SBS overview

Contents

1 Global system for mobile communication GSM

Standardization

The Global System for Mobile Communications GSM is a ("2nd generation") standard for mobile communication. This standard was developed by the European Telecommunication Standards Institute ETSI (founded in 1988).

Today the Specifications for the GERAN (GSM and Edge Radio Access Network) can be found in the internet under www.3gpp.org.

The 3rd Generation Partnership Project (3GPP) is a collaboration agreement that was established in December 1998. The collaboration agreement brings together a number of telecommunications standards like ARIB, CCSA, ETSI, ATIS, TTA, and TTC.

Public Land Mobile Network PLMN

A Public Land Mobile Network is a network, established and operated by its licensed operators, for the specific purpose of providing land mobile communication services to the public.

Radio cell

A radio cell is the smallest service area in a PLMN. The term “cell” comes from the (idealized) honeycomb shape of the areas into which the PLMN coverage area is divided. A cell consists of a base station transmitting over a small geographic area that is represented as a hexagon. The whole PLMN area is covered by a great number of radio cells.

A cell is also called Base Transceiver Station BTS.

The nominal radius of a cell may be

- up to 35 km radius for the GSM900 system and
- up to 8 km radius for the GSM1800/GSM1900 system.

Mobile Station MS and SIM

The Mobile Station is the radio equipment needed by a subscriber to access the services provided by the PLMN. The MS may be a fixed station (e.g. installed in a vehicle) or a portable handheld station. The Subscriber Identity Module SIM provides the mobile equipment ME with a subscriber's identity.

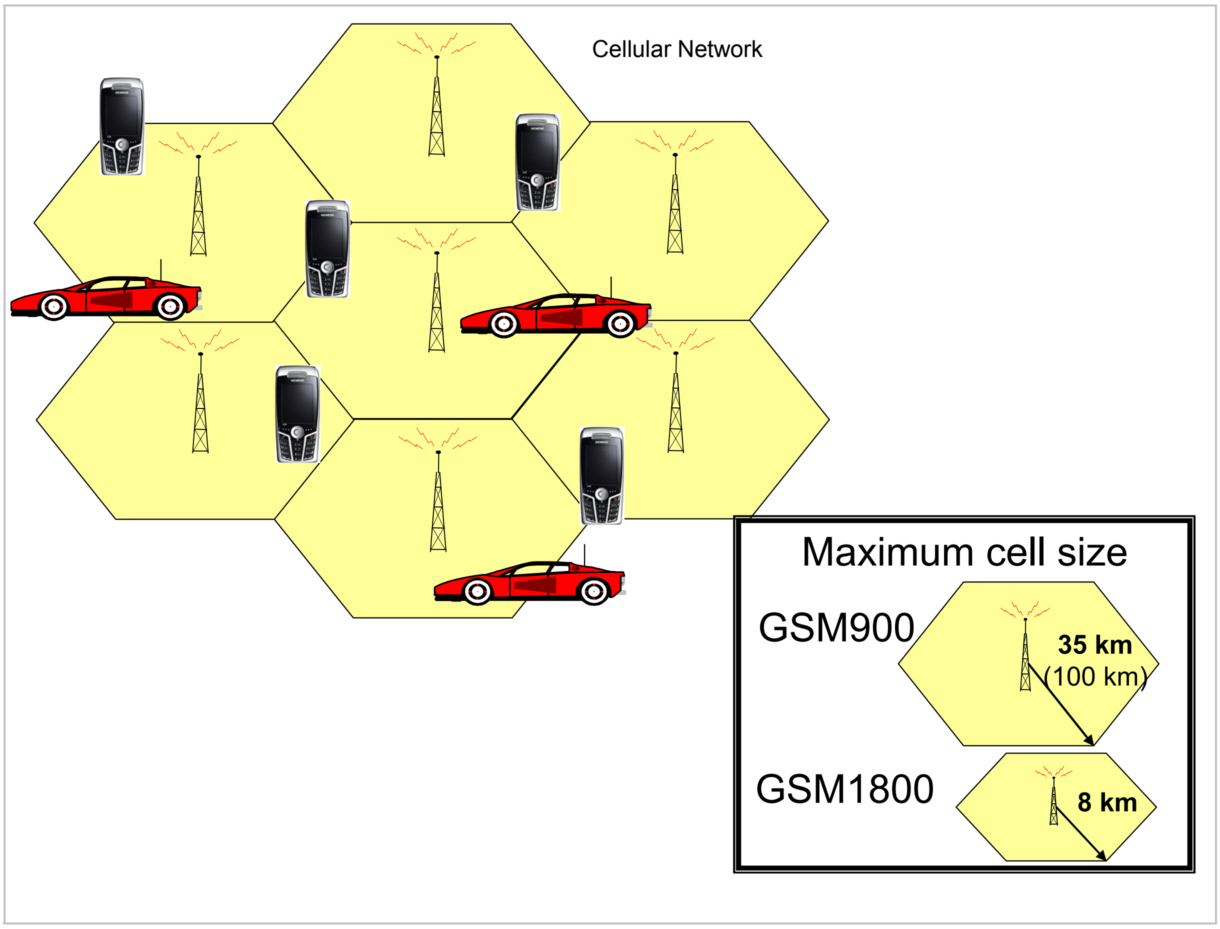
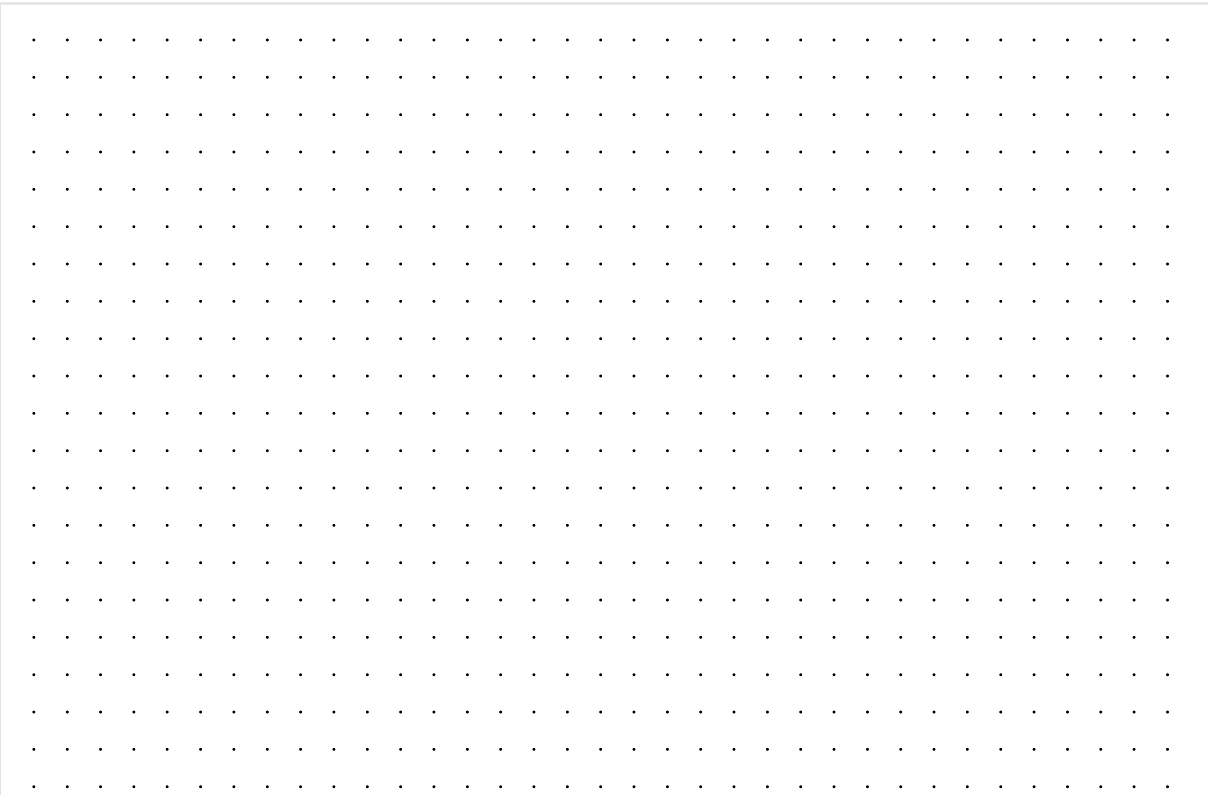


Fig. 1 Radio cells



2 Network elements for PLMN

The major subsystems of a Public Land Mobile Network are:

- Operation and Maintenance Subsystem ("management system"))
- Switching Subsystem ("core network")
- Radio Subsystem ("radio access network")

Network Elements

The subsystems functions are grouped into functional units or network elements. Functional units may be realized either as standalone Hardware HW units or associated with other GSM functional units in one HW unit.

The **Radio SubSystem RSS** consists of the **Mobile Stations MS** and the **Base Station Subsystem BSS**, which is composed of the following functional units:

- Base Station Controller BSC
- Base Transceiver Station BTS
- Transcoding and Rate Adaption Unit TRAU

The **Network Switching Subsystem NSS** (Phase ½) consists of the following functional units:

- Mobile services Switching Center MSC
- Visitor Location Register VLR
- Home Location Register HLR
- Authentication Center AC
- Equipment Identity Register EIR.

The **Operation SubSystem OSS** consists of Operation & Maintenance Centers OMC; in the Siemens solution:

- Operation & Maintenance Center for the Base Station Subsystem is the Radio Commander (RC)
- Operation & Maintenance Center for the Switching Subsystem is the Switch Commander (SC).

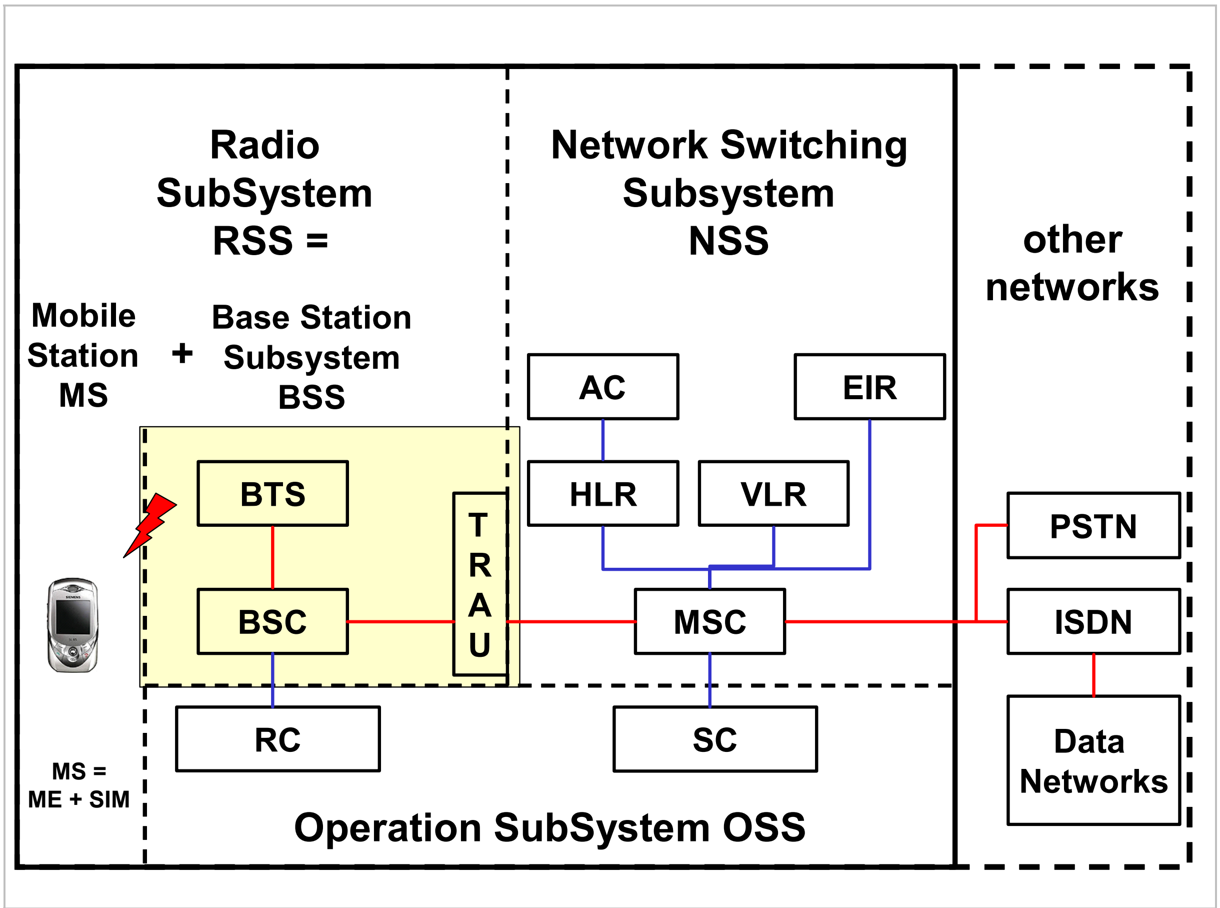


Fig. 2 GSM PLMN

3 Radio access network: radio subsystem

The Radio Subsystem RSS is composed of:

- Mobile Station MS
- Base Station System BSS
- Radio Interface Um

The Mobile Station and the Base Station System communicate across the Um interface ("air interface" or "radio link").

The BSS includes the:

- Base Station Controller BSC
- Base Transceiver Station Equipment BTSE
- Transcoder and Rate Adapter Unit TRAU

Note: The Siemens realization of GSM's BSS is called Siemens Base Station System **SBS**.

The connections between the network elements are typically PCM30 (or PCM24) lines running via copper lines, coaxial cables or microwave links.

