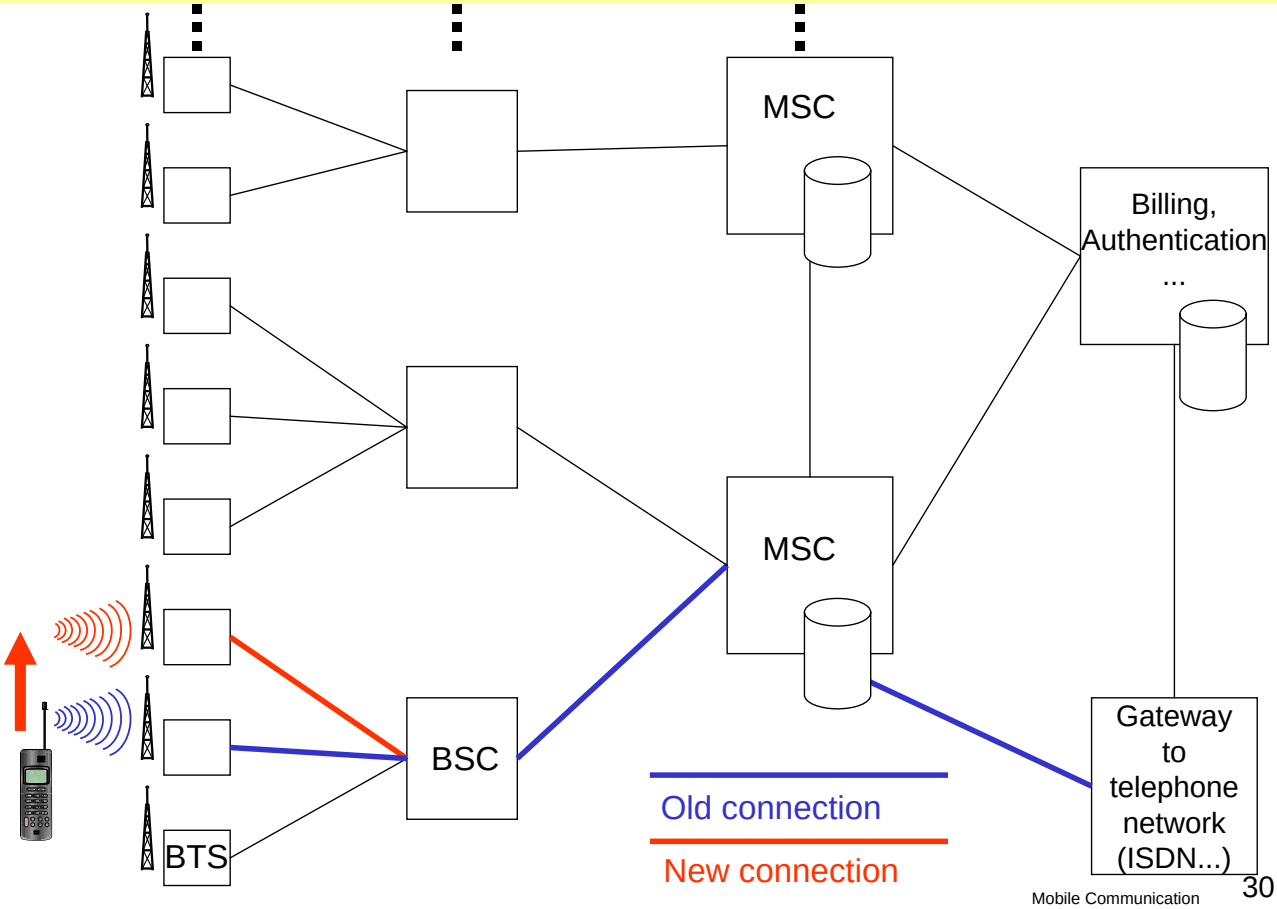
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Overview handover types: Intra-Cell Handover



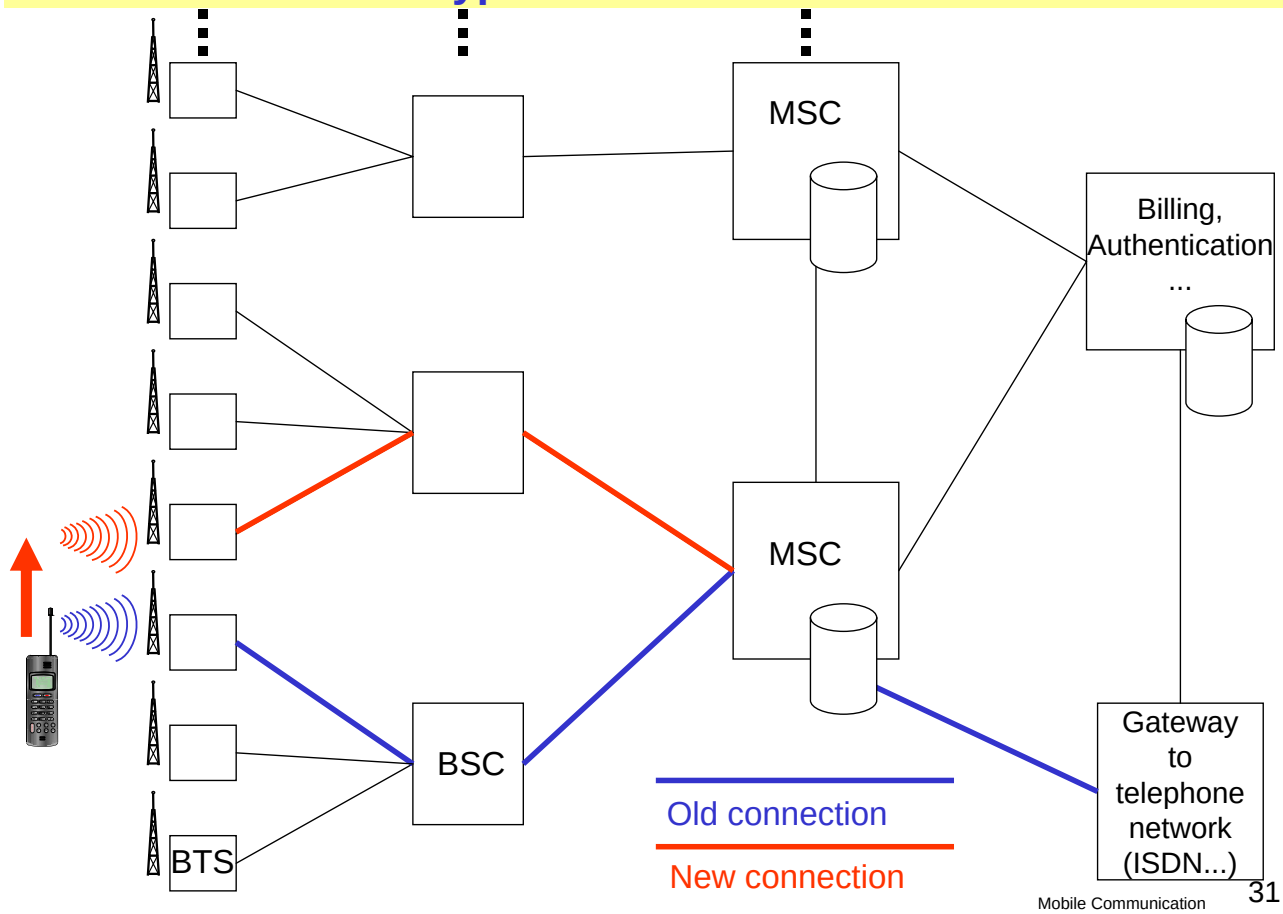
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Overview handover types: BTS-BTS Handover



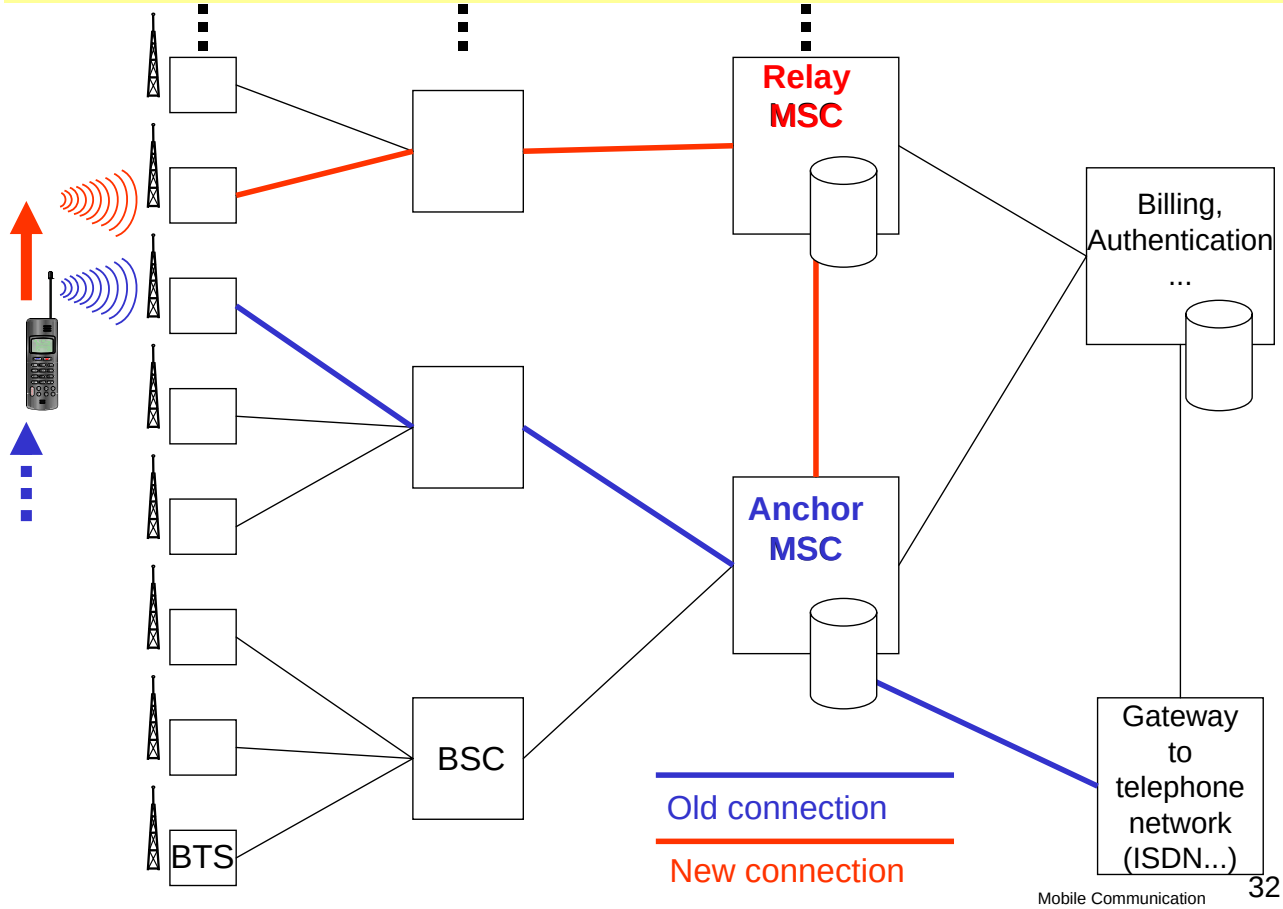
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Overview handover types: BSC-BSC Handover