The following table summarizes the (terrestrial) RSS interfaces and their associated PCM lines:

Interface	PCM line	Protocol Used
A	PCMA	CCSS#7 (open interface to circuit-switched core network)
Asub	PCMS	LAPD ("LPDLS", proprietary)
Abis	PCMB	LAPD ("LPDLM & LPDLR", proprietary)
Gb	PCMG	BSSGP (open interface between SGSN and Packet Control Unit PCU (located in BSC))

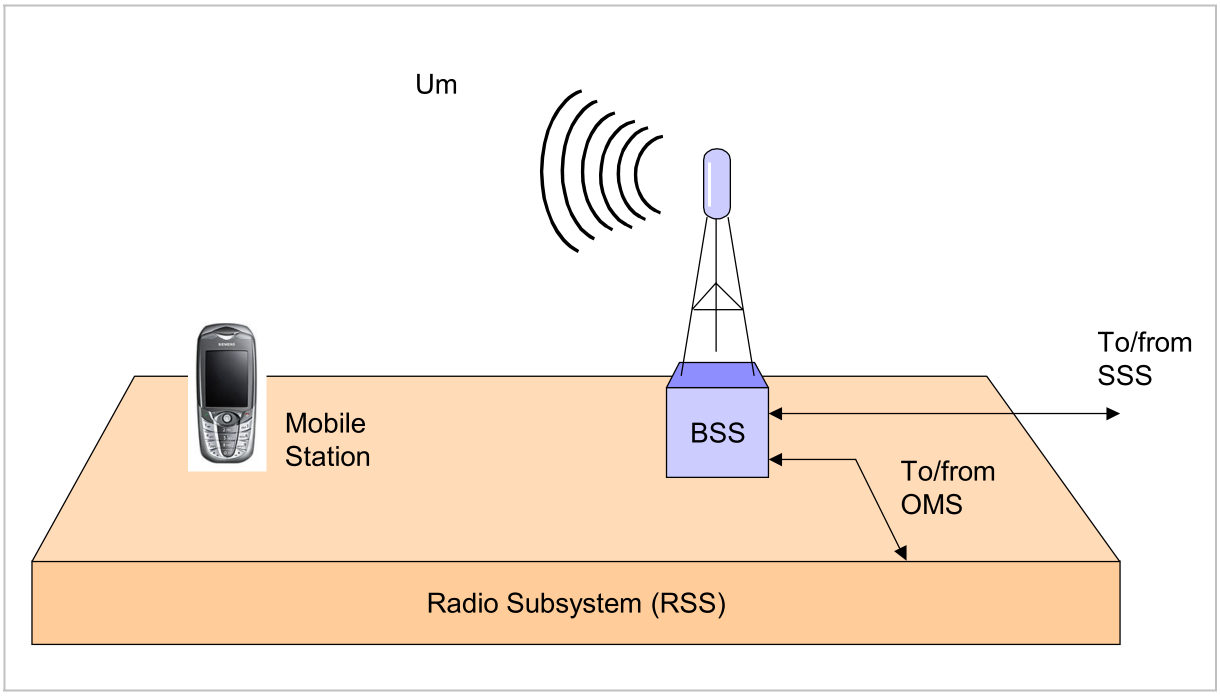


Fig. 3 Radio Subsystem RSS

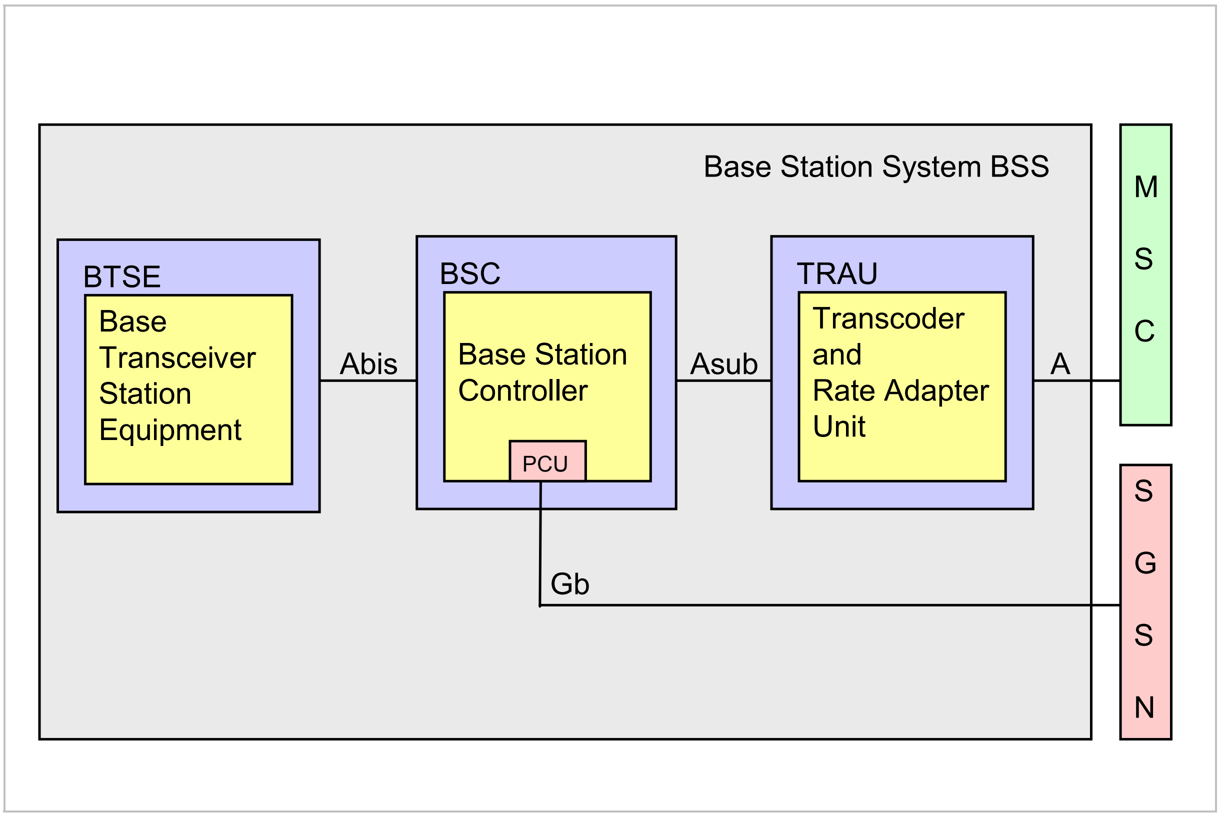


Fig. 4 Base Station Subsystem BSS

PCMB and LAPD configuration

Time slots (signaling/traffic) can be assigned to a BTSE on up to eight PCMB lines in case of the BTSplus family. These multiple links support load-sharing and fault recovery.

The LAPD signaling timeslots may be 16 kbit/s sub slots (if max 2 TRX are used) or 64 kbit/s time slots. On the BTSM side, these time slots are called **LAPDLE** while in the BSC database they are called **LPDLM** (although they may carry both LPDLM and LPDLR type signaling).

Minimum for each PCMB line at least one LAPDLE/LPDLM is required.

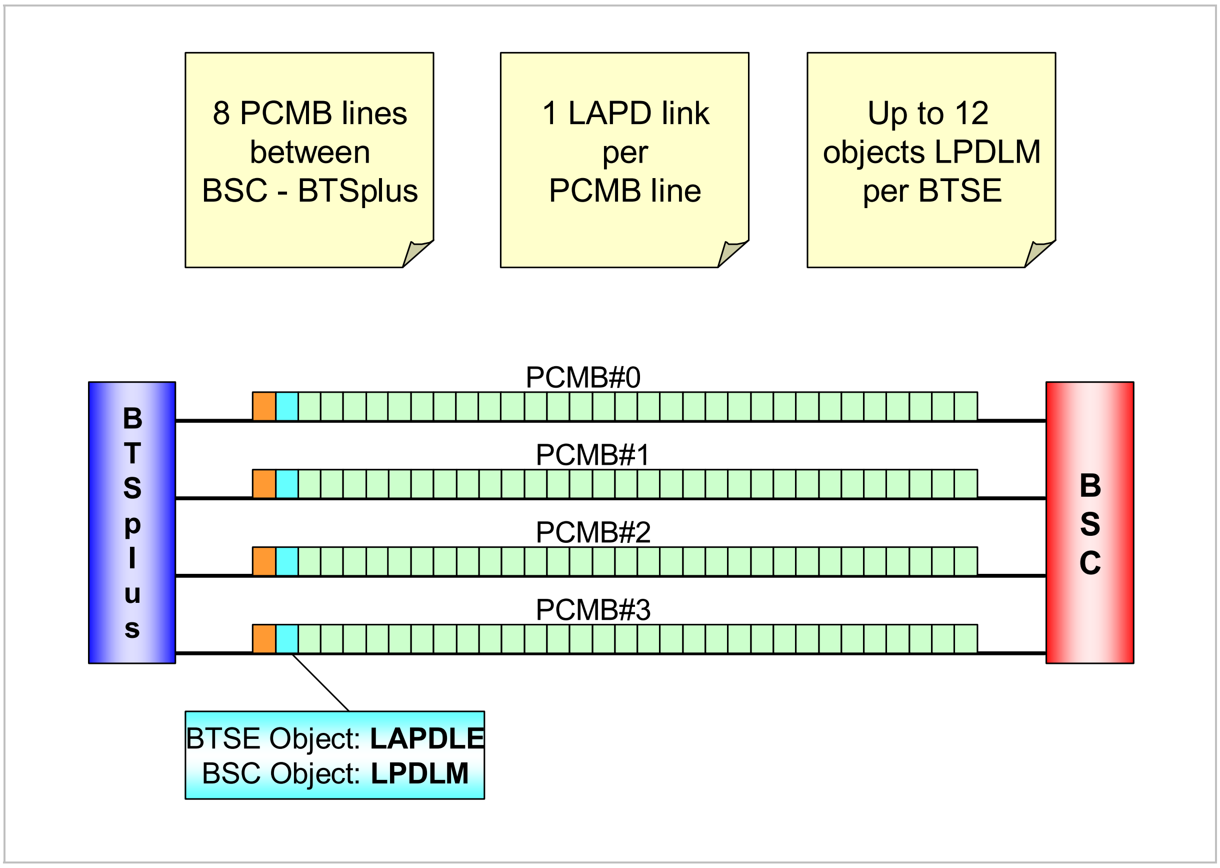


Fig. 5 Multiple Abis LAPD links

3.1 Base Station Controller BSC

The Base Station Controller is the "brain" of the Base Station System. The BSC

- switches traffic channels from the core network to the MS (via BTSE),
- handles the signaling between access and core network,
- supervises the complete BSS (central Operation & Maintenance).

There are two different BSC types:

- eBSC: enhanced BSC based on ATCA platform
- cBSC: classic BSC (BSC72, BSC120)

Each BSC is composed of max 2 shelves in an indoor rack.

BSC capacity figures for different BSC hardware in the BR9.0 release are given in the following table:

	BSC72	**BSC120**	**eBSC**
Controlled TRXs*	500	900	2000
Controlled Cells	250	400	1000
Controlled BTSE	200	200	500
Controlled TRAU	32	48	100
PCM lines	72	120	540
LAPD (Abis+Asub)	up to 240	up to 240	1300
GPRS channels	1536	3072	8500
SS7L	8	16	8*16

Given capacity is obtained under the assumption:

- PCM30 lines are used
- network planning is properly done and
- normal network operational conditions are normal conditions.

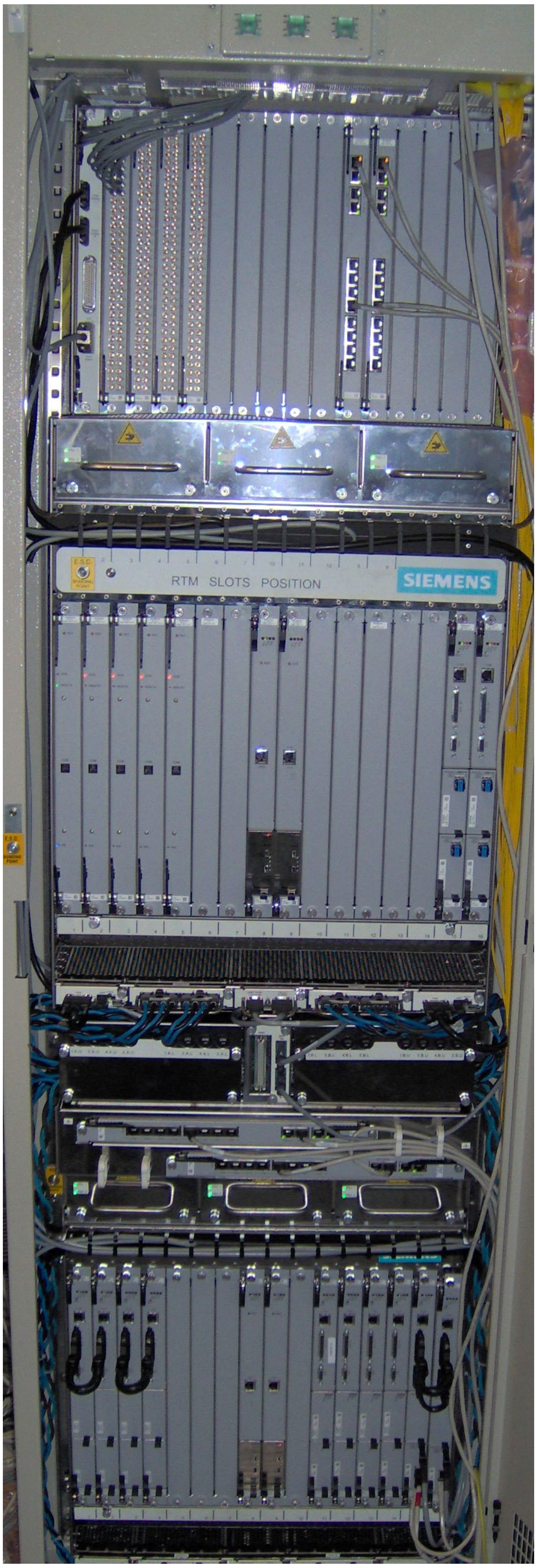


Fig. 6 eBSC rack layout

3.2 Base Transceiver Station Equipment BTSE

The Base Transceiver Station Equipment comprises the radio transmission and reception equipment, including the antennas, and also the signaling processing for the radio interface.

The BTSE provides up to 48 transceivers (TRX) with the Flex CU and serves up to 12 cells in case of BS240. Max 8 racks in total (max 3 of which provide TRX) make up a BTSE.

Up to 8 PCMB lines terminate on BTSE.

Two (main) product lines are in use:

- The ("classic") **BTSone** and
- the (new) **BTSplus** family.

BTSE Type	Product Line	Max Number of TRX	Max Total No of Racks (Radio/Service Racks)
BS40, 41	BTSplus	8	5 (1/4)
BS240, 241	BTSplus	48	8 (3/5)
BS240XL	BTSplus	48	7 (2/5)
BS240XS	BTSplus	6	1
BS82	BTSplus	8	2 ("cabinets")
BS82II	BTSplus	12	3 ("cabinets")
BS288	BTSplus	12	1
BS20, 21, 22	BTSone	2	1
BS60, 61	BTSone	6	2 (1/1)

BTSE names indicate if they are used

- indoor (-5 ... +55 °C, last digit "0"),
- outdoor (-45 ... +55 °C, last digit "1") or
- indoor and outdoor (perhaps with some limitation, last digit "2").

The first digits give often a hint to the number of Carrier Unit slots available.

Fig. 7 BS240

3.3 Transcoder and Rate Adapter Unit TRAU

The Transcoder and Rate Adapter Unit performs de-/coding (for speech calls) and rate adaptation (for circuit-switched data calls).

The two main functional units of the TRAU are:

- Transcoder for speech coding/compression
- Rate Adapter for data rate adaptation

Although the TRAU is (logically) part of the Base Station System (and controlled from the BSC), it is usually located near the MSC to save transport capacity on PCMS (typical PLMN speech takes 16 kbit/s bandwidth vs. 64 kbit/s for PSTN speech).

The TRAU (shelf) has a capacity of 120 speech channels. Up to eight (independent) shelves can be housed in the same rack.