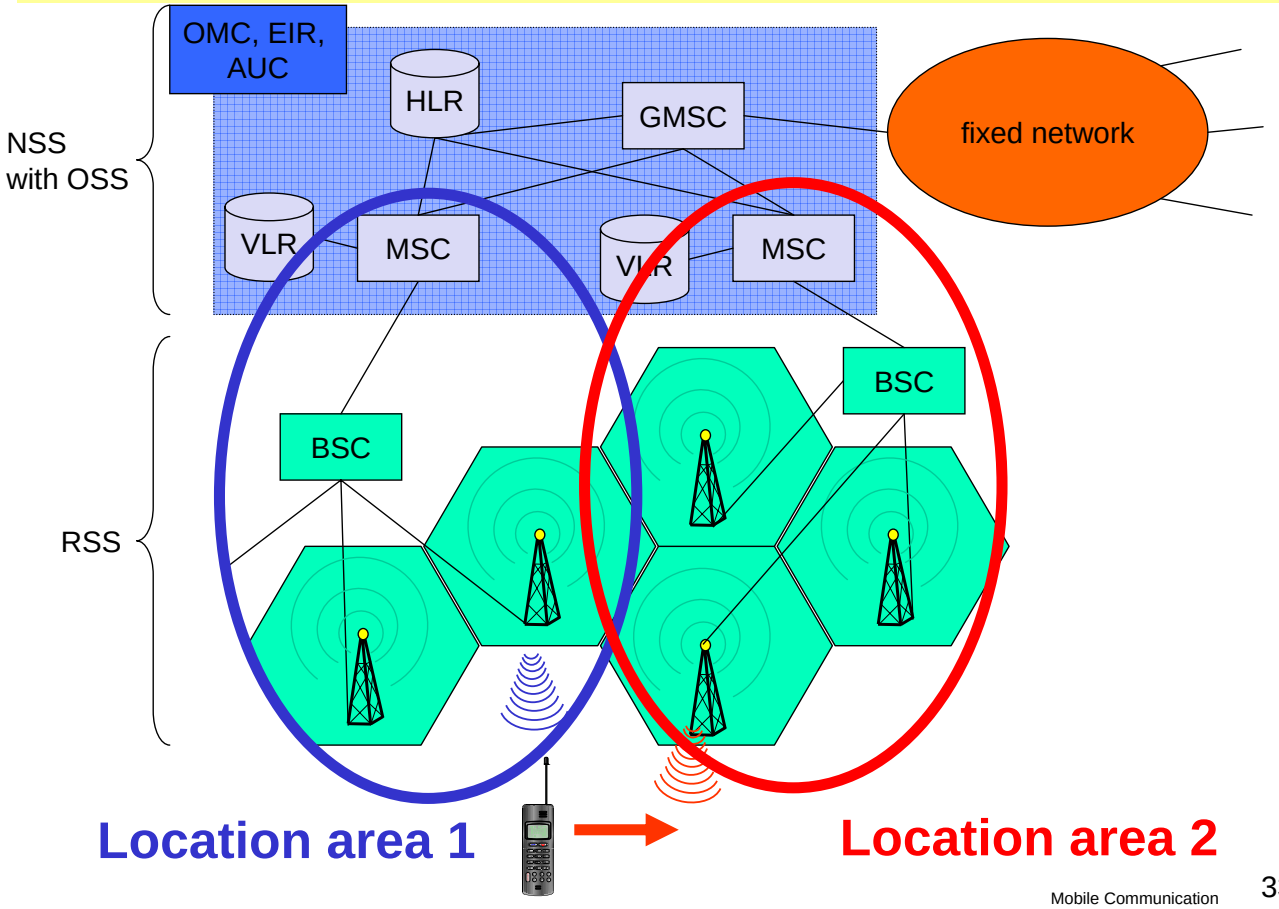
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Overview handover types: MSC-MSC Handover



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Location update overview *JS*



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Location update

Important procedure to update location information in HLR and VLR

Location update - prerequisite

- mobile station is switched on
- but MS is “idle” (= no phone call going on – in contrast to handover)

Carrying out location update

- mobile station frequently measures reception quality of BTSs
- MS decides to “camp on a cell” (select best BTS)
- MS analyses location area identity (LAI) as broadcasted from BTS

- if LAI has changed when moving from old BTS to new BTS

=> MS initiates location update

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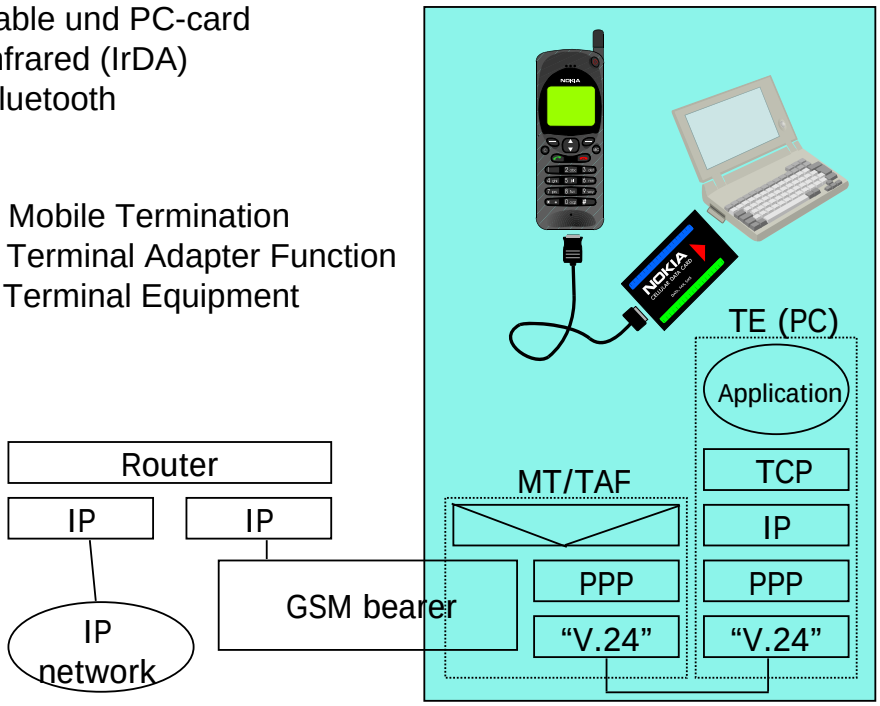
6.3 GSM Data Services

Connection MS - PC

MS + PC as the data terminal

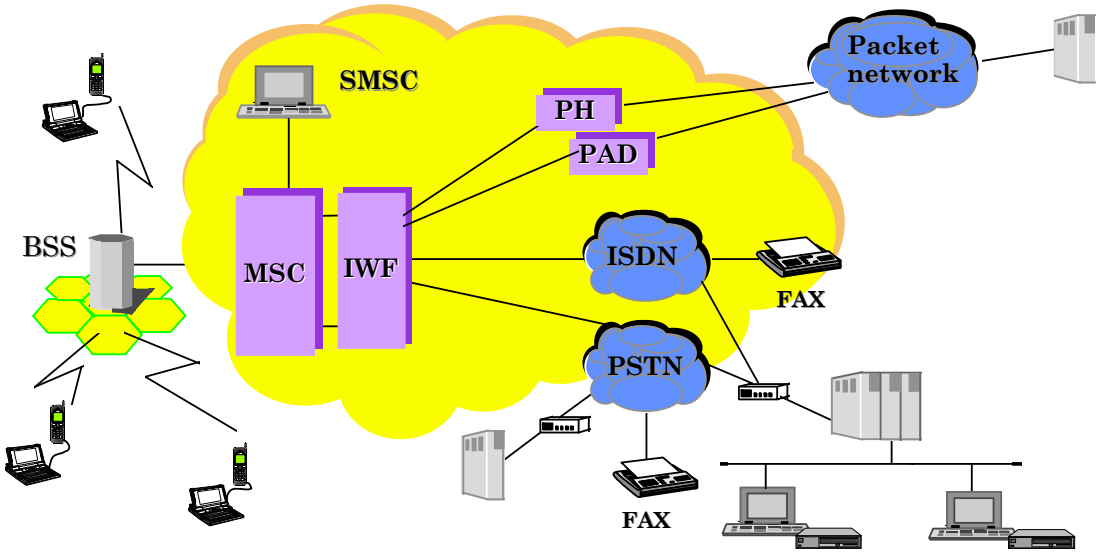
- via cable und PC-card
- via Infrared (IrDA)
- via Bluetooth

MT = Mobile Termination
TAF = Terminal Adapter Function
TE = Terminal Equipment



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GSM Data Services



The **IWF (Interworking Function)** allows communicating with any "**data network**"

- PH = **Packet Handler**, transition to synchronous data network, e.g. X.25
- PAD = **Packet Assembler/Disassembler**, e.g. transition to the Internet
- via PSTN/ISDN to a **Fax**
- via PSTN/ISDN to a **modem dial-up server**

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Properties of GSM Data

Circuit-Switched Operation

- **Channels** are allocated collectively for Uplink and Downlink **during the entire dial-up time**
- **Billing** is based upon the **dial-up time** and not the amount of data transmitted

Time for establishing a connection

- approx. **20...25 seconds** (end-to-end via PSTN/ISDN)

Link Capacity

- **9.6 kbits/s** (each with uplink and downlink)

Connection possibilities

- to any **modem dial-up server** (in PSTN/ISDN)

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Properties of GSM Data

Connecting to the Internet

- ISP (**Internet Service Provider**) registration is necessary
- **Data call to dial-up number** of the ISP is necessary
- Communication with the ISP's **Terminal Server**
- Using PPP (**Point-to-Point Protocol**) or SLIP (**Serial Line Internet Protocol**)
- **Billing and Authenfication** of the user is done **separately** for the GSM bearer service and the ISP service

- Alternatively: **mobile network provider and ISP are identical**

Performance

- 9.6 kbits/s **nominal data rate** (decreased by error correction)
- **round-trip delay** 400...500 ms
- The **transparent mode** as well as the **non-transparent mode** is possible,

  - **transparent**: no error correction/ack-retransmission on link layer
  - **non-transparent**: with error correction on link layer

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Improving Circuit-Switched Data Services

Without modifying the radio interface

Using an **ISDN connection** instead of a PSTN modem connection

- **decreases** the **time for connection establishment** to approx. 5 seconds
- supports the **caller's identification**
- most GSM **MSCs support ISDN Interworking**
- the ISP must allow **ISDN connections** from **MSC to Terminal Server**

Compression of user data according to V.42bis

- Increases **user data rate** up to **32 kbit/s**
- Compression **between MS and MSC/IWF**
- Compression of **text** is **typically 4:1** (does not apply to already compressed or encrypted data)
- **high processor usage**

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ETSI Work Items (1)

GSM **14.4 kbit/s Data**

- standard completed in 1997

High-Speed (Circuit Switched) Data (**HSCSD**)

- standard completed in 1997

=> combining both

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ETSI Work Items (2)

GSM Packet Radio System (**GPRS**)

- Phase 1 completed in 1998
- Phase 2 completed during UMTS (Release 1999, March 2000)

GSM 384 or EDGE (**Enhanced Data-rates for Global Evolution**)
(formerly Enhanced Data for GSM Evolution)

- Phase 1 completed in 2000 (also E-GPRS: Enhanced GPRS)
- Phase 2 completed during UMTS (Release 2000)
- since July 2000 new 3GPP TSG **GERAN** (GSM/EDGE Radio Access Network)
  to be released with future Releases

UMTS uses **Wideband-CDMA** as concept for multiple access

- Standardization process started, first Release (Rel 1999) March 2000
- Release 2000 (renumbered to release 4) March 2001
- Release 5 March/June 2002
- Release 6 December 2004 – March 2005
- Release 7 “Stage 3 freeze December 2007”
- Release 8 “*Stage 3 freeze December 2008 ?*”

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GSM 14.4 kbit/s Data

- **new channel coding** for data TCH
- **less protection** (more data) with **good radio reception**
- results in **reduced coverage** of the radio cells
  => mechanisms should switch back to a more efficient channel coding (9.6 kbit/s) at the border of a radio cell

- **compatible** with **High-Speed Data** and **V42.bis** compression

- **V34 modems** (28.8 kbit/s) may be realized by using **2 Time Slots** (2 TCHs) each with 14.4 kbit/s.