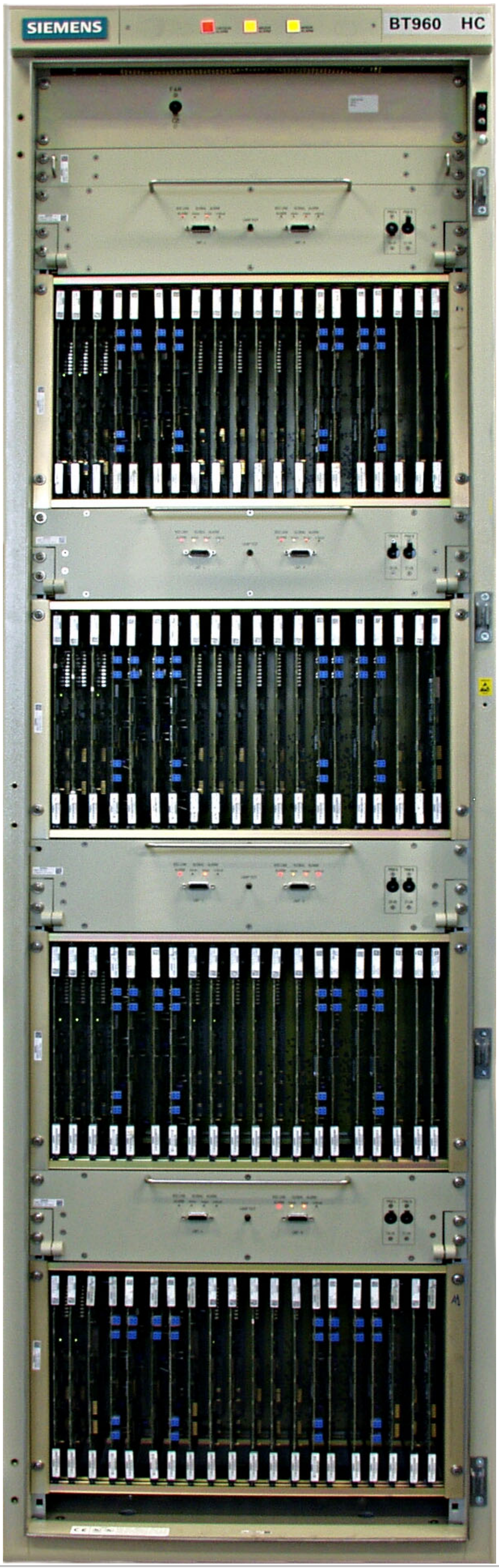


Fig. 8 High Capacity TRAU Rack

3.4 Local Maintenance Terminal LMT

The LMT software runs on a desktop or a laptop computer. The LMT is indispensable for commissioning BSC, BTSE and TRAU and for local maintenance.

For (central) operation and supervision of larger networks the RC's graphical user interface is better suited.

The O interface between RC and BSC is either a X.25 connection realized as a dedicated link via a PSPDN, an IP based link or embedded within the Asub and A interfaces via a semi permanent connection through the MSC ("nailed-up connection").

The LMT's T interface is based on X.21+V.11 and HDLC+ proprietary layer specifications (ITU-T) using the LAPB protocol and is used for the BSC, TRAU and all BTSE.

The LMT interface for the eBSC is an IP link. The software "LMT evolution" is the same as for the other NEs.

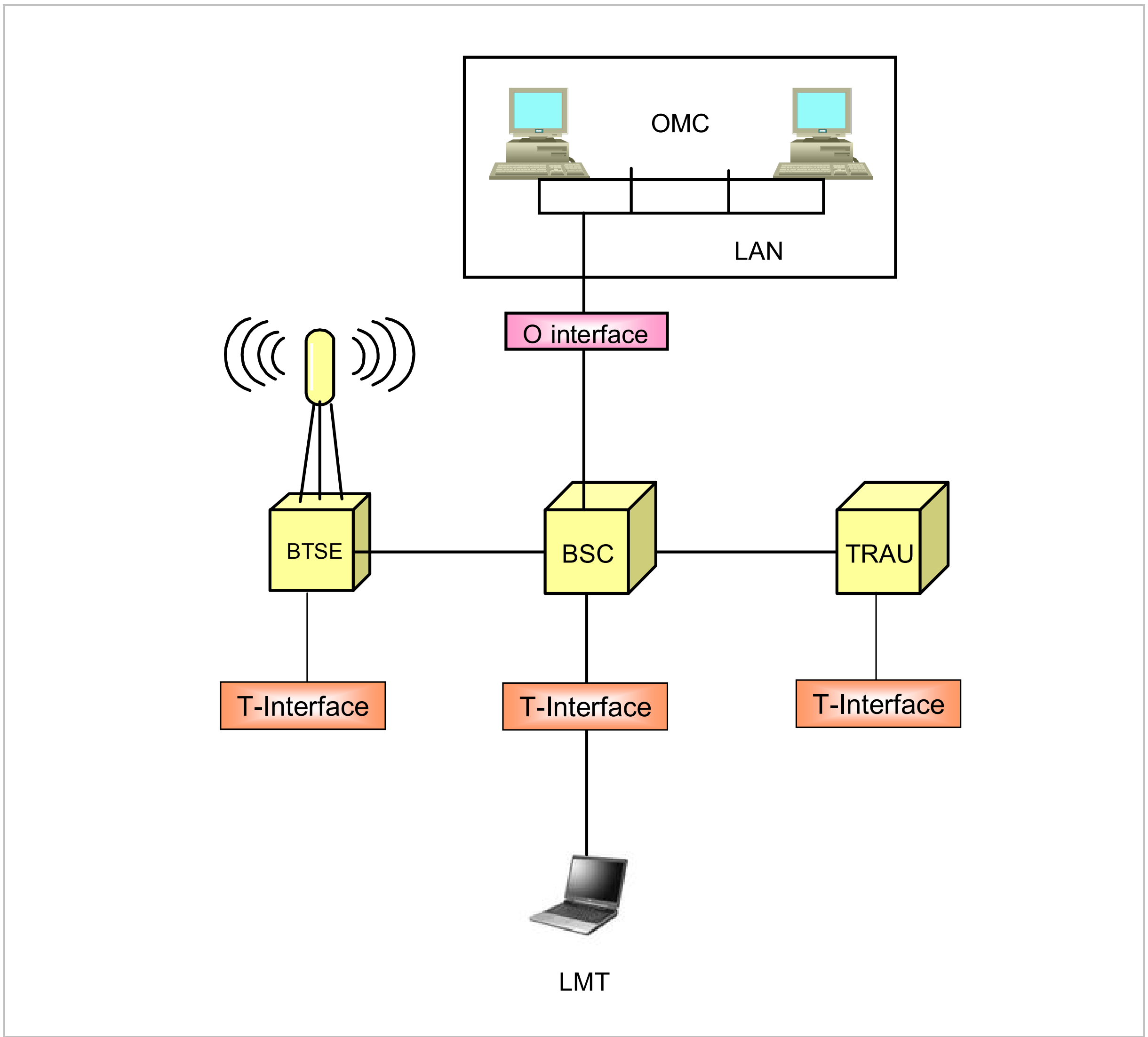


Fig. 9 Operation & Maintenance Interfaces on Base Station System

3.5 Documentation

SBS documentation may be divided into the following main categories:

System Descriptions

providing information on network architecture and functions for e.g. GSM-PLMN or GPRS-PLMN.

Technical Descriptions TED

explaining functions, features, hardware and software architecture as well as external and internal interfaces.

Operator Guidelines OGL

giving LMT and OMS-B handling information.

Operation Manuals OMN

containing the most relevant (LMT and OMS-B) operating procedures.

Maintenance Manuals MMN

providing replacement procedures for all SBS modules.

Installation and Test Manuals ITMN

explaining the step-by-step commissioning (incl. e.g. switch settings).

Command Manuals CML

referencing all available commands (and input parameter ranges) for LMT and OMS-B.

Installation Manuals IMN

dealing with the hardware related aspects of installation e.g. physical setup and cabling.

Performance Measurements PM

providing information on performance counters and signaling message flows.

The documentation is provided electronically on CD-ROM as PDF (portable data format) files. The **operating documentation** includes the following manuals (in alphabetical order, approximately 80 documents in total):

Manual	Abb.	Content
Abbreviations		Abbreviations
Command Manuals	CML	For BSC, BTSE, OMS-B, TRAU
Glossary		Explanation of terms
Installation Manuals	IMN	Hardware related information, for BSC, BTSE (all types), OMS-B, TRAU
Installation and Test Manuals	ITMN	Step-by-step commissioning, for BSC, BTSE (all types), OMS-B, TRAU
Maintenance Manuals	MMN	Replacement procedures incl. hardware related information, for BSC, BTSE (all types), OMS-B, TRAU
Network Integration Manual	NIMN	Testing network configuration (incl. database) "as planned"
Operator Guidelines	OGL	For LMT, OMS-B (commands, description, graphical panels, interactive panel architect, main menu, states and repertories, tools)
Output Manuals	OML	All error messages for BSC, BTSE and TRAU
Operation Manuals	OMN	For BSC (via LMT) and OMS-B
Performance Measurements	PM	SBS counters and SBS message flows
System Descriptions	SYD	For GPRS PLMN, GSM PLMN, GSM-R, Network System Concept, WAP/MIA for Mobile Solutions
Technical Descriptions	TED	Separate documents for "Common" and BS40/41, BS240/241, BS240XL, BS82, BS82II, BS2x/6x, … information (hardware related)
Terminology		Guide to documentation

Fig. 10 Document types

4 Radio interface Um

The Um interface is the radio interface between the BTSE (antenna) and the mobile station.

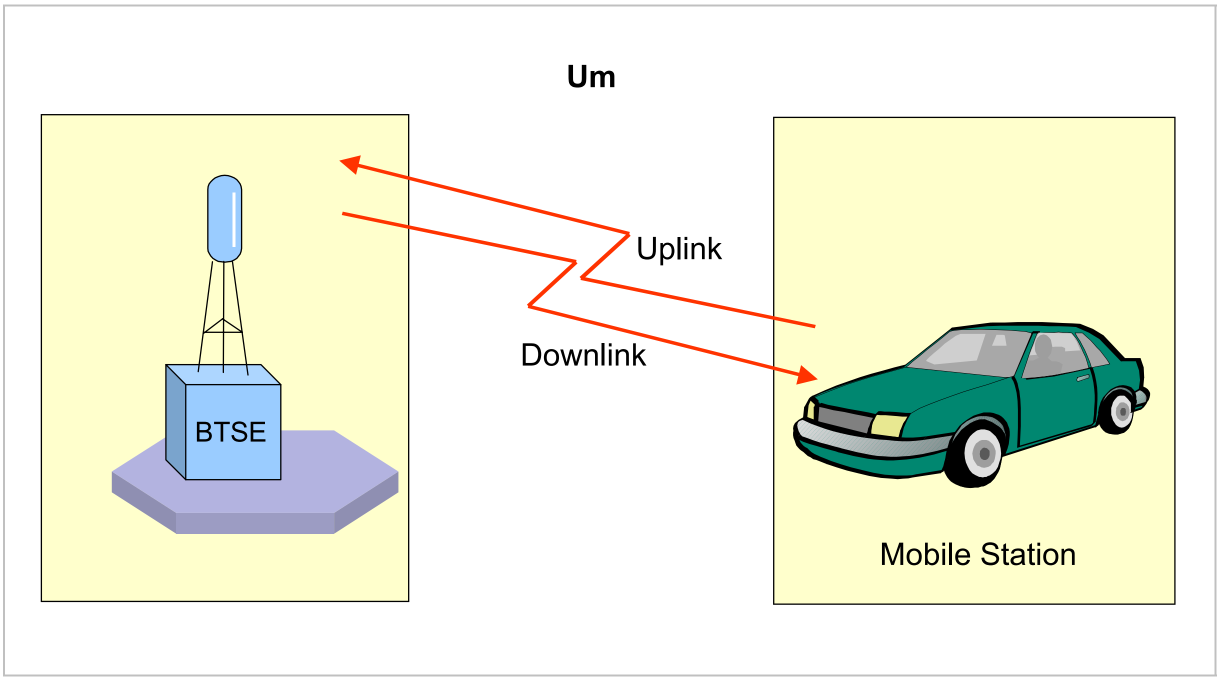


Fig. 11 Um interface

4.1 GSM900/GSM1800/GSM1900 frequency bands

A specific frequency range is assigned to GSM900/GSM1800/GSM1900 systems.

Each frequency range is divided into two sub-bands:

1. **Uplink** UL for the radio transmission between the MS and the BTSE,
2. **Downlink** DL for the radio transmission between the BTSE and the MS.

The fact that different frequency bands are used for uplink and downlink transmission is called **Frequency Division Duplex FDD**.

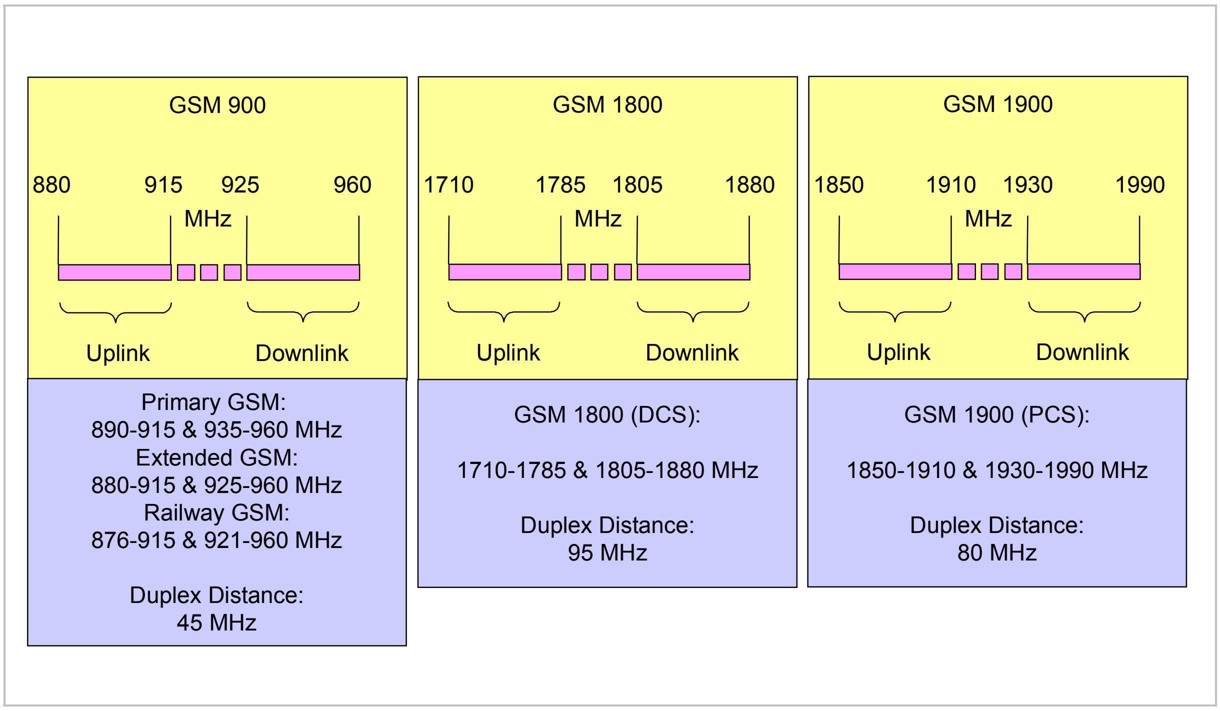


Fig. 12 Frequency ranges for GSM900, GSM1800 and GSM1900

4.2 Radio Frequency Carriers RFC

Both sub-bands (Uplink and Downlink) are divided into Radio Frequency Carriers with a bandwidth of 200 kHz each (**Frequency Division Multiple Access FDMA**).

The differences between GSM900, GSM1800 (DCS) and GSM1900 (PCS) relate to:

- Operating frequency
- Bandwidth of the sub-bands
- Number of Radio Frequency Carriers RFC available.

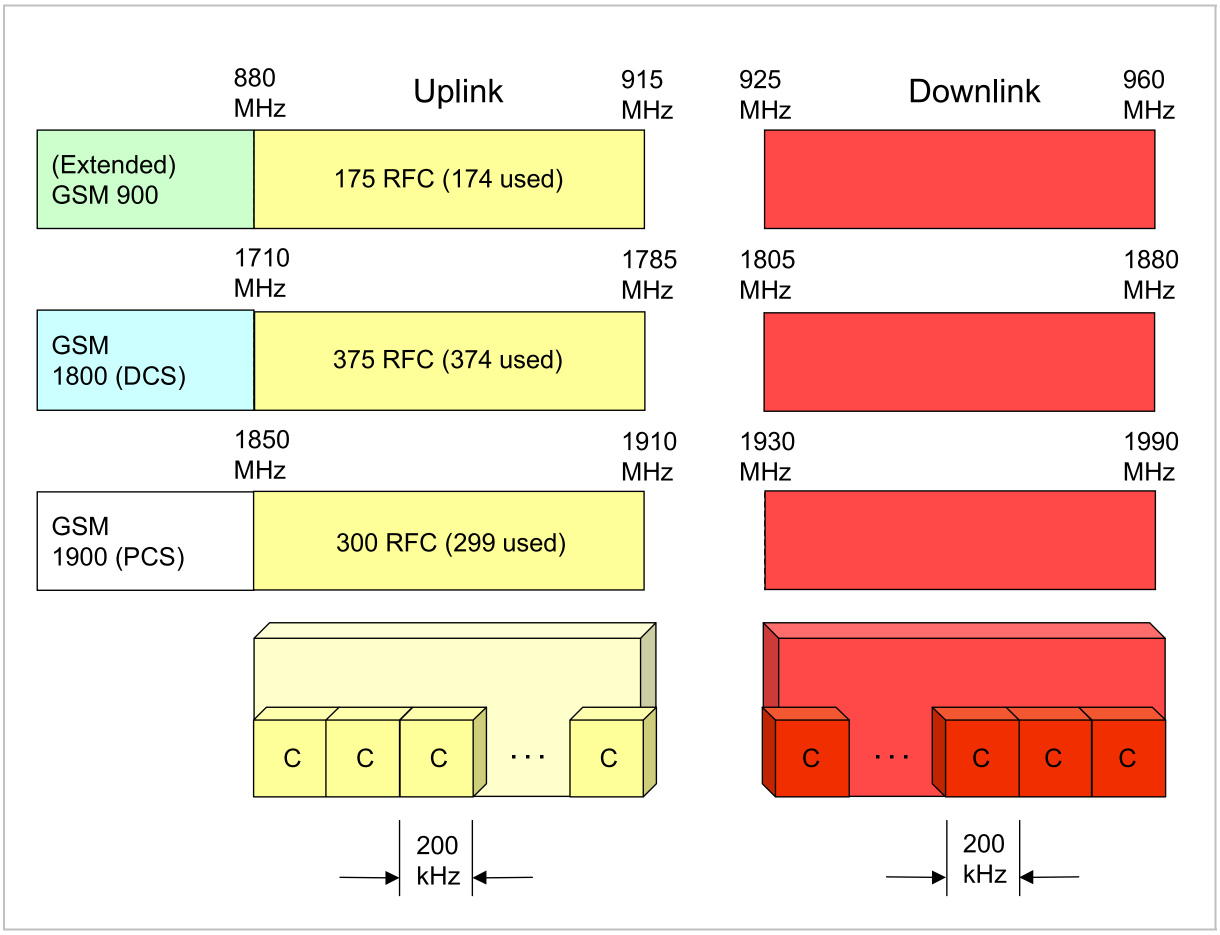


Fig. 13 Radio frequency carriers for GSM900, GSM1800 (DCS) and GSM1900 (PCS)

Depending on the traffic volume, every radio cell uses one or more RFC. Since the number of RFC is limited, the same RFC must be used several times. To avoid co-channel interference, a safe distance is required between the BTSE using the same RFC. This safe distance is called **reuse distance**.

The size of a single cell depends on topology and on traffic volume. In hilly regions or in densely populated areas with high traffic volume the cell radius is kept small. A small cell radius can be achieved by reducing the output power of the base station

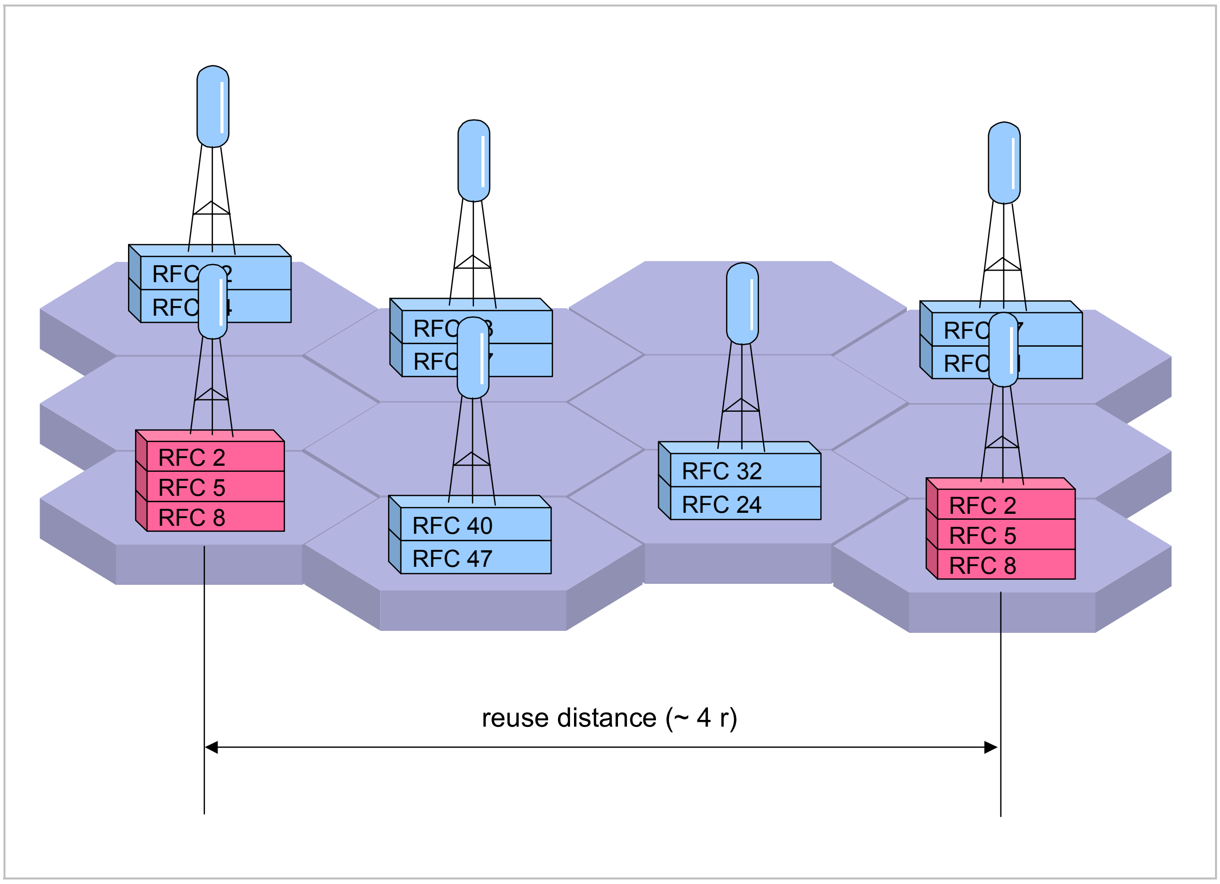


Fig. 14 Radio frequency carriers and reuse distance

4.3 Physical channels

One RFC is divided into eight time slots (**Time Division Multiple Access TDMA**). This is comparable to Pulse Code Modulation (transmission) technology where PCM30/24 frames are composed of 32/24 time slots, respectively.

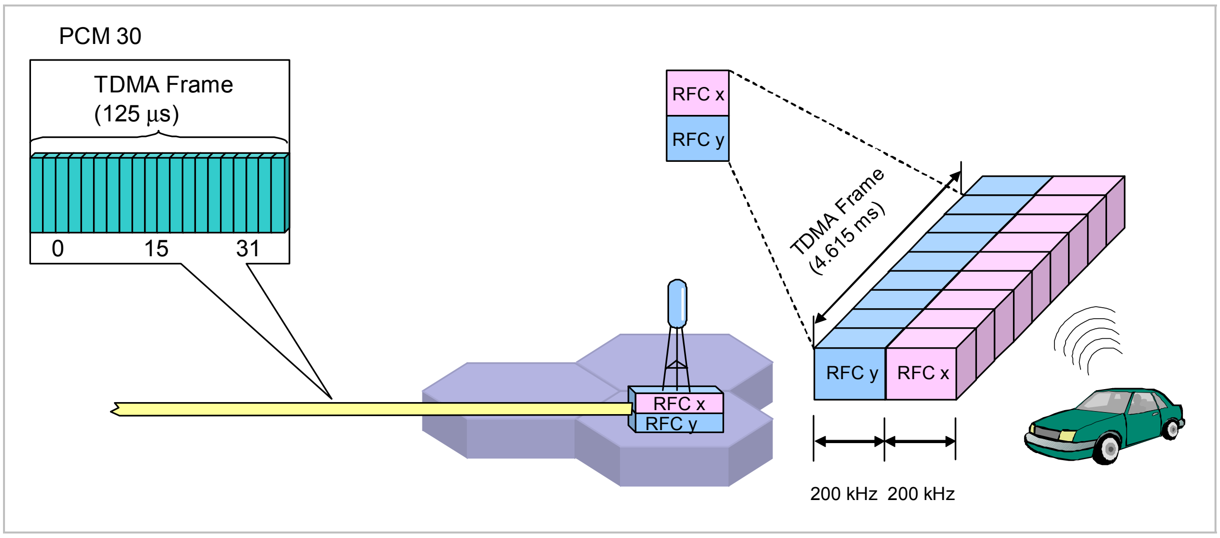


Fig. 15 Time division multiple access TDMA

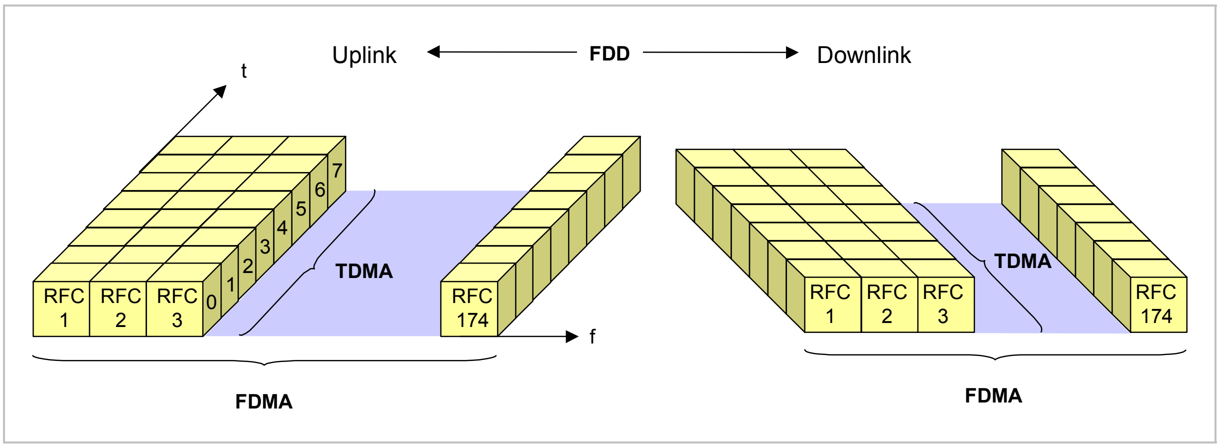


Fig. 16 Frequency division multiple access and time division multiple access (t=time, f=frequency)

A physical channel is defined by the timeslot number (in the TDMA frame) on a specific carrier (RFC) in the uplink band and the corresponding carrier in the downlink band.

A physical channel may carry only one or several logical channels ("multiplexing").

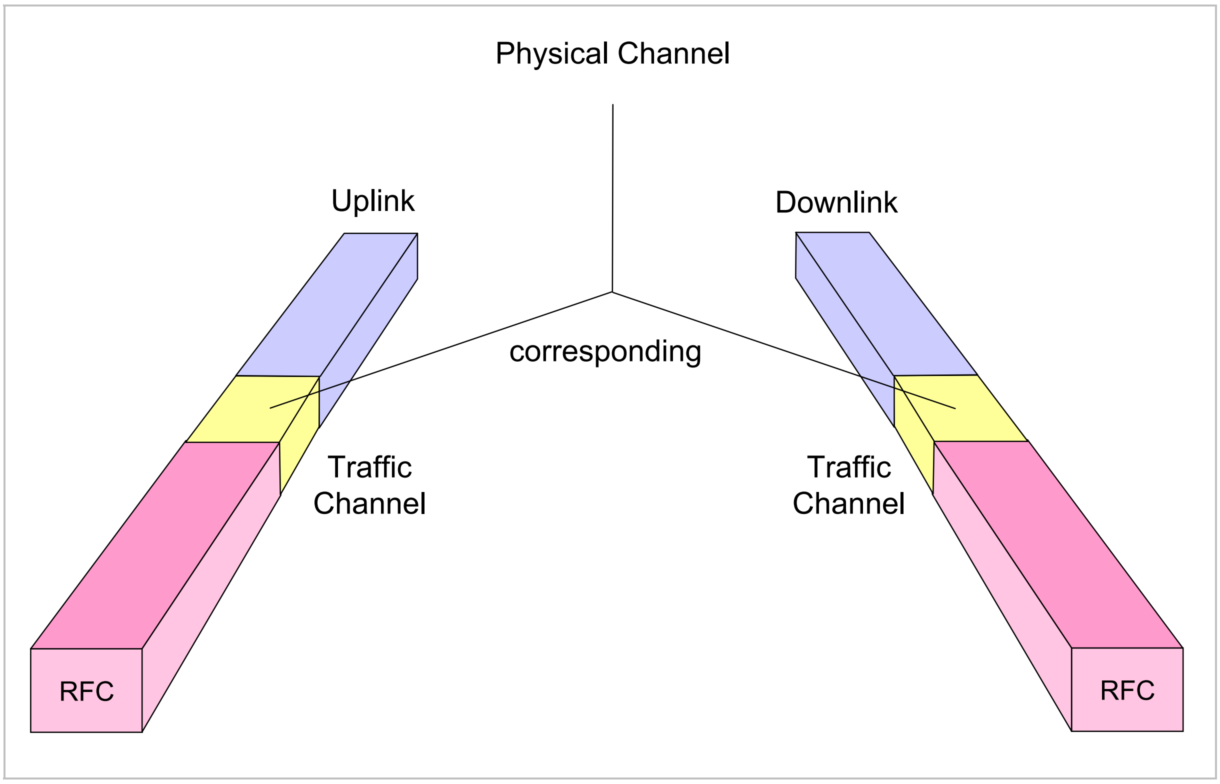


Fig. 17 Physical channel

4.4 Logical channels for CS services

Logical channels carry payload (speech or data) or signaling.