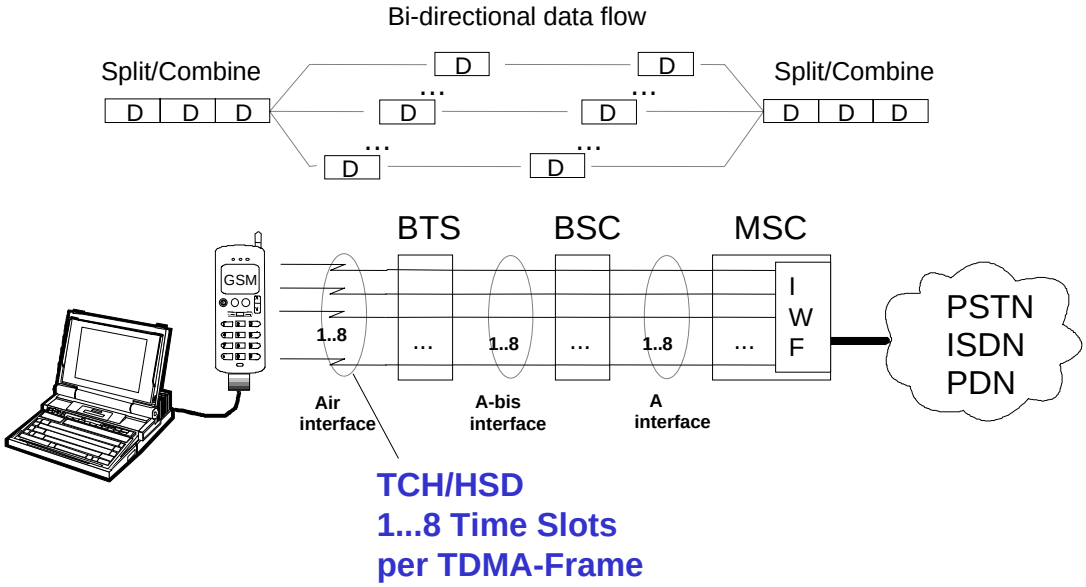
- **Standardization completed** in 1997

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High-Speed Circuit-Switched Data

Principle of **Multi-Slot Access**

- Multiple Time-Slots (2..8) are allocated to a single MS



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High-Speed Circuit-Switched Data (2)

Multi-Slot Access

- **Multiple (2...8) Time-Slots** are allocated to a **single MS**
- the normal traffic channels (n x TCH/F9.6) are combined to a **single (logical) High-Speed Channel** (TCH/HSD)
- Using the channel coding 14.4 allows multiples of n x 14.4 kbit/s

- **Splitting/Combining** data from higher layers need to be done in the MS and the MSC/IWF

- **BTSe** does not require **any knowledge** of the multi-slot access
- **BSCs** need to control **all sub-channels as a single channel**, e.g. during handover

- The **transparent mode** as well as the **non-transparent mode** is possible,

  As with GSM Data:
  - **transparent**: no error correction/ack-retransmission on link layer
  - **non-transparent**: with error correction on link layer

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Data services in GSM (HSCSD rates summary) JS

- Data transmission standardized with only 9.6 kbit/s
  - advanced coding allows 14,4 kbit/s
  - not enough for Internet and multimedia applications
- HSCSD (High-Speed Circuit Switched Data)
  - mainly software update
  - bundling of several time-slots to get higher AIUR (Air Interface User Rate) (e.g., 57.6 kbit/s using 4 slots, 14.4 each)
  - advantage: ready to use, constant quality, simple
  - disadvantage: channels blocked for voice transmission

AIUR [kbit/s]	TCH/F4.8	TCH/F9.6	TCH/F14.4
4.8	1		
9.6	2	1	
14.4	3		1
19.2	4	2	
28.8		3	2
38.4		4	
43.2			3
57.6			4

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Summary of Circuit-Switched Data

- GSM data services enable **Wide-Area Mobile Data Applications**
- **Improvements** to conventional **9.6 kbit/s data services** have been specified and are in use
- **Circuit-switched data** is suited for applications with a **continuous data flow** (e.g. file transfer of large files)
- **Billing** is based on the **dial-up time**, and **not** the amount of **transmitted data**
- A **limited number of mobile users** can be supported per frequency
- **Not well** suited for **packet-oriented protocols** (such as IP) and their typical applications (bursty and asymmetric data traffic)

=> **Demand for GPRS** is obvious

GPRS = **GSM Packet Radio System**
GPRS = **General Packet Radio Service**

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6.4. Overview of GPRS

Design goal: Network

- GPRS uses a **packet-oriented allocation of resources**
  - resources are only allocated when data is to be sent or received
- **flexible channel allocation**
  - **one to eight time slots** of TDMA may be allocated
  - available resources **are shared by all active users**
  - **Uplink** and **downlink** are allocated **individually**
  - **GPRS** and circuit switched **GSM** may use the same **frequency/time slots** (allocated dynamically)
- Connections with **data networks**
  - **TCP/IP Internet** (and also **X.25**)
- More efficient transmission of **SMS over GPRS**

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Overview of GPRS

Design goal: Applications

Conventional applications for data networks:

- **TCP/IP**: WWW, E-Mail, FTP, Telnet, …
- **WAP (Wireless Application Protocol)** over GPRS
- **X.25**: Packet Assembly/Disassembly (PAD) Applications

GPRS-specific applications:

- **Point-to-point (PTP) Applications**: toll billing for roads, ...
- **Point-to-multipoint (PTM) Applications**: weather information, traffic information, news, …
  push-to-talk

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Overview of GPRS

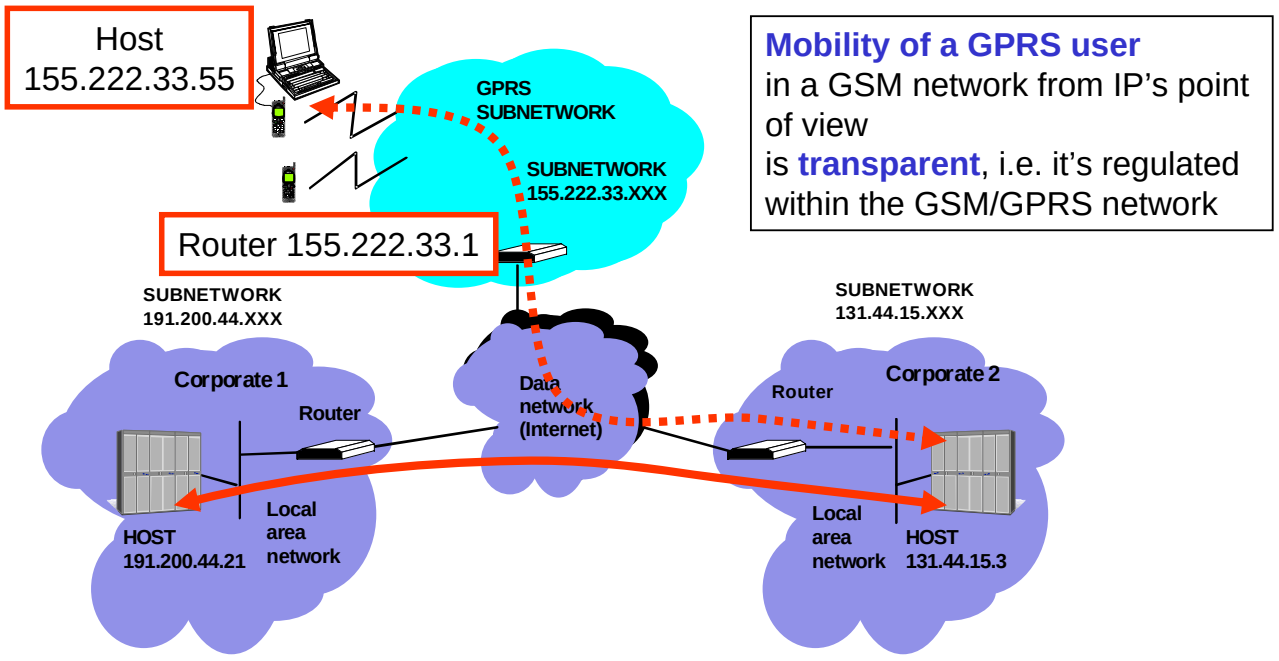
Design restrictions

- **Changes to Hardware** at BTSs should be **prevented**
- **Scalability** of GPRS networks
- there may/should be also **GPRS-only mobile terminals** (no speech)

- **Billing** should be based on the **actual amount of transmitted data**
- A **typical "Connection"** may last **several hours**
- **Several applications** may be **active simultaneously**

- **HLR** should **not** be contacted for **every single GPRS-packet**

User's view of a GPRS Network



Mobility of a GPRS user
in a GSM network from IP's point of view
is **transparent**, i.e. it's regulated within the GSM/GPRS network

Communication in the Internet between two hosts

Communication of a GPRS host (in GSM) with an arbitrary host in the Internet

GPRS Mobile Station

Three classes of different GPRS mobile stations:

Class A

- **simultaneous usage** of packet-oriented and circuit-switched services

Class B

- **Simultaneous logging into** GSM and GPRS system is possible
- **no simultaneous traffic** is possible (automatic sequential changeover)

Class C

- **Logging into** either GSM or GPRS is possible
- may be a **"GPRS-only" MS**

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Examples for GPRS device classes *JS*

Class	Receiving slots	Sending slots	Maximum number of slots
1	1	1	2
2	2	1	3
3	2	2	3
5	2	2	4
8	4	1	5
10	4	2	5
12	4	4	5

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GPRS user data rates in kbit/s