For circuit-switched CS traffic there is a clear separation between the physical channels used for payload and those used for signaling.

Signaling channels

Three types of signaling channels are used:

- Broadcast Control Channels (CS and PS)
- Common Control Channels (CS and PS)
- Dedicated Control Channels (CS only)

TIP
Channel Combinations

The allowed channel combinations of logical channel types are specified in GSM Rec. 05.02.

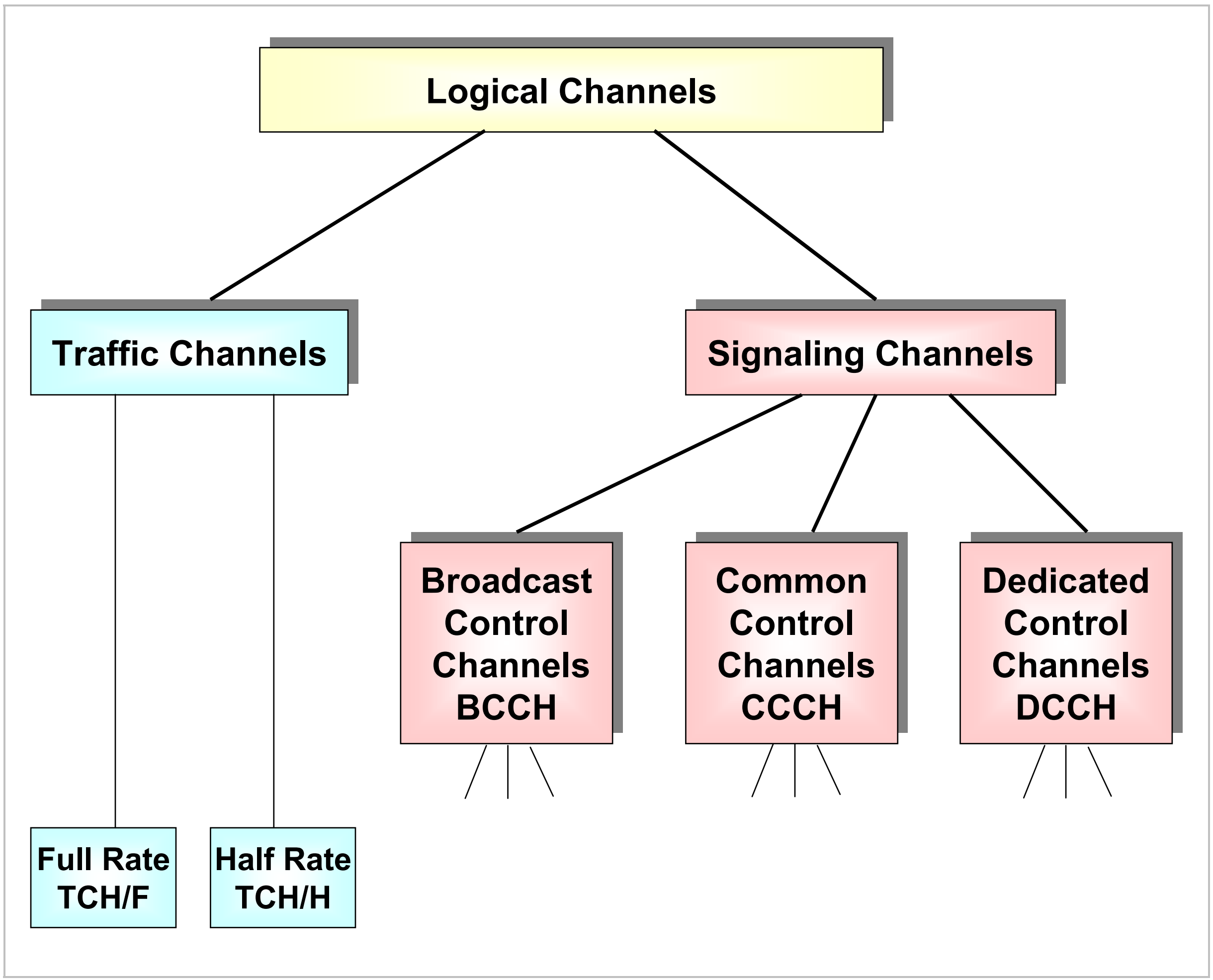


Fig. 18 Logical channels for circuit-switched traffic

4.4.1 Broadcast control channels

The broadcast control channels are defined for the BTSE to MS direction (downlink) only and are subdivided into the:

1. **Broadcast Control Channel BCCH** (defined per cell) which informs the mobile station about various cell parameters including country code, network code, local area code, PLMN code, RF channels used within the cell where the mobile is located, surrounding cells, and frequency hopping sequence number.
2. **Frequency Correction Channel FCCH** carrying information for frequency correction of the MS downlink ("fine tuning" of MS to BTS).
3. **Synchronization Channel SCH** providing information about the frame number and BTS identification code BSIC.
4. **Cell Broadcast Channel CBCH** used by the cell broadcast service for distributing e.g. weather information.

4.4.2 Common control channels

Common Control Channels are specified as unidirectional channels, either on the downlink or the uplink. The following sub-channels are distinguished:

1. **Paging Channel PCH** which is used DL to page mobile stations,
2. **Access Grant Channel AGCH**, also used DL, to assign a dedicated channel to a mobile station,
3. **Random Access Channel RACH** which is an UL channel to indicate a mobile station’s request for a dedicated channel,
4. **Notification Channel NCH**, which is used in ASCI (Adv. Speech Call Items, paging MS using Voice Group Call Service / Voice Broadcast Service VBS).

4.4.3 Dedicated control channels

Dedicated Control Channels are full duplex (bi-directional) channels. They are subdivided into the

1. **Slow Associated Control Channel SACCH**, which is always associated with a TCH or SDCCH (embedded within the same frame structure). The SACCH is used for the transmission of radio link measurement data.
2. **Fast Associated Control Channel FACCH**, which is always associated with a TCH and is used for the transmission of signaling data, after the set-up of the call, when the SDCCH has been already released. The FACCH data are inserted into the TCH burst instead of traffic data (bit stealing), indicated by a "stealing flag" (i.e., the FACCH may contain handover information).
3. **Stand-alone Dedicated Control Channel SDCCH** which is normally assigned after the MS access request has been granted and is used for signaling purposes (set-up of the calls etc.)

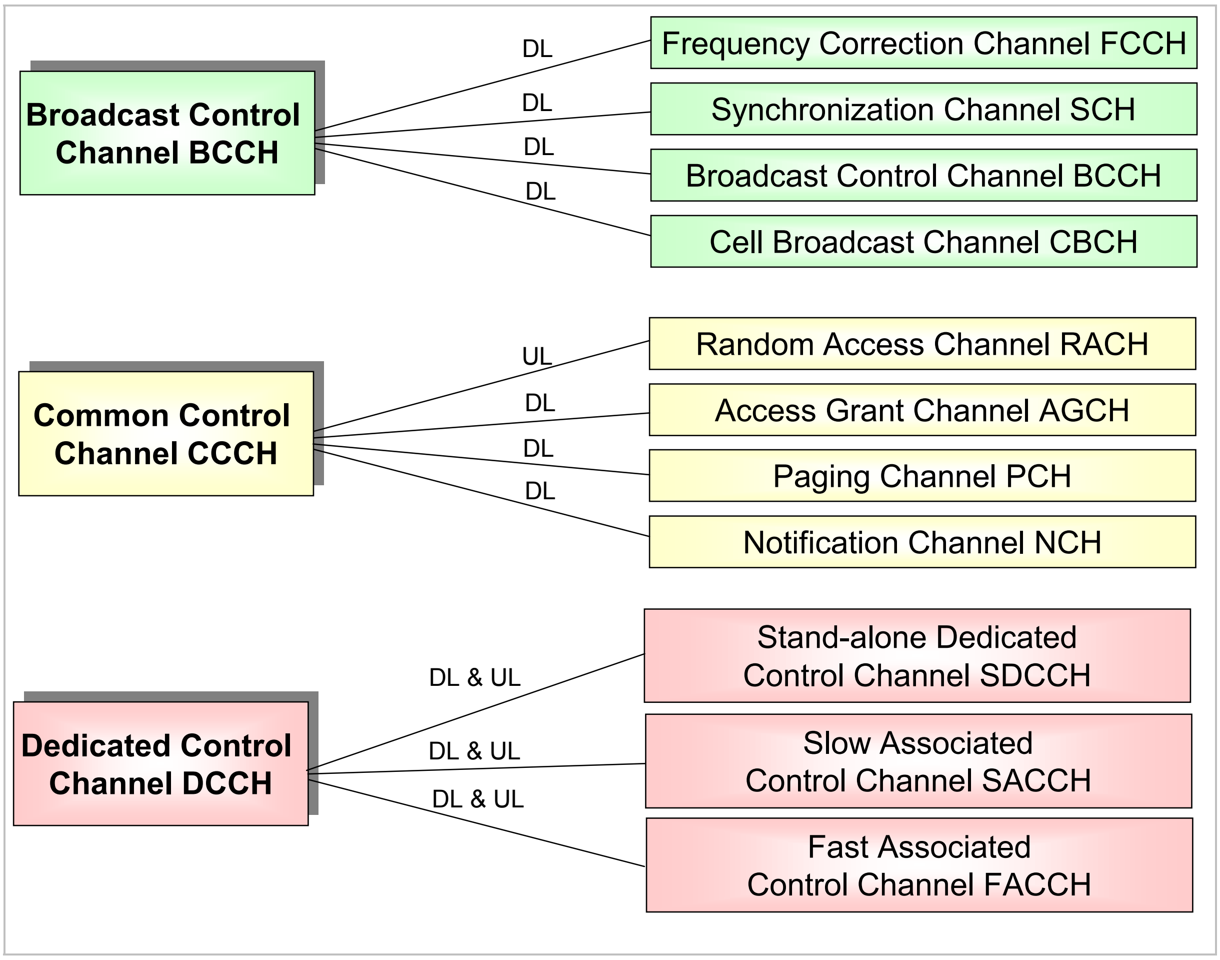


Fig. 19 Signaling channels

4.5 Logical channels for PS services

For packet-switched PS traffic, the same physical channel may carry both signaling and payload.

The packet data logical channels are mapped onto the physical channels that are dedicated to packet data. The physical channel dedicated to packet data traffic is called a Packet Data Channel (PDCH).

- GPRS introduces the following new types of logical channels:
- PBCCH (packet broadcast control channels)
- PCCCH (packet common control channels)
- PDCCH (packet dedicated control channels)
- PDTCH (packet data traffic channels)

4.5.1 Packet Data Traffic Channels (PDTCH)

PDTCH is a channel allocated for data transfer. It is temporarily dedicated to one MS or to a group of MSs in the PTM-M case. In the multislot operation, one MS may use multiple PDTCHs in parallel for individual packet transfer.

All packet data traffic channels are unidirectional, either uplink (PDTCH/U), for a mobile originated packet transfer or downlink (PDTCH/D) for a mobile terminated packet transfer.

A PDTCH when used for single timeslot operation may be either full-rate (PDTCH/F) or half-rate (PDTCH/H) depending on whether it is carried on a PDCH/F or PDCH/H respectively. A PDTCH, when used for multislot operation shall be full-rate

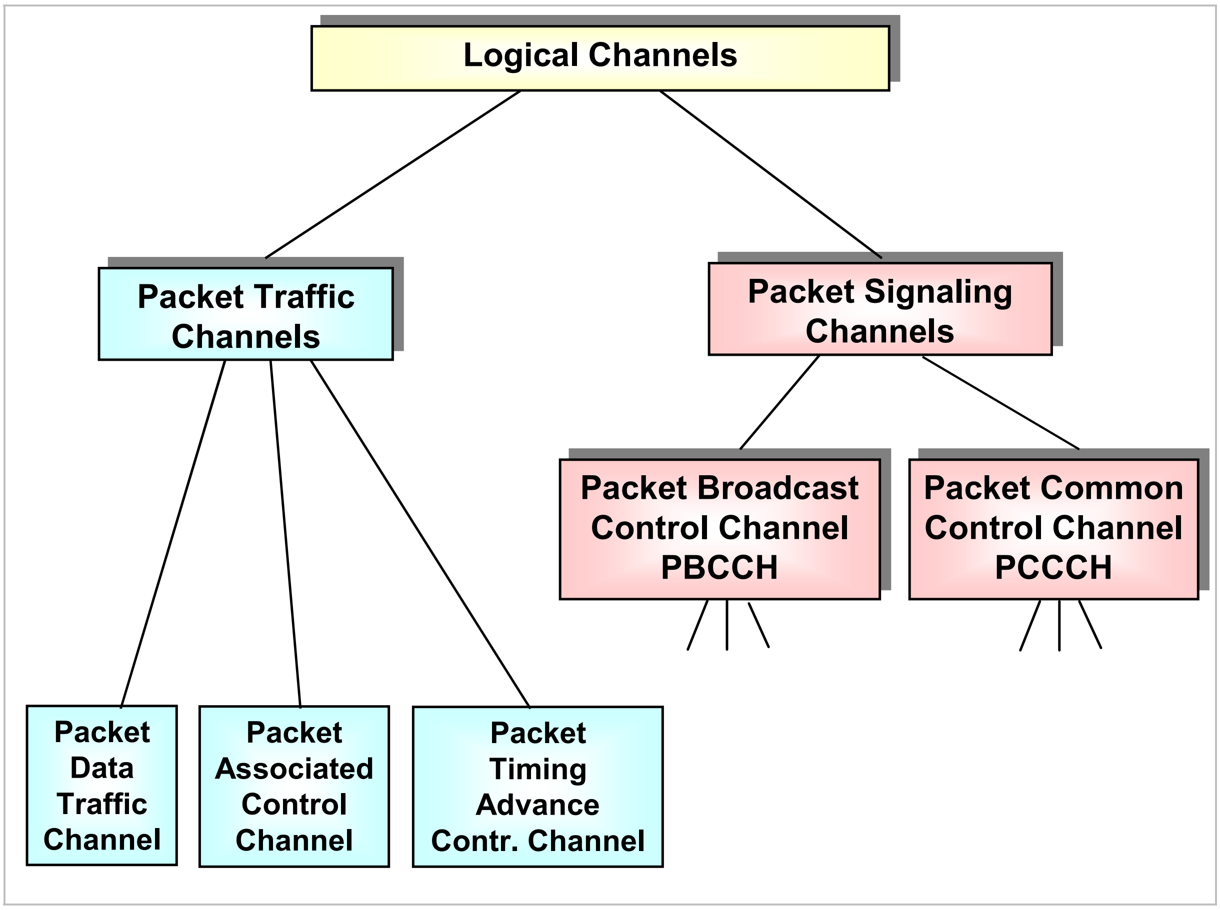


Fig. 20 Logical channels for packet-switched traffic

4.5.2 Packet Broadcast Control Channels (PBCCH)

1. Packet Broadcast Control Channel PBCCH broadcast packet data specific System Information. If PBCCH is not allocated, the packet data specific system information is broadcast on BCCH. This channel is used downlink only.