JS

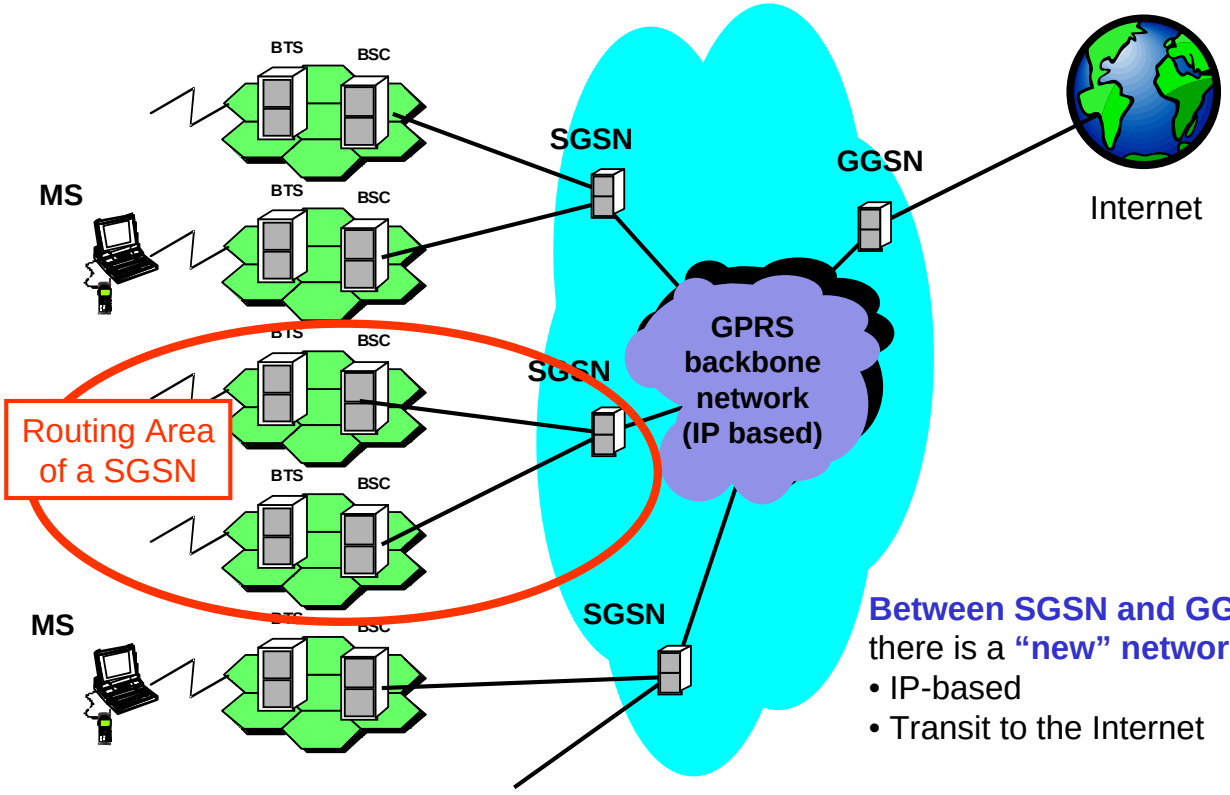
Coding scheme	1 slot	2 slots	3 slots	4 slots	5 slots	6 slots	7 slots	8 slots
CS-1	9.05	18.1	27.15	36.2	45.25	54.3	63.35	72.4
CS-2	13.4	26.8	40.2	53.6	67	80.4	93.8	107.2
CS-3	15.6	31.2	46.8	62.4	78	93.6	109.2	124.8
CS-4	21.4	42.8	64.2	85.6	107	128.4	149.8	171.2

Different/new coding schemes compared to GSM data CSD/HSCSD

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Architecture of a GPRS System

Between MS and SGSN „conventional“ **GSM network** (minor modifications)



Between SGSN and GGSN there is a **“new” network:**

- IP-based
- Transit to the Internet

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Two new Network Components

GGSN - Gateway GPRS Support Node

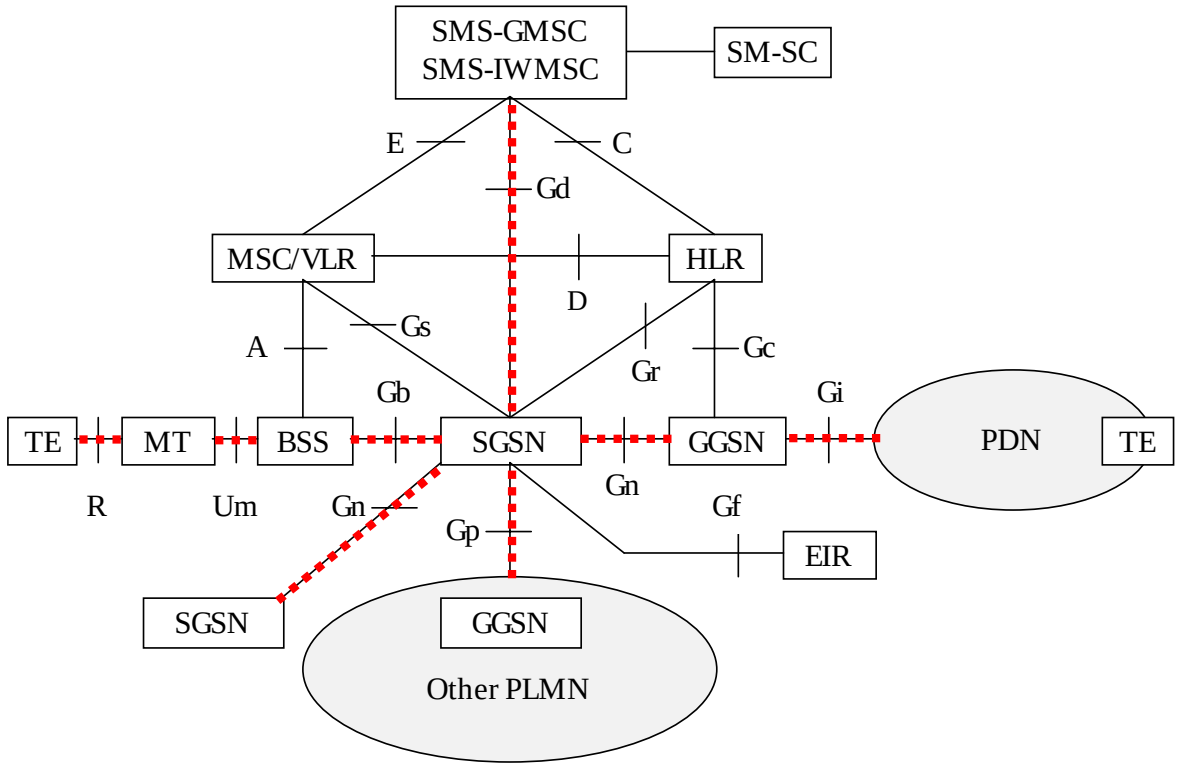
- comparable to GMSC (Gateway MSC)
- access point to an external data network (e.g. access to the Internet)
- centralized network component, does not change with mobility of the MS
- GGSN keeps track of routing-information to the SGSN corresponding to the MS

SGSN - Serving GPRS Support Node

- comparable to MSC/VLR (responsible for a Location Area)
- SGSN responsible for a Routing Area (typically a subset of a Location Area)
- Parting point between GSM-BSS and GPRS-backbone
- decentralized network component, changes with mobility of the MS
  (change of the Routing Area)

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Architecture and Interfaces of a GPRS Network



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Interfaces of a GPRS Network

GPRS Network Signalling interfaces

Gb LLC (User Plane) and BSSGP (Signalling) over Frame Relay
Transition from the “new net” to the “old net” (GSM-BSS)

Gc MAP Protocol for **Location Information Retrieval**
Gd MAP Protocol for **Short Messaging over GPRS**
Gf MAP Protocol for **verifying the ME identity**

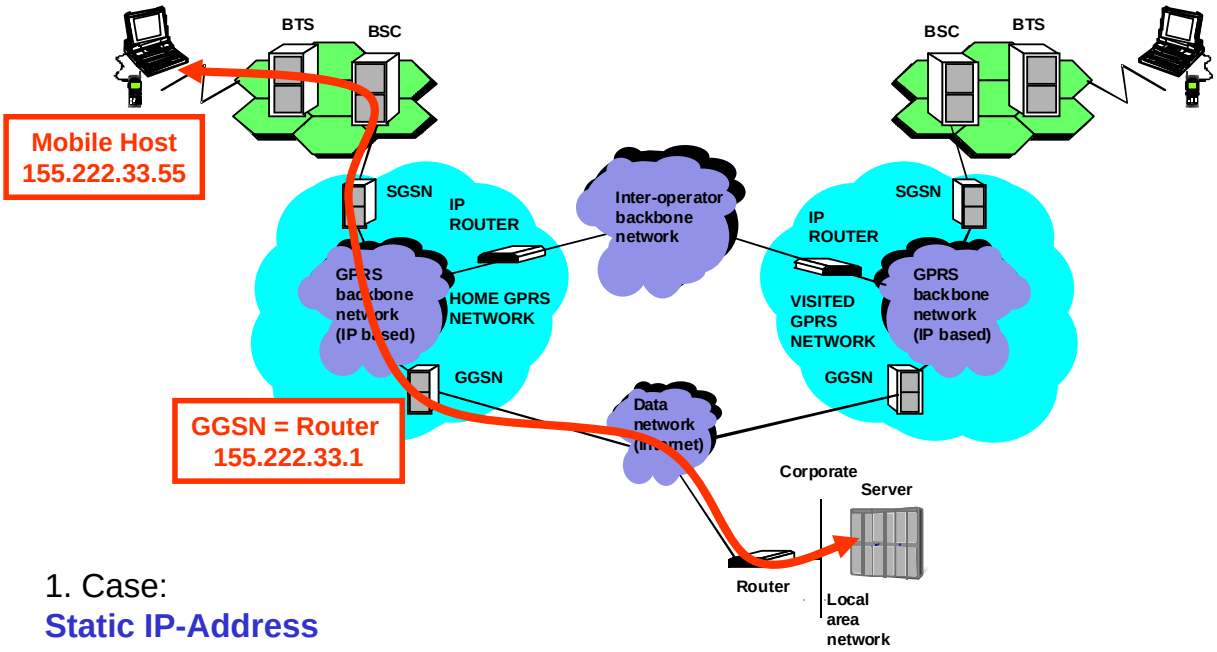
Gn **GPRS Tunneling Protocol** (GTP) for intra-PLMN traffic treatment
Gp **GTP** (over IP) for **inter-PLMN traffic**

Gr MAP Protocol access to **Subscriber Information**
Gs BSSAP+ Protocol for **Normal Location Updates** and **Paging** via MSC/VLR

Gi IP (oder X.25) Protocol **Interface to external data networks**

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Scenario: Roaming with GPRS (1)

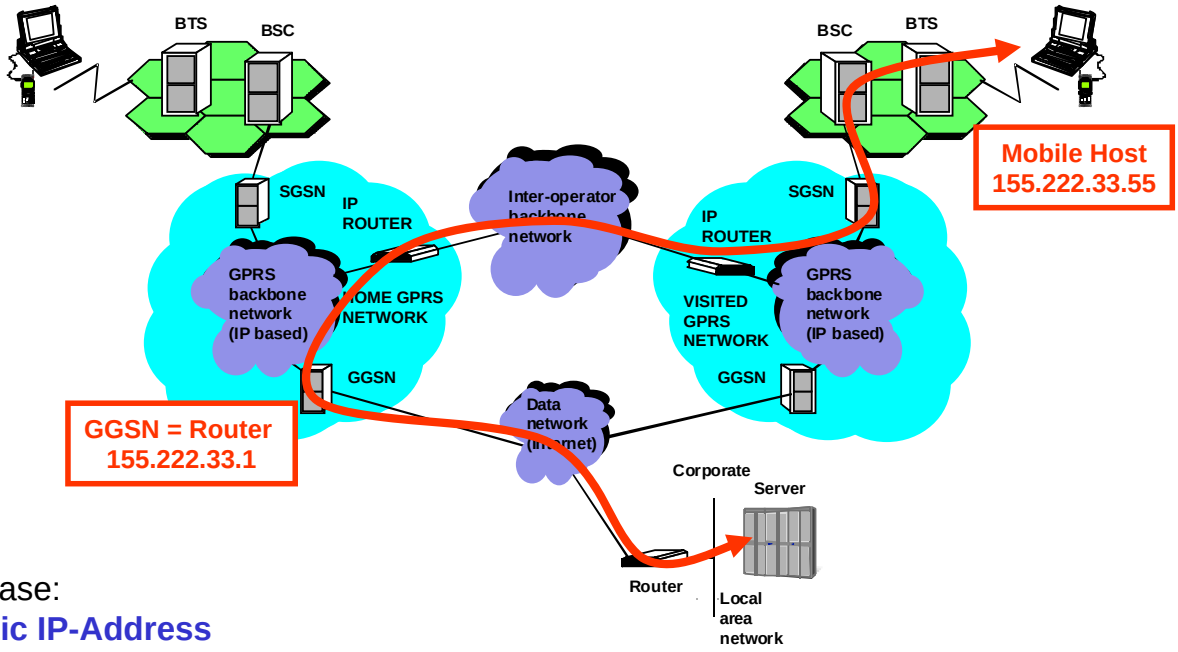


1. Case:
Static IP-Address
assigned by the home GPRS network

User is located in his home network

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Scenario: Roaming mit GPRS (2)



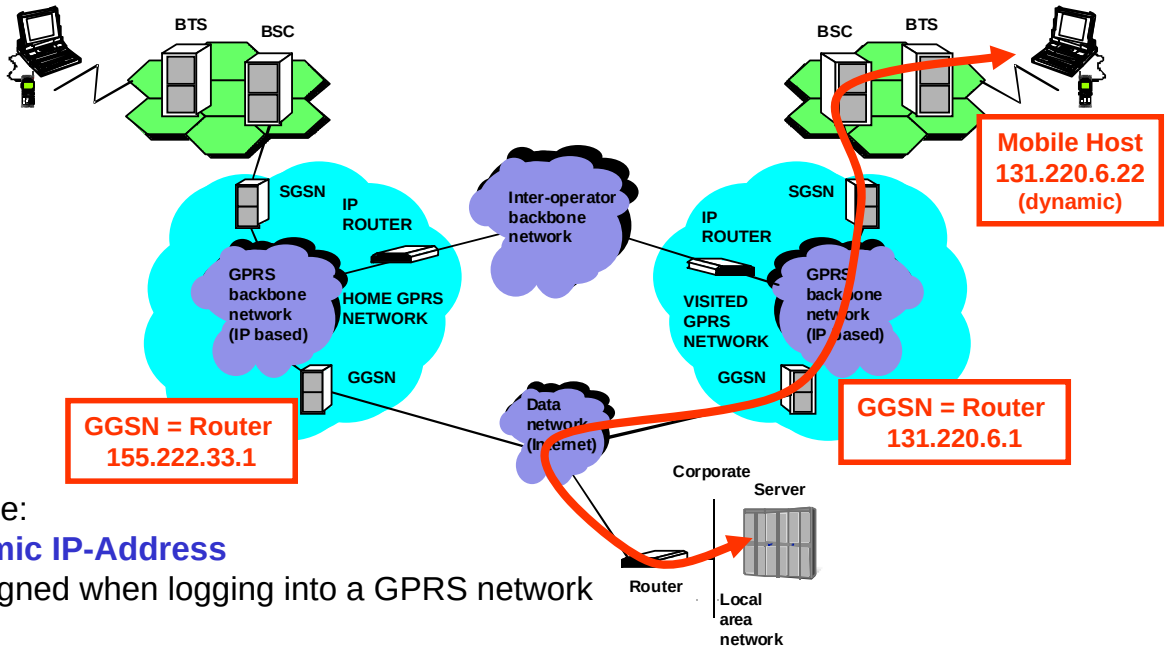
2. Case:
Static IP-Address
assigned by the home GPRS network

User is located in a foreign network

- Host xyz.55 communicates with GGSN xyz.1 in its home net
- „foreign“ SGSN tunnels with GTP over Inter-Operator Backbone to „home“-GGSN

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Scenario: Roaming with GPRS (3)



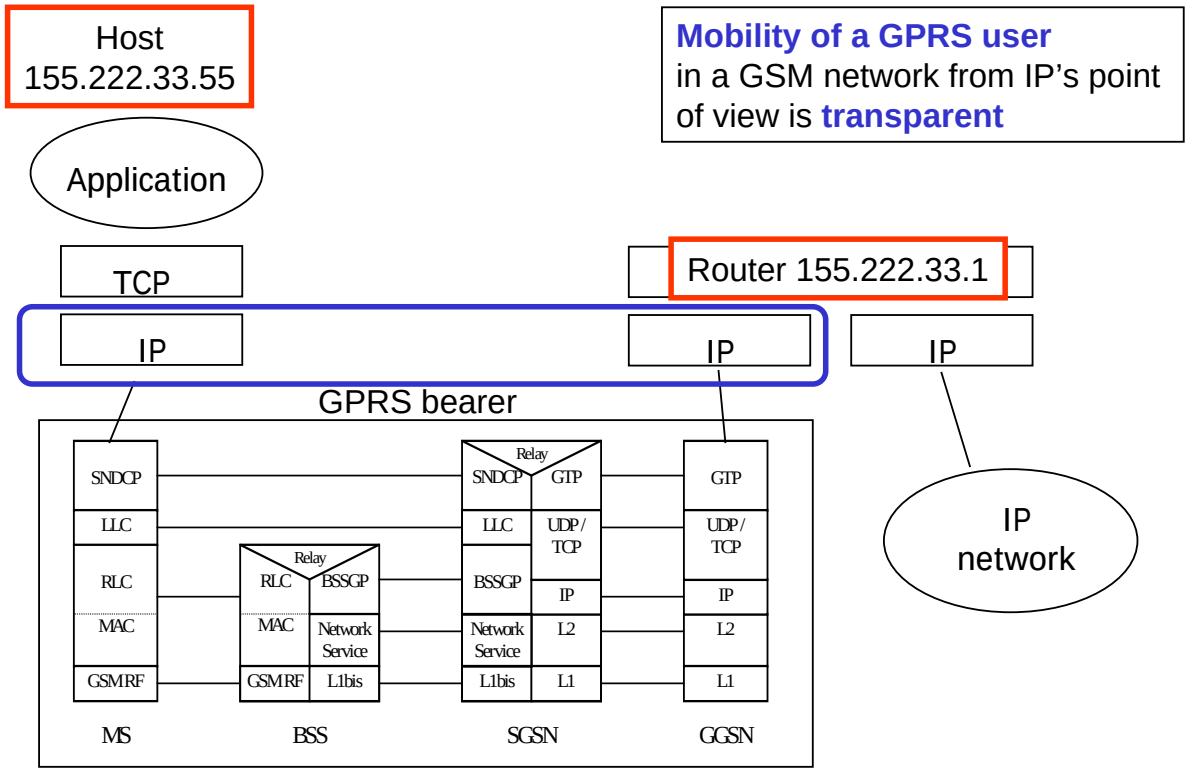
3. Case:
Dynamic IP-Address
is assigned when logging into a GPRS network

User is located in a foreign network
allows optimal routes across GPRS-IP-Backbone and Internet

“Roaming” between two GPRS networks is not possible when using dynamically assigned IP-addresses

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GPRS User Plane Protocols



Mobility of a GPRS user in a GSM network from IP's point of view is **transparent**

Handovers between different SGSN is supported within the GSM/GPRS network

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GTP – GPRS Tunnel Protocol

- IP to/from MS **without tunnelling over the Air-Interface**
  Next hop Router is GGSN
- **GTP tunnels** IP datagrams to/from MS between SGSN and GGSN
- IP-Addresses of SGSN and GGSN are only internally used
- **Comparison to Mobile IP**:

GGSN is Home Agent: Does not change after movement of MS
All traffic is routed through GGSN

SGSN is Foreign Agent: Changes with movement of MS
Home Agent routes to corresponding SGSN

Advantages and Disadvantage of GTP

\+ IP datagrams on the Air-Interface do not need "mobility-overhead"

\- "complex" protocol stack + overhead in Backbone (IP/GTP/UDP/IP)

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GPRS Media Access

Accessing Traffic Channel TCH is "**circuit-switched**",
previous data traffic (as well as speech) is "**connection-oriented**"

For "**connectionless**" GPRS

⇒ **"emulate" a connectionless service across a connection-oriented media**

However: Some kind of "**connection**" is needed!

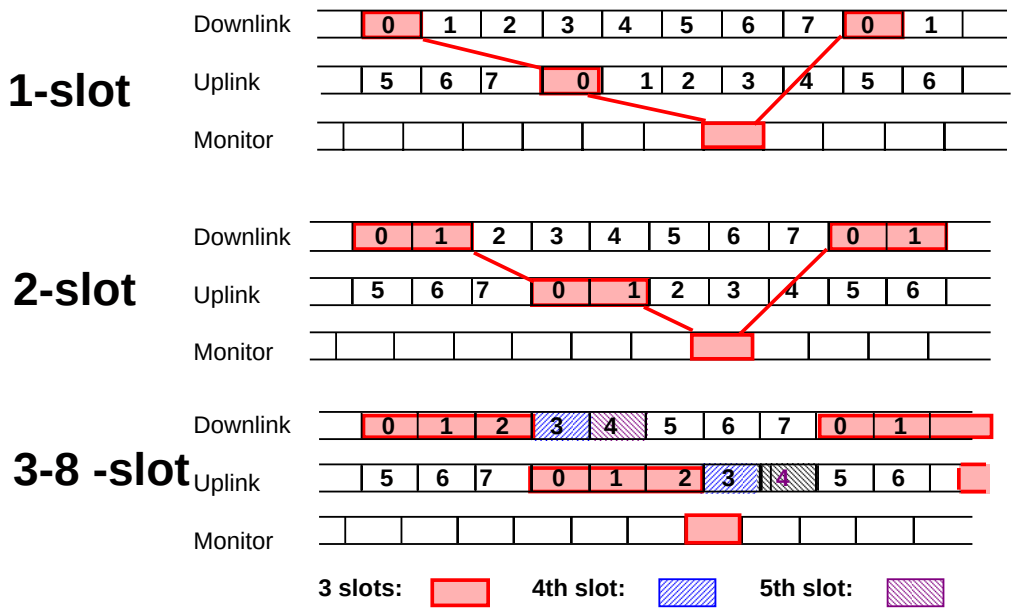
- **GPRS Attach and Detach** = Logging into the GPRS network
  - "Registering" with the mobility management
  - with movement of the MS a "Routing Area Update Request" is applied
  - MS is reachable

- **Packet Data Protocol (PDP) Context** activation and deactivation
  - PDP Context between MS and SGSN/GGSN
  - choses the supported data protocol (e.g. IP, X.25)
  - required in order to enable data communication to/from MS
  - binds misc. parameters (routing, QoS, Identity of MS, Status, ...)
  - may be initiated by the MS or the network

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How does GPRS Media Access work in TDMA?

Using several TDMA-Slots is now possible

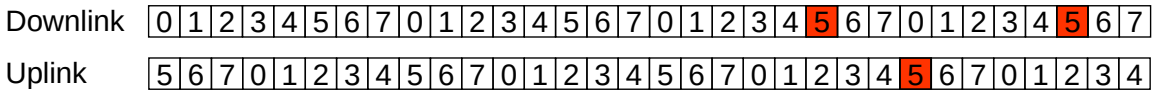


The figure suggests that the same slots are used in a regular interval.
This is not the case! They are dynamically assigned to different MS!!!