4.5.3 Packet Common Control Channel (PCCCH)

1. Packet Random Access Channel PRACH is used by MS to initiate uplink transfer for sending data or signaling information. This channel is used uplink only.
2. Packet Paging Channel PPCH is used to page an MS prior to downlink packet transfer. PPCH can be used for paging of both circuit switched and packet data services. This channel is used uplink only.
3. Packet Access Grant Channel PAGCH is used in the packet transfer establishment phase to send resource assignment to an MS prior to packet transfer. This channel is used downlink only.
4. Packet Notification Channel PNCH is used to send a PTM-M (Point To Multipoint - Multicast) notification to a group of MSs prior to a PTM-M packet transfer. This channel is used downlink only.

4.5.4 Packet Dedicated Control Channels (PDCCH)

1. Packet Associated Control Channel PACCH conveys signaling information related to a given MS. The signaling information includes e.g. acknowledgements and power control information. The PACCH shares resources with PDTCHs, that are currently assigned to one MS.
2. Packet Timing advance Control Channel PTCCH is necessary to allow estimation of the timing advance for one MS in packet transfer mode.

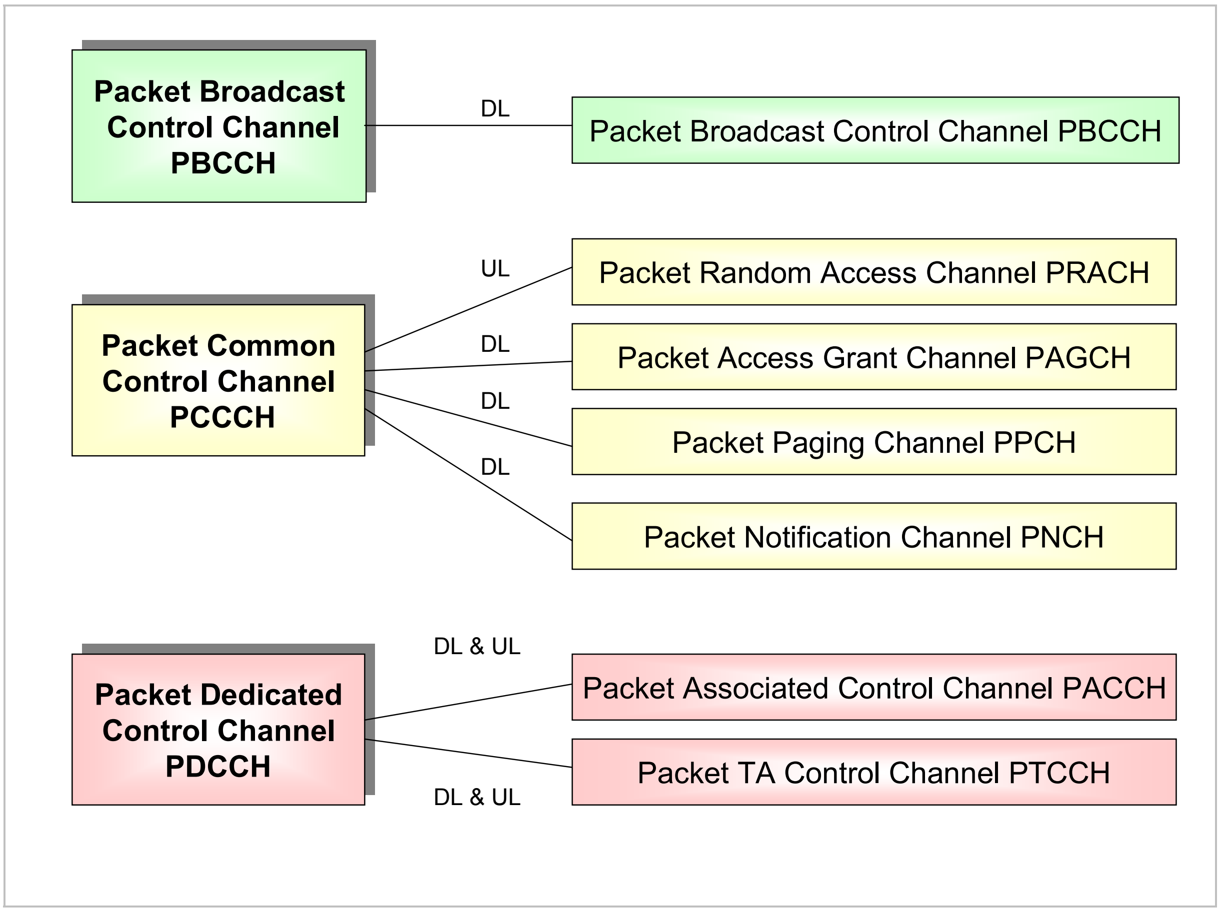


Fig. 21 Packet switched Signaling channels

4.6 Multiframes

There are 8 timeslots per TDMA frame. The TDMA frames are forming the multiframes. There are different multiframes in case of:

- Circuit switched Traffic channels
- Circuit switched signaling channels
- Packet switched channels

4.6.1 Traffic channel multiframe (CS)

For circuit-switched traffic, a TCH is always allocated together with its associated slow-rate channel (SACCH). **Twenty-six TDMA frames** (=120 ms) are grouped together to form one multiframe for speech/data. TCH are sent on 24 timeslots; one slot is used for SACCH signaling information and one slot remains unused (for full rate).

Not only subscriber information (speech/data) can be transmitted in a traffic channel TCH. If the signaling requirement increases (e.g. for a handover), signaling information FACCH is transmitted instead of TCH. A so-called stealing flag in the normal burst indicates this.

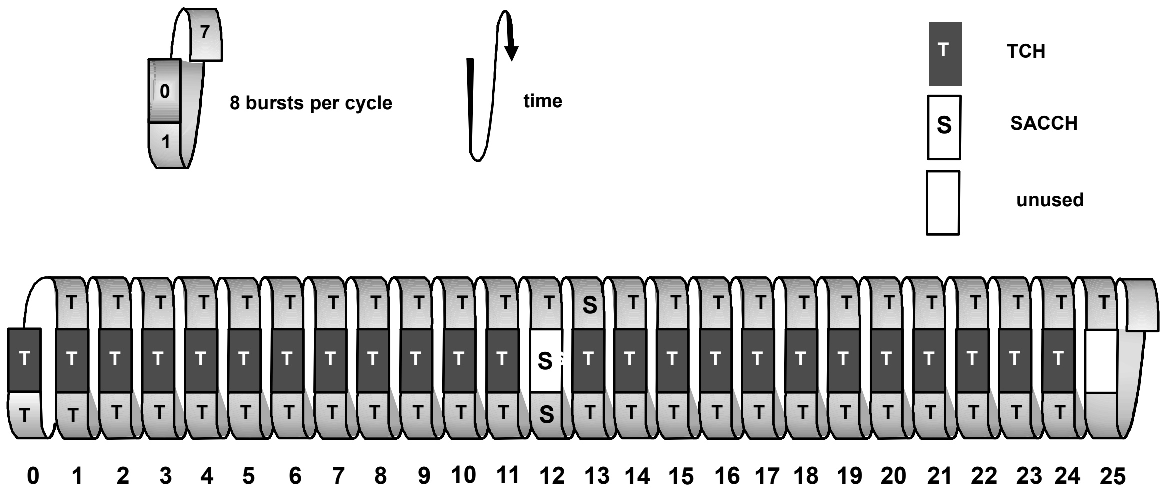


Fig. 22 Traffic channel multiframe

4.6.2 Signaling channel multiframe (CS)

For circuit-switched traffic, **fifty-one TDMA frames** (=235.4 ms) are grouped together to form one signaling channel multiframe.

As an example the following figure shows the basic combination including (downlink direction) a FCCH, SCH, BCCH, and AGCH/PCH all on the same timeslot (i.e., 0). The uplink direction contains a RACH.

The BCCH with the AGCH/PCH uses 40 slots per multiframe. These 40 timeslots are grouped together as 10 groups of four. The BCCH use the first four timeslots of the first group of 10. The remaining timeslots are used by the AGCH/PCH.

The FCCH is sent on timeslot 0 in frames 0, 10, 20, 30 and 40, while the SCH is sent in timeslot 0 on frames 1, 11, 21, 31 and 41.

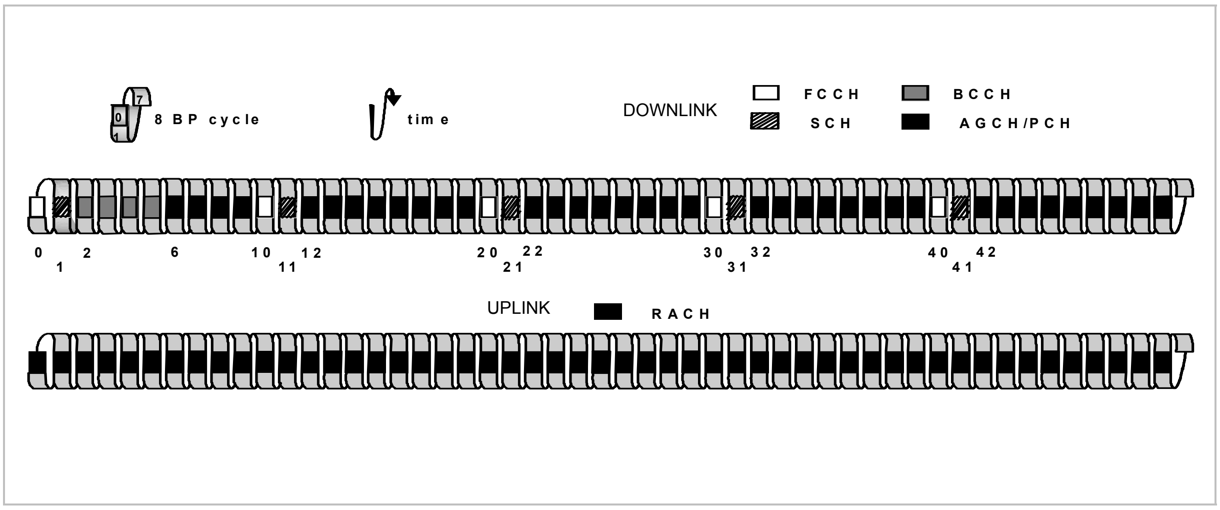
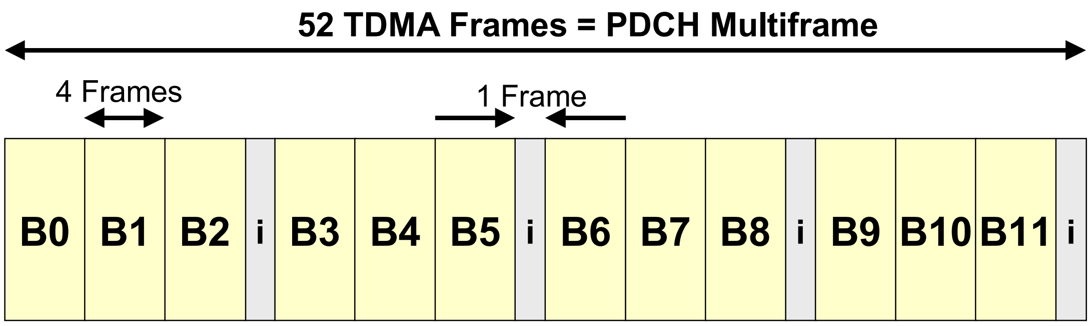


Fig. 23 Signaling channel multiframe (including FCCH, SCH, BCCH and AGCH/PCH)

4.6.3 Packet switched Multiframes

The packet data traffic is arranged in **52-type multiframes** (GSM Rec. 03.64). 52 TDMA frames are combined to form one GPRS traffic channel multiframe, which is subdivided into 12 blocks with 4 TDMA frames each. One block (B0-B11) contains one radio block in each case (4 normal bursts, which are related to each other via convolutional coding). Every thirteenth TDMA frame is idle. The idle frames are used by the MS to determine the various base station identity codes BSIC, to carry out timing advance updates procedures or interference measurements for power control.

For packet common control channels PCCH, conventional 51-type multiframes can be used for signaling or 52-type multiframes.



B0 - B11 = Radio Blocks (Data / Signalling)
i = Idle frame

Idle frame:
- **Identification of BSICs**
- **Timing Advance Update Procedure**
- **Interference measurements for Power Control**

- **BCCH** indicates **PDCH** with **PBCCH (in B0)**
- **DL**: this PDCH bears PDCCH & PBCCH
  PBCCH in B0 (+ max. 3 further blocks; indicated in B0)
  PBCCH indicates PCCCH blocks & further PDCHs with PCCCH
- **UL**: PDCH with PCCCH: all blocks to be used for PRACH, PDTCH, PACCH
  PDCH without PCCCH: PDTCH & PACCH only

Fig. 24 GPRS multiframes

4.7 Timeslot structure

The RF signal sent in a timeslot is called "burst". Depending on the type of logical channel transmitted, different kinds of bursts are used:

- Normal burst
- Access burst
- Frequency correction burst
- Synchronization burst
- Dummy burst

The modulation is applied for the useful duration of the burst. In general, the useful duration of the burst is equivalent to 148 bits excluding the access burst that has a useful duration equivalent of 88 bits. To minimize interference, the mobile station is required during the guard periods to attenuate its transmission amplitude and to adjust possible time shifts and amplitudes of the bursts.

The **normal burst** is used to carry information on traffic channels and on signaling channels (exception: Random Access Channel, Synchronization Channel and Frequency Correction Channel). Its structure is shown below:

- T = Tail Bits: This burst section consists of three bits (always coded with "000") and is needed for synchronization at the receive side.
- Coded (encrypted) bits: There are two burst sections, which contain the coded and encrypted traffic information (speech or data) in 2 x (57 +1) bits. The 1 bit is called stealing flag and indicates whether the 57 bits are really user data or FACCH signaling information.
- Training Sequence: This burst section contains 26 bits used for synchronization. Eight different training sequences have been defined by GSM.
- GP = Guard Period: These "8.25" bits serve to guard phase deviations (due to moving MS) and to reduce the transmission power.

The **access burst** has an extended guard period that helps to control the initial time lag of the signals due to the distance between mobile station and BTSE. Once the time lag has been corrected (timing advance), the remaining time lag resulting from the alteration of distance of a moving mobile station is controlled with the aid of the normal guard period of 8.25 bit duration.

Frequency correction bursts are sent by the BTSE and are used by the mobile station to adjust its receiver and transmitter frequencies (frequency synchronization).

Synchronization bursts are used to establish an initial bit and frame synchronization (time synchronization).

Dummy bursts are inserted if TCH timeslots on the BCCH carrier are not filled with user data to reach a constant level of the BCCH carrier. This is necessary because the level of the BCCH carrier is evaluated for handover decisions and also for the decision, which is the serving cell (for call set up).