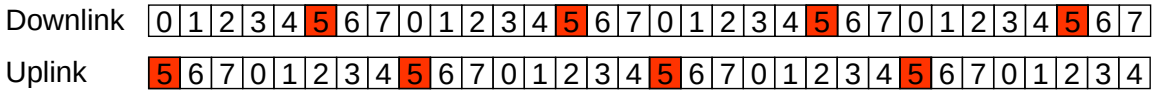
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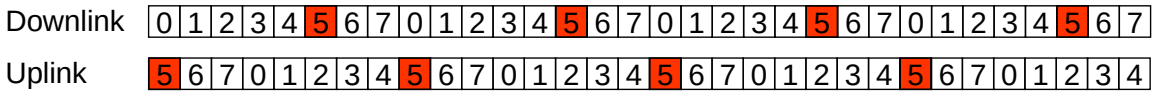
Use of TDMA slots with CSD

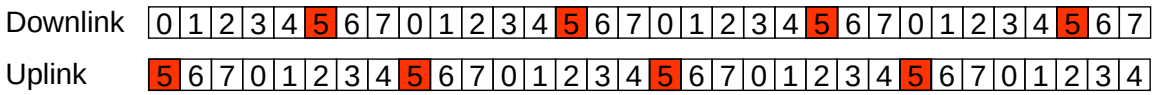
CSD (Circuit Switched Data) = same as telephony, one fixed channel



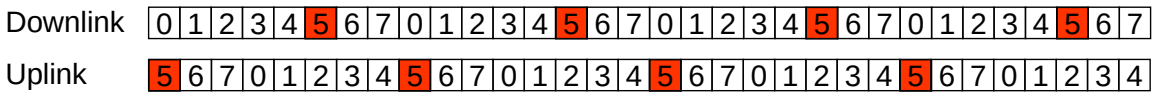
Example: Time-Slot No. 5 has been assigned as data channel







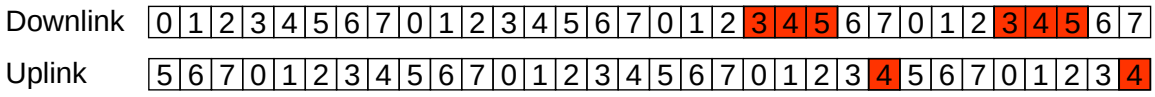
During passive time slots, MS is able to measure reception of other cells.



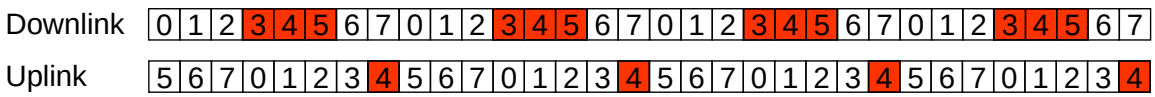
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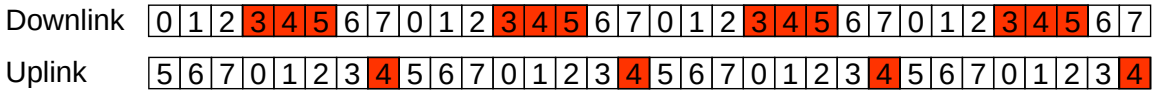
Use of TDMA slots with HSCSD

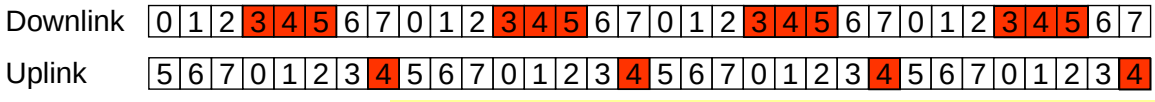
HSCSD (High Speed Circuit Switched Data) = same as CSD, several fixed channels



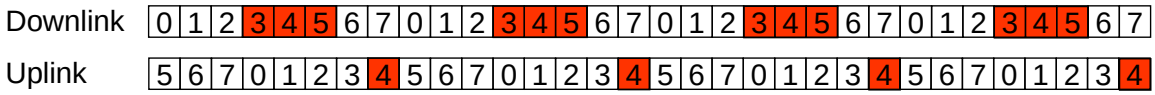
Asymmetric example: Time-Slot No. 3+4+5 (D) + 4 (U) assigned for data channel







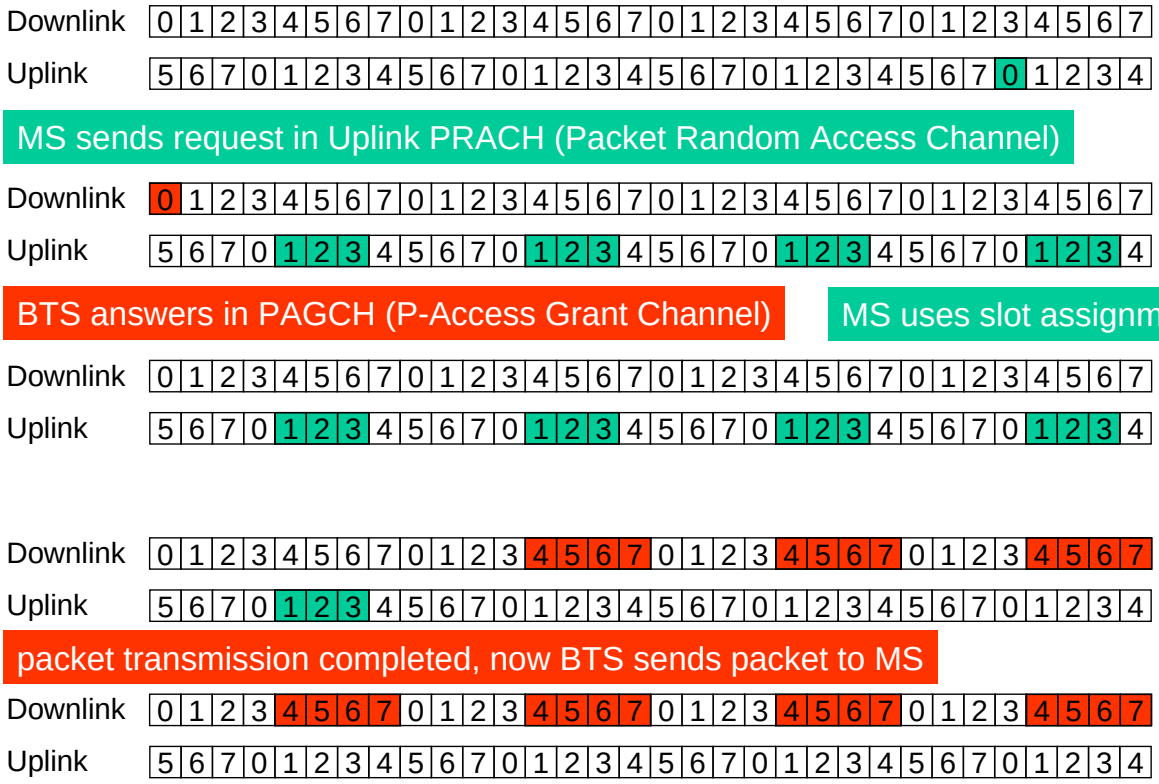
During passive time slots, MS is able to measure reception of other cells (but now only 4 out of 8 slots).



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Use of TDMA slots with GPRS

GPRS, packet-oriented, access via RLC/MAC protocol, using Master/Slave principle



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RLC/MAC Protocol

RLC - Radio Link Control

- for the radio interface MS - BSS
- segmentation of user data
- selective ARQ mechanism

MAC - Medium Access Control

- Downstream (BTS → MS) no challenge: BTS is the only sender

- Upstream (MSe → BTS): When is the MS allowed to access a specific slot?

- Master-Slave-mechanism: BTS is Master, MS are slaves
- Slaves indicate their wish for sending data to the master
  (Collisions may occur!)

- Master informs slaves who has access to the media
  Use the Uplink State Flag USF (12 Bit) to mark slots unused or reserved for a specific MS
  (Here too, collisions may occur)

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Summary of GPRS

- **Packet-oriented data transfer** with data rates up to **21.4 kbit/s per Time-Slot** and **up to 8 Time-Slots** per user
- Two new network components: **SGSN** and **GGSN**
- New network structure: **GPRS Backbone Network** transports user data between SGSNs and GGSN, **based on IP**
- **Conventional IP applications** may be used
- **Billing** may be based on the **amount of transferred data**
- **Costs for data transfer** may be negotiated (e.g. a better QoS is more expensive)

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6.5. Mobility Management Internet vs. GSM/GPRS

Mobility in the Internet – Mobility GSM/GPRS

Basic difference between GSM and the Internet:

• GSM is a "**connection-oriented**" network for telecommunication

• The Internet is a "**connectionless**" network for data communication

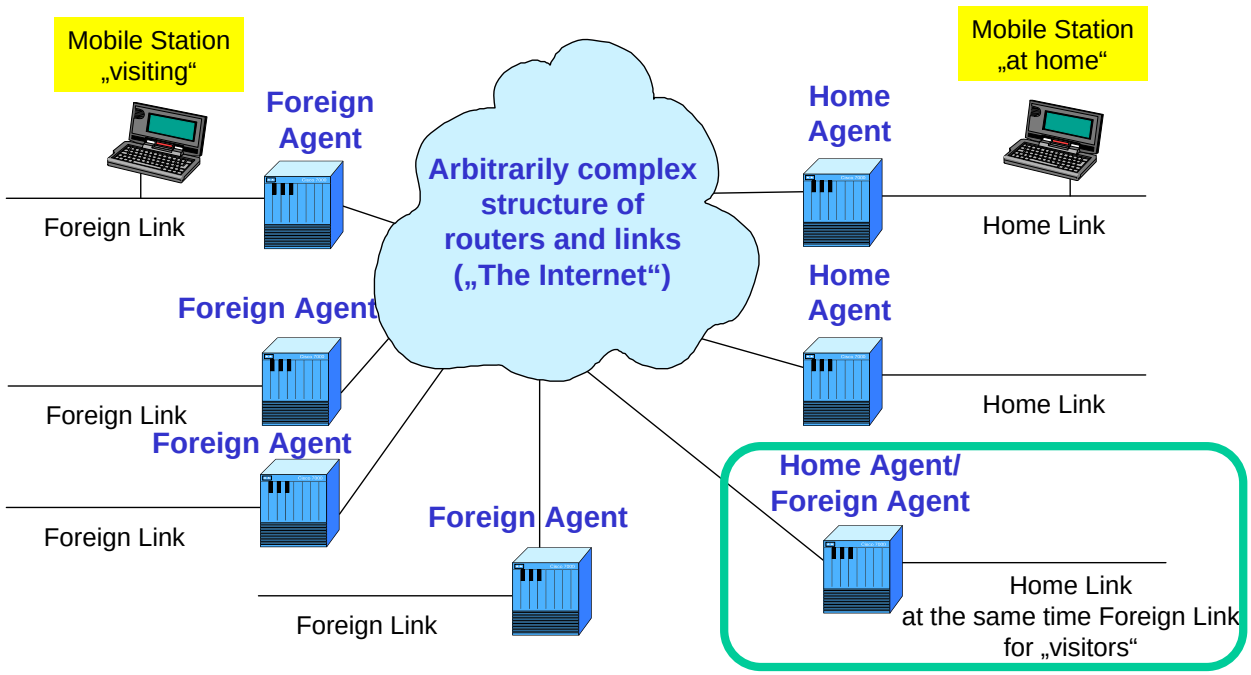
In terms of mobility management, there are several issues in common!