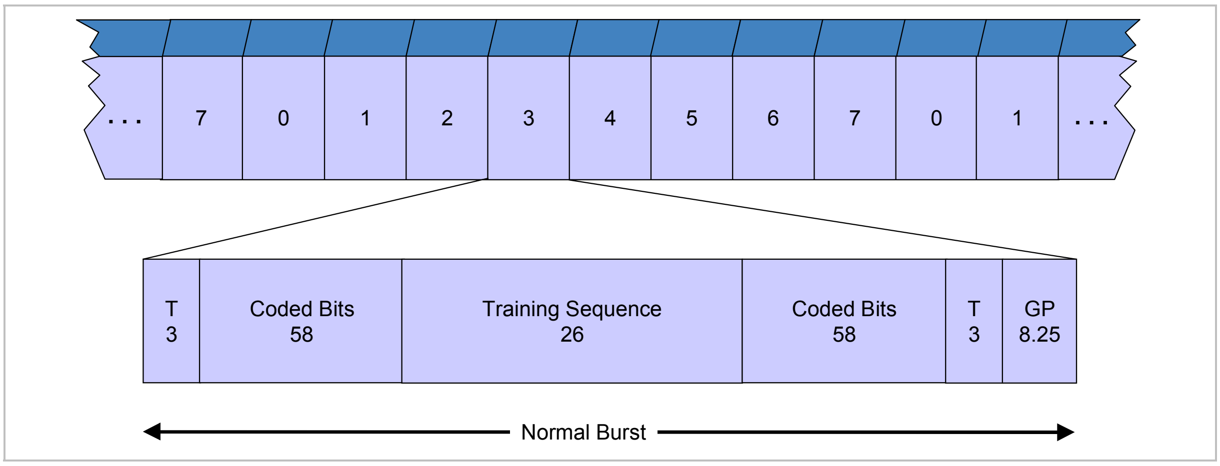


Fig. 25 Normal burst

Bursts on Um interface:

Duration **577 µs** or **156.25 bit**

Normal Burst

3 T	57 Encrypted	1 S	26 Training	1 S	57 Encrypted	3 T	8.25 GP

Access Burst

8 T	41 Synch. Sequence	36 Encrypted	3 T	68,25 GP

Frequency Correction Burst

3 T	142 Fixed Bits	3 T	8.25 GP

Synchronization Burst

3 T	39 Encrypted	64 Extended Training Sequence	39 Encrypted	3 T	8.25 GP

Dummy Burst

3 T	58 Mixed Bits	26 Training	58 Mixed Bits	3 T	8.25 GP

Fig. 26 Burst formats

5 Abis and Asub interface

5.1 Asub and A interfaces

Timeslot 0 of every PCM line carries the Service Word / Frame Alignment Word (SW/FAW) which is used e.g. for synchronization and is therefore unavailable for payload.

Often, timeslot 31 is used for LPDLS signaling between TRAU and BSC on the PCMS line. As a result, four timeslots on the TRAU's 4 PCMA lines remain empty.

Timeslot 16 on the Asub interface is commonly used to carry CCSS7 signaling information. This signaling requires a transmission rate of 64 kbit/s. One of the 4 PCMA lines carries the signaling information to the MSC. Therefore, timeslot 16 of one of the PCMA lines is occupied, whereas three timeslots on the other PCMA lines remain empty.

Note: **Not** every TRAU carries CCSS7 signaling information.

An OMAL signaling link defined as AINT (nailed up connection) is, e.g. put in timeslot 30. OMAL is transmitted with 64 kbit/s on a single PCMA line. Correspondingly, three timeslots on the other PCMA lines remain empty.

The traffic timeslots on the PCMA line, containing 64 kbit/s of speech, are sub-multiplexed to one sub slot with 16 kbit/s on the PCMS line.

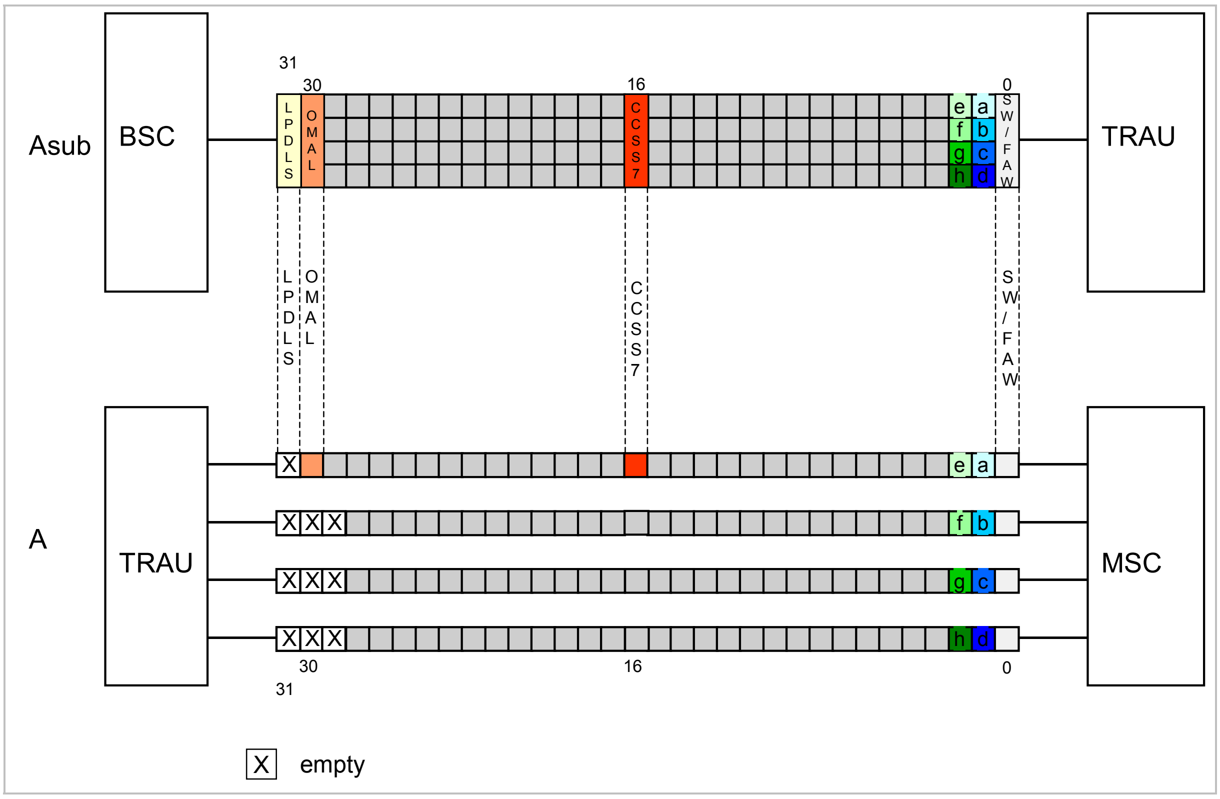


Fig. 27 Time slot assignment on Asub and A interfaces (basic pattern, w/o HSCSD or NUC)

a

5.2 Abis and Um interface

The higher data rates for packet switched services require an enhanced Abis capacity. The flexible A_{bis} Allocation Strategy (FAAS) is based on A_{bis} pools and appropriate A_{bis} subpools, which can be configured per base station site via O&M procedures.

The pool concept no longer assigns a fixed relation between the air interface and the appropriate $A_{bis\ .}$ An A_{bis} pool is the amount of 16kbit/s subslots, which is defined per base station site. An A_{bis} pool is composed by one or several subpools. Each subpool belongs to a single PCM line, routed together with one associated LAPD link to manage a correct fault propagation from the LAPD link to the A_{bis} resources.

The dimension of the pool is defined by the operator and can be changed via OAM commands.

When a user requires radio timeslots in a cell, the BSC selects the appropriate number of A_{bis} resources from the common A_{bis} pool, associates them to the radio channel and signals their association to radio channels and Abis resources to the BTS.

The amount of allocated 16kbit/s abis resources per radio time slot depends on several factors, first of all the service type (e.g. GPRS coding scheme CS4 requires 2x16kbit/s TS, while EGPRS coding scheme MSC7 needs on Abis side 4x16kbit/s TS).

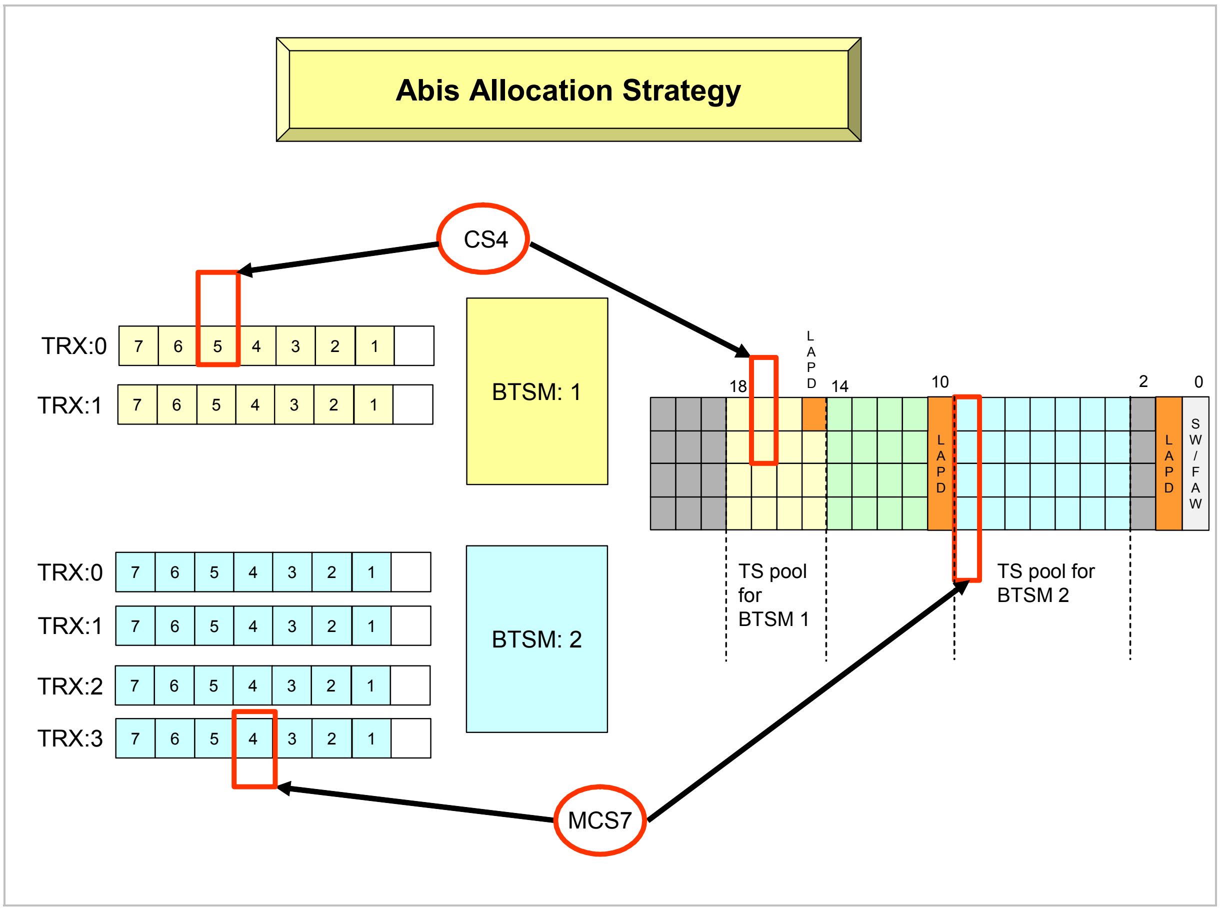

Abis Allocation Strategy
CS4
TRX:0
TRX:1
7 6 5 4 3 2 1
BTSM: 1
L A P D
18
14
10
2
0
L A P D
L A P D
S W / F A W
TS pool for BTSM 1
TS pool for BTSM 2
TRX:0
TRX:1
TRX:2
TRX:3
BTSM: 2
MCS7

Fig. 28 FAAS

Dynamic Abis Resource allocation is applied both to packet switched services and to circuit switched services. According to the service applied, the appropriate number of A_{bis} resources is dynamically allocated. As the capacity of each air interface timeslot can vary during runtime, the dynamic A_{bis} allocation adopts the A_{bis} capacity to the required air interface capacity.

A_{bis} pools and A_{bis} subpools have the following properties and relations:

- Different A_{bis} subpools, belonging to the same or different A_{bis} pools can be defined on the same PCM line
- Subpools can be distributed over all PCM lines belonging to a base station site (at least one subpool per line)
- The A_{bis} subslots allocated to a radio channel may be distributed over different subpools and consequently over different PCM lines. It is not necessary to guarantee that the subslots are adjacent.
- Overlapping between pools and subpools are forbidden

With the common pool concept any radio timeslot is dynamically associated to an appropriate number of A_{bis} resources from the A_{bis} pool.

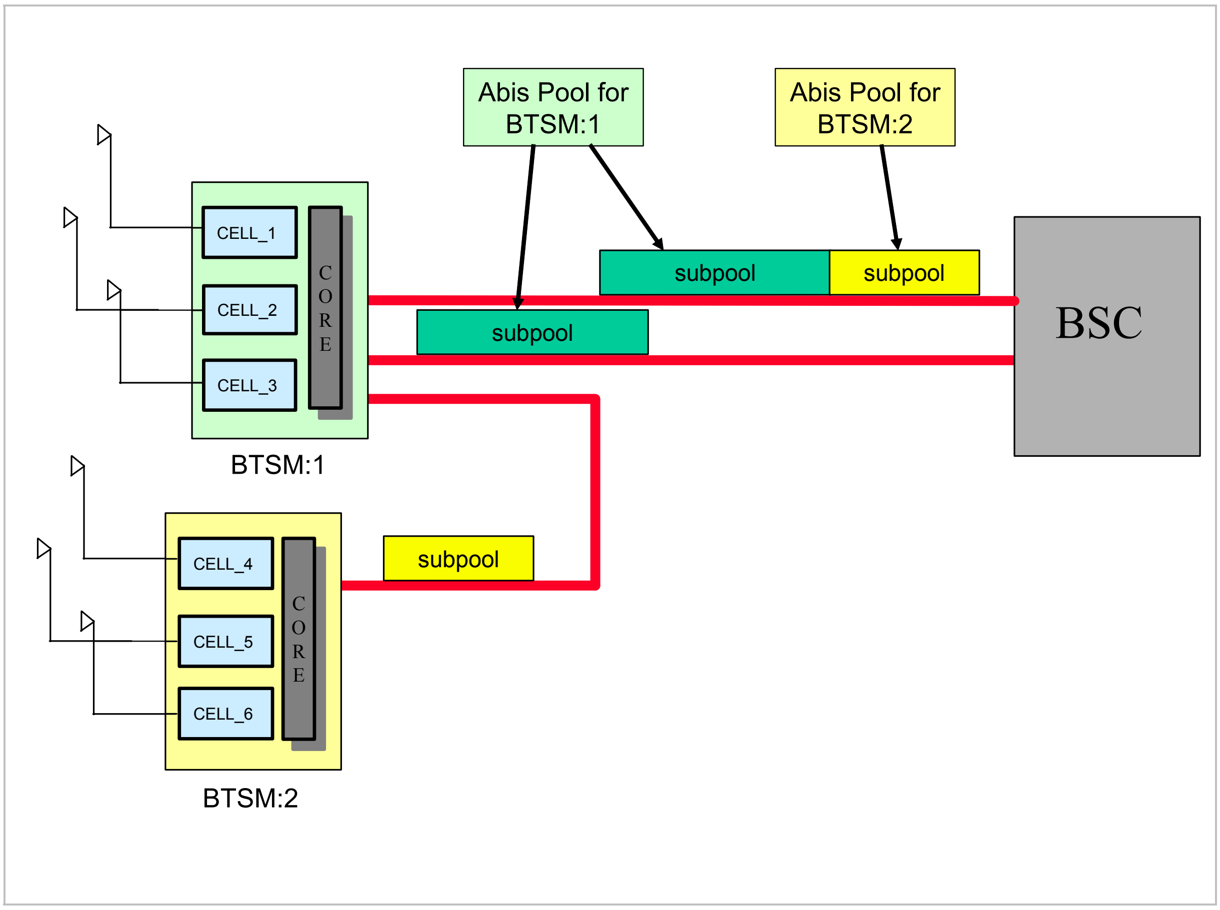


Fig. 29 Abis pools per BTSM

6 GSM basic features

6.1 Power control

Power Control is used to adapt the RF output power (of the MS and the BTS) **dynamically** to the propagation conditions on the radio path. The aim is to use the lowest possible TX power still yielding acceptable transmission quality. Thus,

- the power consumption of the Mobile Station and
- the total interference level in the radio system

are minimized.