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Mobility Management in the Internet

Support of Macro Mobility

• when the IP subnetwork changes, the mobility configuration will be updated



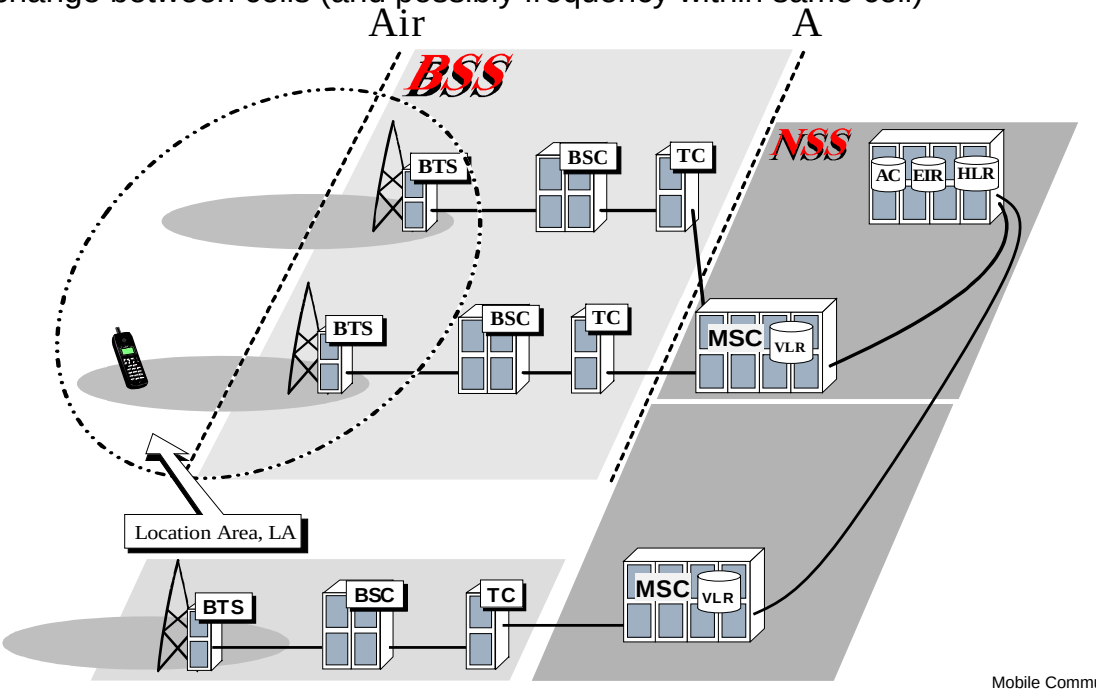
(Rem.: Foreign Agent with MIPv4 and IPv6 Router with MIPv6)

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Mobility Management with GSM

Support of Macro and Micro Mobility

• international Roaming (between different GSM-PLMN)
• Mobility between MSC-Regions (Location Area)
• change between cells (and possibly frequency within same cell)



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Comparison Internet - GSM

Mobility Internet	Mobility GSM
Home Agent	**Home Location Register** (HLR)
HA de-central: Each "Home Network" in the Internet has its own HA	**HLR is central** for all users of a PLMN (**de-central** when considering International Roaming: **Each PLMN has its own HLR**)
IP cares for **global addressing (world wide)**	ISDN numbering scheme cares for **global addressing** (e.g. +49-170-xxx leads to PLMN of T-Mobile)
Home Address of mobile device (IP Home Address)	MSISDN is "**Home Address**" of mobile user/SIM (but there is no physical home link)
Foreign Agent	Analogy in GSM: "Visited" MSC with its VLR (Visited Location Register)

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Comparison Internet - GSM (2)

Note:	TMSI = Temporary Mobile Subscriber Identity
cf. sl. 25	MSRN = Mobile Station Roaming Number similar to Care-of-Address in Mobile IP

Mobility Internet	Mobility GSM
Reachability: **Care-of Address** is used for IP-Routing to the mobile station	Reachability: **TMSI/MSRN** allows for ISDN-Routing to the visited MSC, paging is used to determine detailed location within Location Area
Reachability (2): Care-of Address stored **in Home Agent**	Reachability (2): TMSI stored **in HLR** of Home PLMN (MSRN is only assigned when needed)
"**connectionless**" Communication	"**connection-oriented**" Communication
When changing the Link-Layer access (wired and/or wireless) to a different IP subnetwork, the configuration will be changed (FA, Care-of Address)	• with active call "Handover" between - frequencies and cells (BTS) - BSCs - MSCs • in Idle Mode a "Location Update" is performed when changing the Location Area
No advanced concept for detection of movement	Detection of movement by frequent measurement of current and alternative wireless reception of BTSs

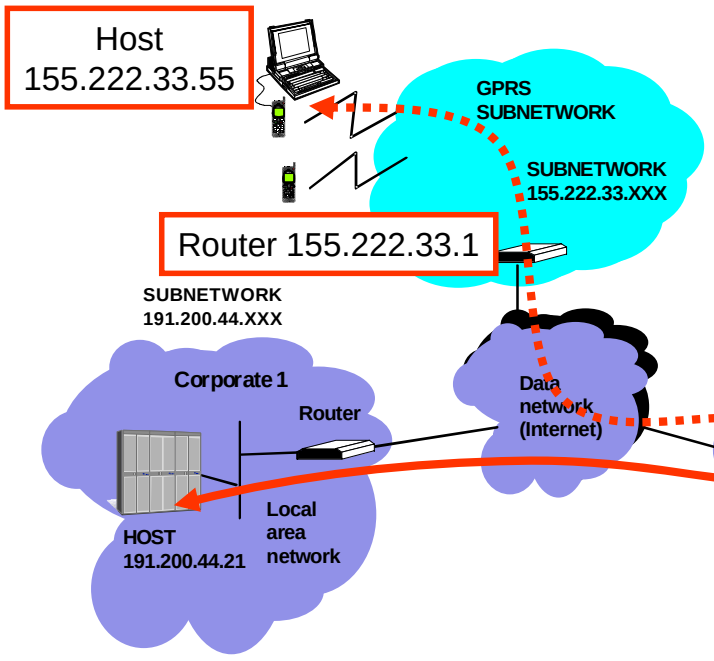
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Comparison Internet - GSM (3)

Mobility Internet	Mobility GSM
Macro-Mobility: = basic goal Mobile IP • change in configuration of Mobile IP upon change of network access to different IP subnetwork	**Macro-Mobility**: • International Roaming: Use of services in "visited" PLMN • Mobility in GSM on highest hierarchy level may also be seen as Macro-Mobility (MSC-Handover/Location update, changing TMSI and change information in HLR)
Micro-Mobility: • no support by Mobile IP (never was the goal of Mobile IP) • Support of mobility within a specific link technology (OSI layer 2) is transparent for Mobile IP (e.g. GSM seen as a single IP subnet)	**Micro-Mobility**: Advanced concepts for ("fast") movement in cellular networks • overlapping cells • measurement of reception quality of current and neighbouring cells • "fast" mechanism (handover) for "fast" change between cells – without interruption

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User's view of a GPRS Network (slide 48 recalled)



Mobility of a GPRS user
in a GSM network from IP's point of view
is **transparent**, i.e. it's regulated within the GSM/GPRS network

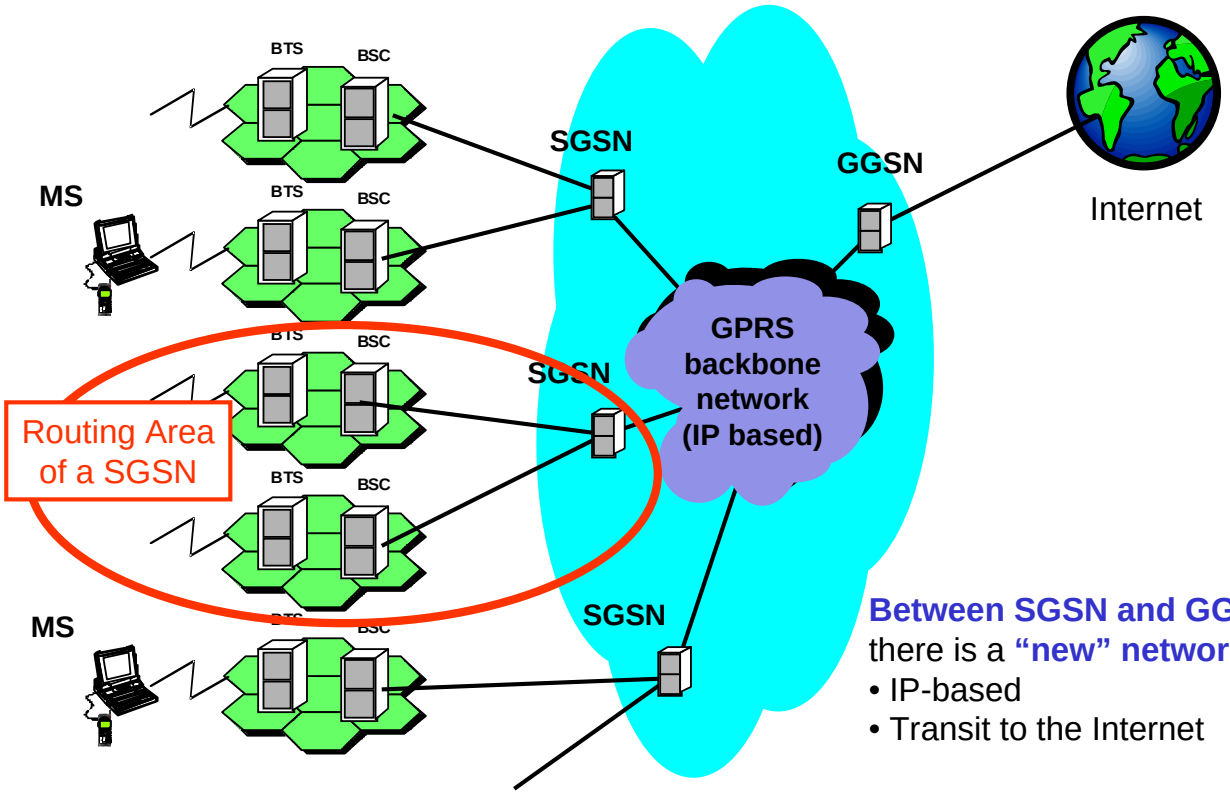
Communication in the Internet between two hosts

Communication of a GPRS host (in GSM) with an arbitrary host in the Internet

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Architecture of a GPRS System (slide 52 recalled)

Between MS and SGSN „conventional“ **GSM network** (minor modifications)



Between SGSN and GGSN there is a **“new” network:**
- IP-based
- Transit to the Internet

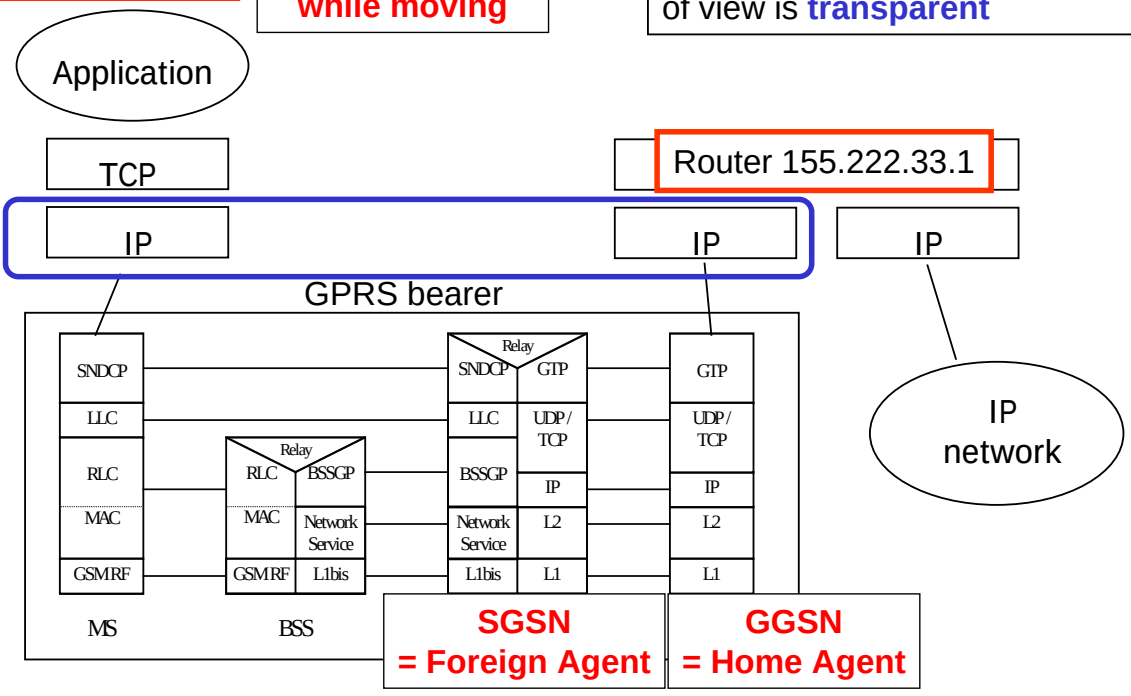
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GPRS User Plane + IP Access (cf. slide 59)

Host 155.222.33.55

Home Address does not change while moving

Mobility of a GPRS user in a GSM network from IP’s point of view is **transparent**

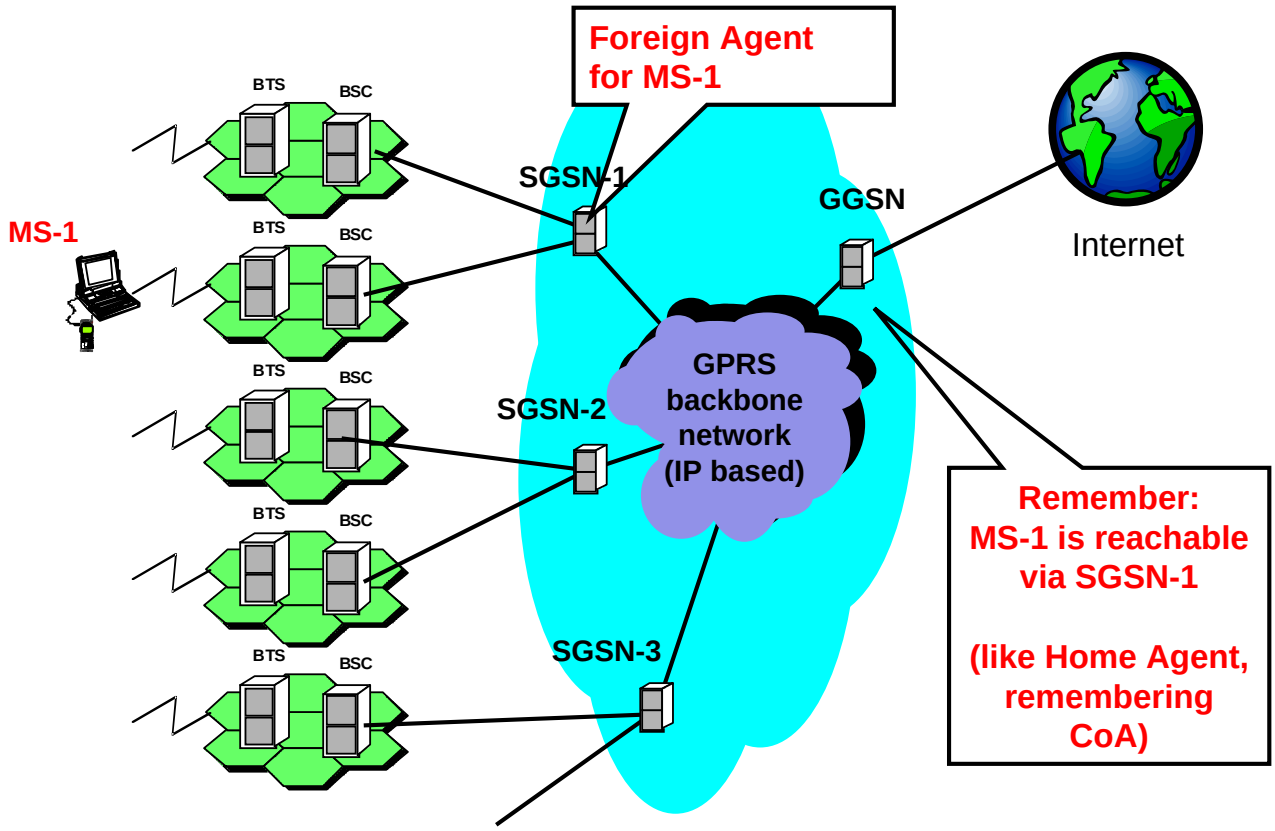


Within the GPRS/GSM network mobility is supported internally.

⇒ Functionality is identical to Mobile IP !!!

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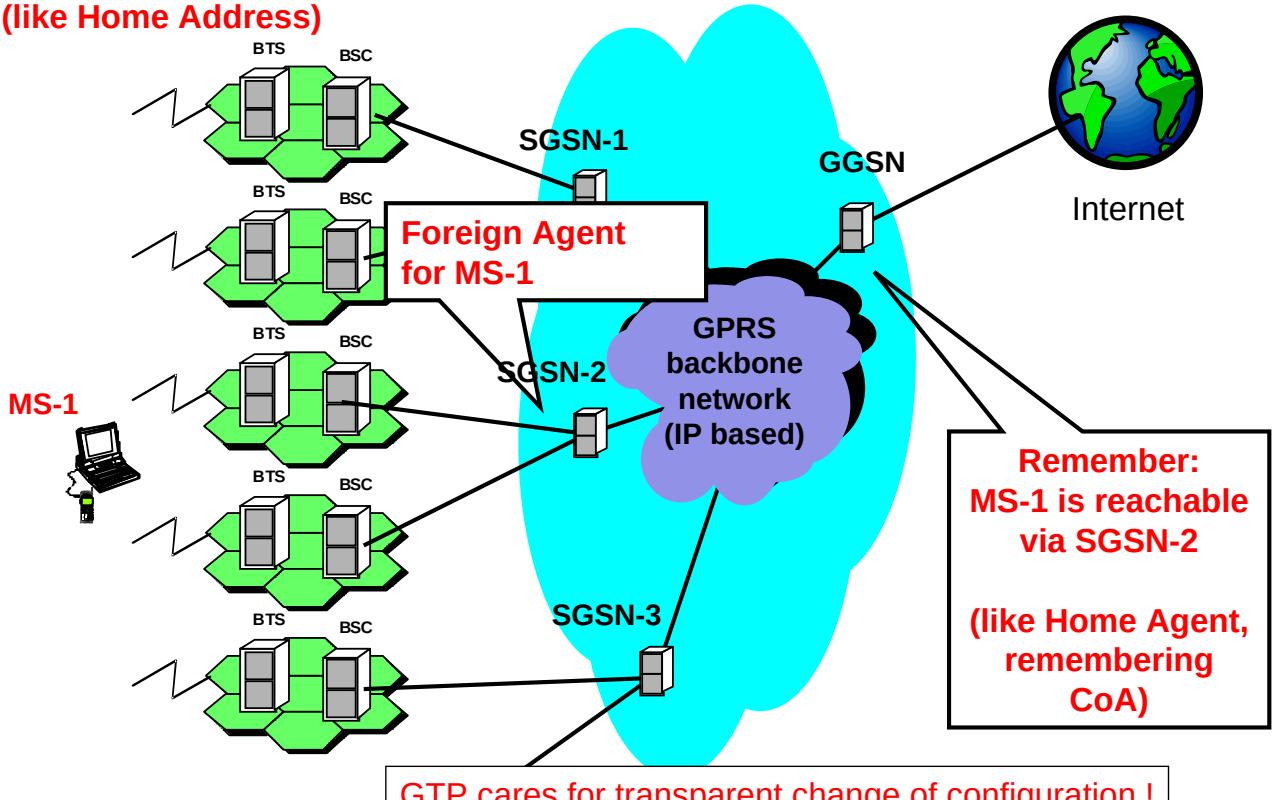
Mobility in GPRS – Example



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Mobility in GPRS – Moving to SGSN-2

IP-Adress of MS unchanged!
(like Home Address)

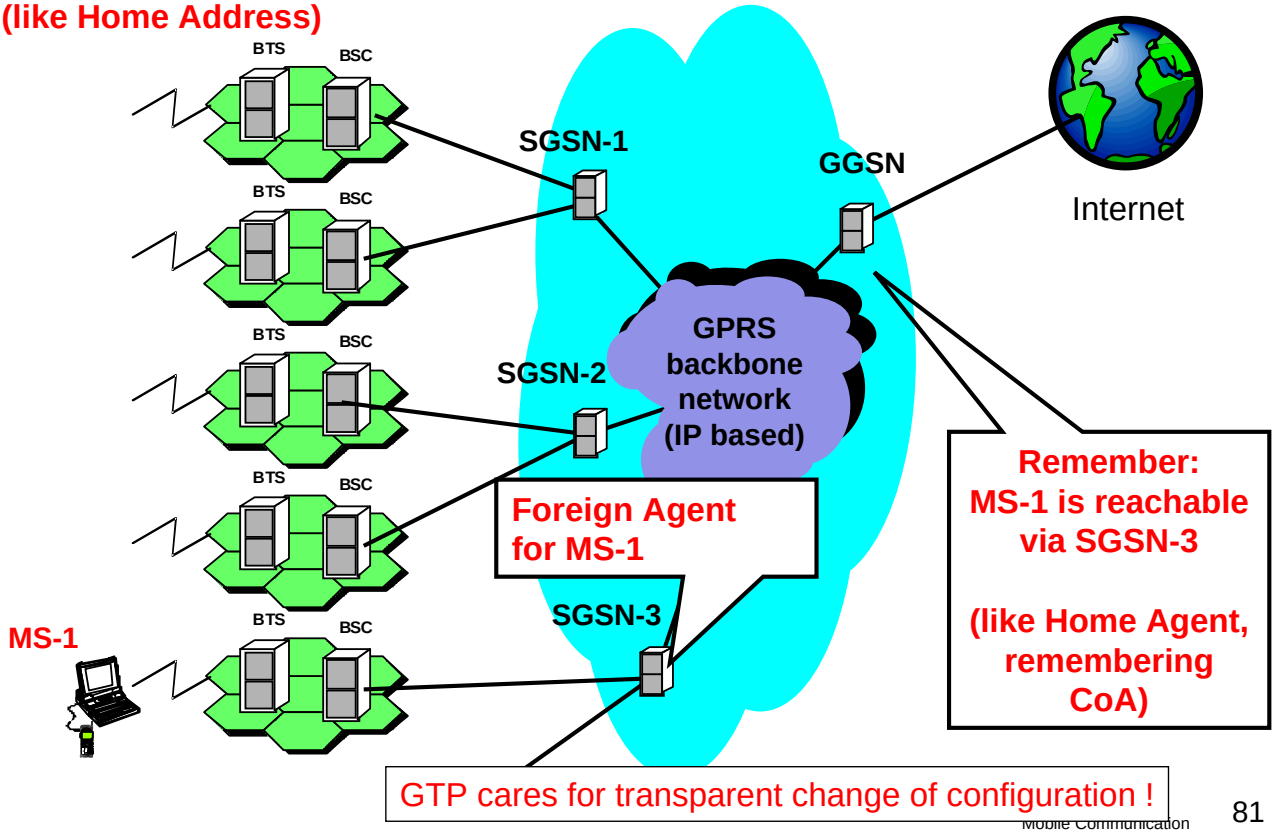


GTP cares for transparent change of configuration !

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Mobility in GPRS – Moving to SGSN-3

IP-Adress of MS unchanged!
(like Home Address)



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