Power Control for the MS is based on uplink measurements, gathered by the BTS. Power Control for the BTS is based on downlink measurements, gathered by the MS.

The criteria for power control decisions are

- the received signal strength
- the received signal quality.

Threshold comparisons, preceded by a measurement averaging process, are made to determine whether a power increase or decrease is required. The measurement averaging process and the power control decision algorithm for each call in progress are performed by the BTS.

Power Control can be set independently for uplink and downlink. In addition, for circuit switched services it can of the type static or adaptive. The last one comprises adaptive power correction step sizes dependent on measured values for the signal level and quality.

Optionally the Service Dependent Power Control offers to define for the fourteen different service groups different threshold levels. Another option is to enable the Derived Power Control for Handovers.

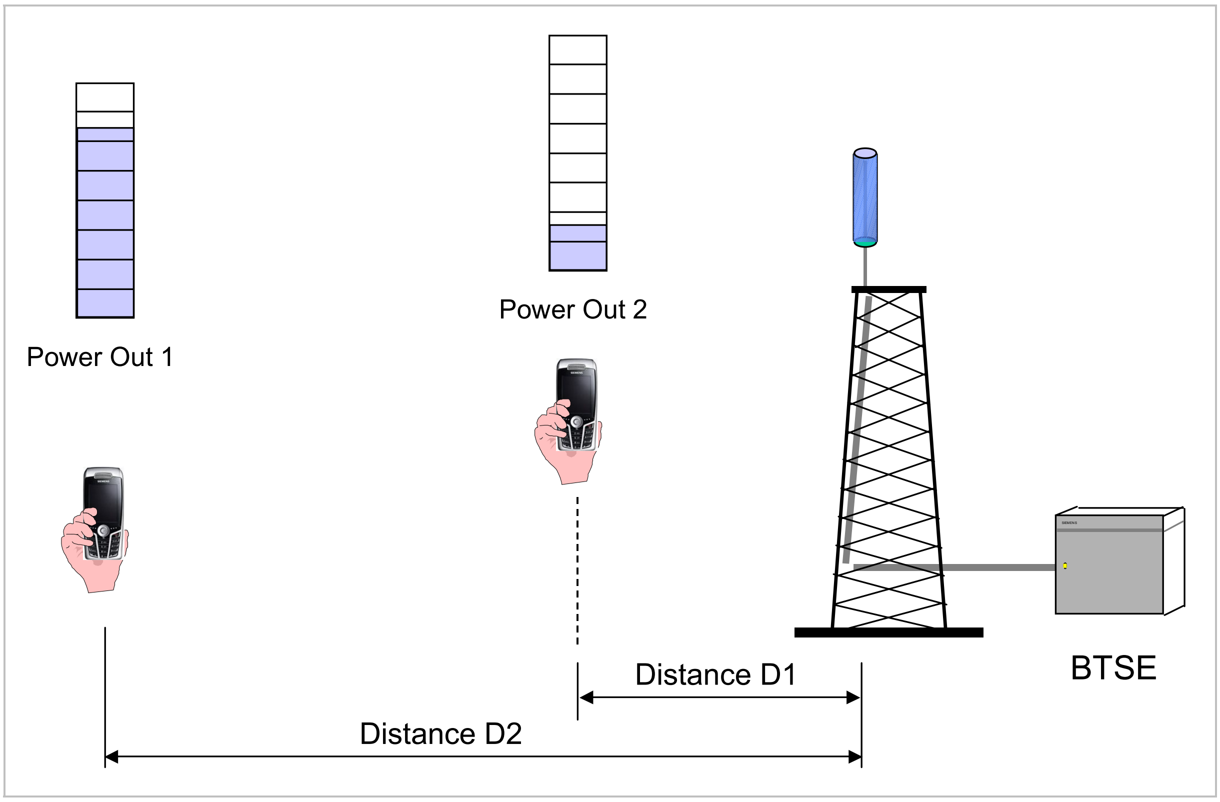


Fig. 30 RF power control

6.2 Cell (re)selection

Idle Mode

MS measures the received level on each RF carrier. Based on these measurements one can estimate whether a cell will be an appropriate serving cell from the radio propagation point of view, i.e. whether there will be a sufficient “link quality”.

While moving within the radio network in idle mode, another cell may be more appropriate to serve the MS. Therefore, cell reselection may be performed.

From the radio propagation point of view it is worth to select a new (neighbor) cell if the received level from that neighbor cell exceeds the received level of the current serving cell:

- Receive level (neighbor cell) > Receive level (serving cell)

The inter-system cell reselection from GSM to UMTS allows a MS to reselect to the UMTS system. For intersystem cell reselection, the Received Signal Code Power is the measure for receive level in case of UMTS neighbor cells.

Packet switched Connections

From a serving GPRS cell the MS is executing the cell reselection to a neighbor GPRS cell. This so called Cell Reselection (packet switched) is performed by the MS in the same way as for circuit-switched connected MS in idle mode.

Also it is possible to do cell reselection from a GPRS cell to a UMTS (packet switched) cell.

TIP
Handover is only used for circuit switched connections and the BSS is deciding about the HO execution.

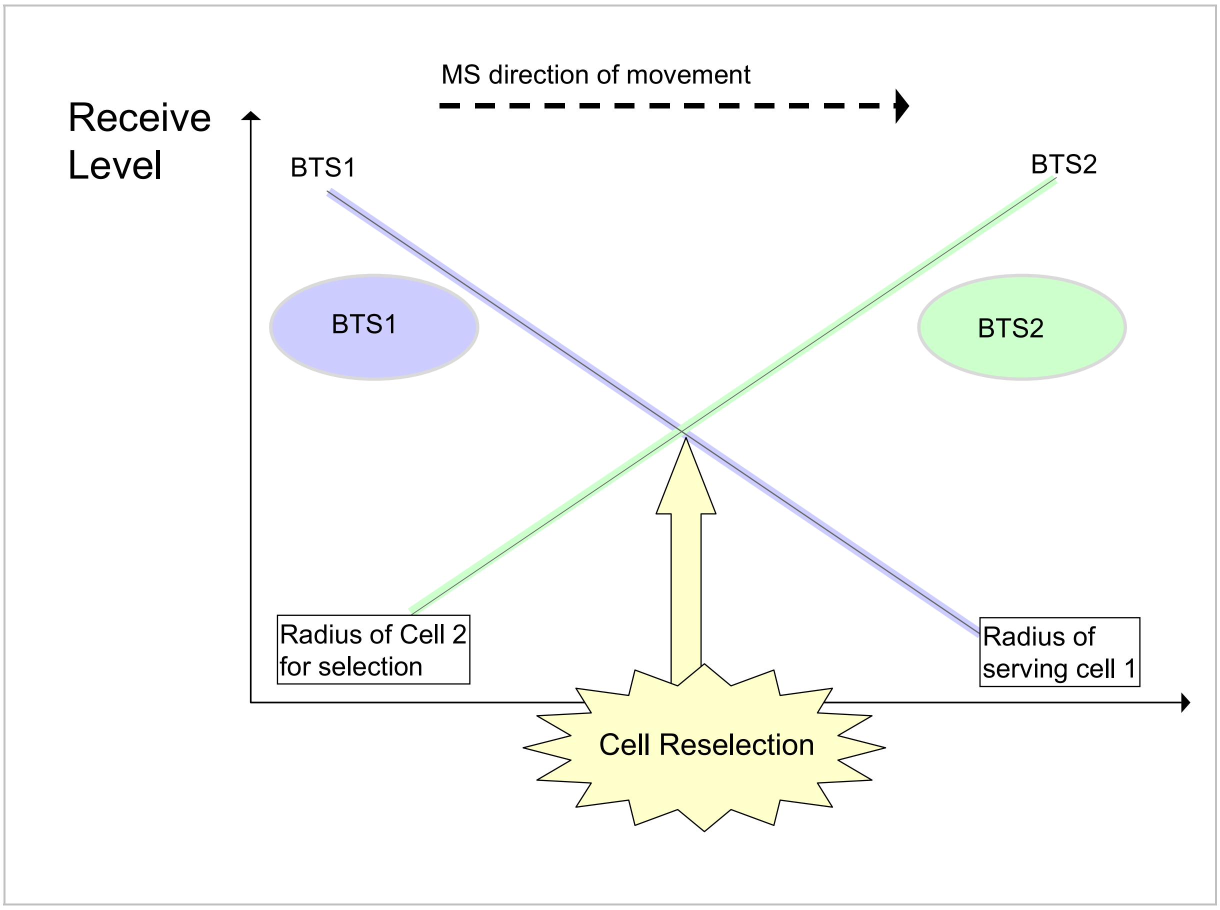


Fig. 31 Cell (re)selection

6.2.1 NACC and NCCR

There are two different solutions to get BSS involved in the CR procedure:

- Network Assisted Cell Change NACC
- Network Controlled Cell Reselection NCCR

History

Up to BR6.0 the Cell Reselection for packet switched connected MS is handled autonomous by the MS. BR7.0 is introducing the Cell Reselection controlled by BSS. In BR8.0 the Network Assisted Cell Change (NACC) is introduced.

NACC

The Information needed to access a new cell is contained in the System Information (SI) or Packet System Information message PSI. This is broadcasted in each cell. For the NACC the BSS helps the MS to get the Information of the new Cell very early. MS gets the SI or PSI with a message and has not to spend the time listen to the broadcast channel.

NCCR

If the Cell Change is controlled completely by the BSS, we have NCCR. The MS sends only measurement reports to the BSS, but the BSS is deciding if the MS has to change to another cell. This solution is similar to handover for CS services and has the advantage that the network can distribute the MS to the cells and optimize the cell load.

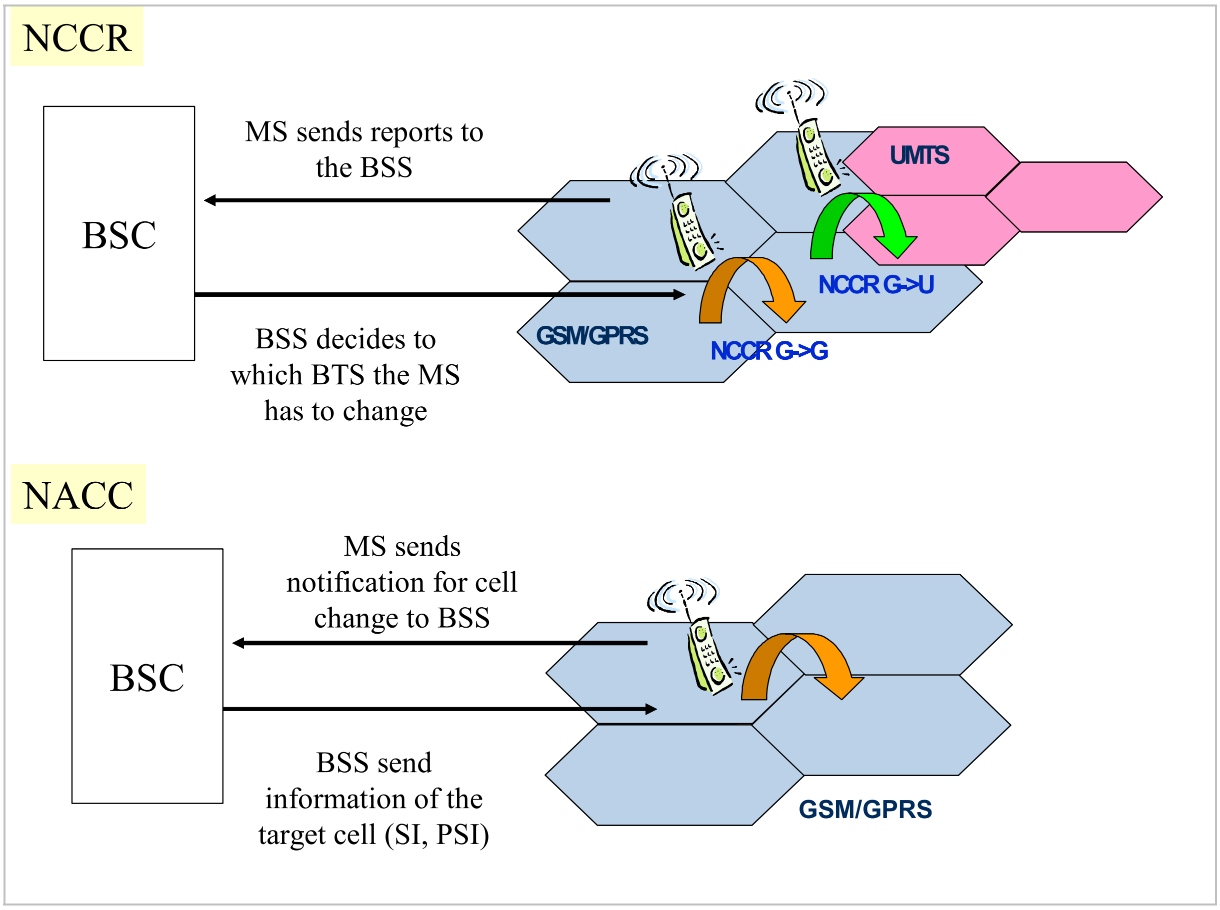


Fig. 32 NCCR and NACC

6.3 Handover

6.3.1 Intra GSM HO

Handover is required to maintain an ongoing call when the Mobile Station passes from one cell coverage area to another. Handover means that a call in progress is switched over seamlessly from one radio channel to another. In Adaptive Multirate Handover, the change is between different "codecs".

Handover takes place between radio channels that may belong

- to the same BTS (**intracell** handover) or
- to different BTS (**intercell** handover).

If the handover is controlled by the BSC or MSC, it is called **inter-BSC** or **inter-MSC** handover, respectively.

The handover due to **radio criteria** is determined from

- uplink measurement results (gathered by the BTS) and
- downlink measurement results (gathered by the MS).

In detail, the radio criteria are

a) received signal strength

b) received signal quality (determined from Bit Error Rate)

c) MS - BTS distance (determined from timing advance)

d) better cell (power budget of serving cell relative to adjacent cells)

In contrast to the first three criteria, which are imperative, the better cell criterion is optional. It derives from signal strength measurements carried out by the MS on the BCCH carriers broadcast by the adjacent BTS. In a well-planned network, "better cell" is the overwhelming HO cause determining the cell boundaries.

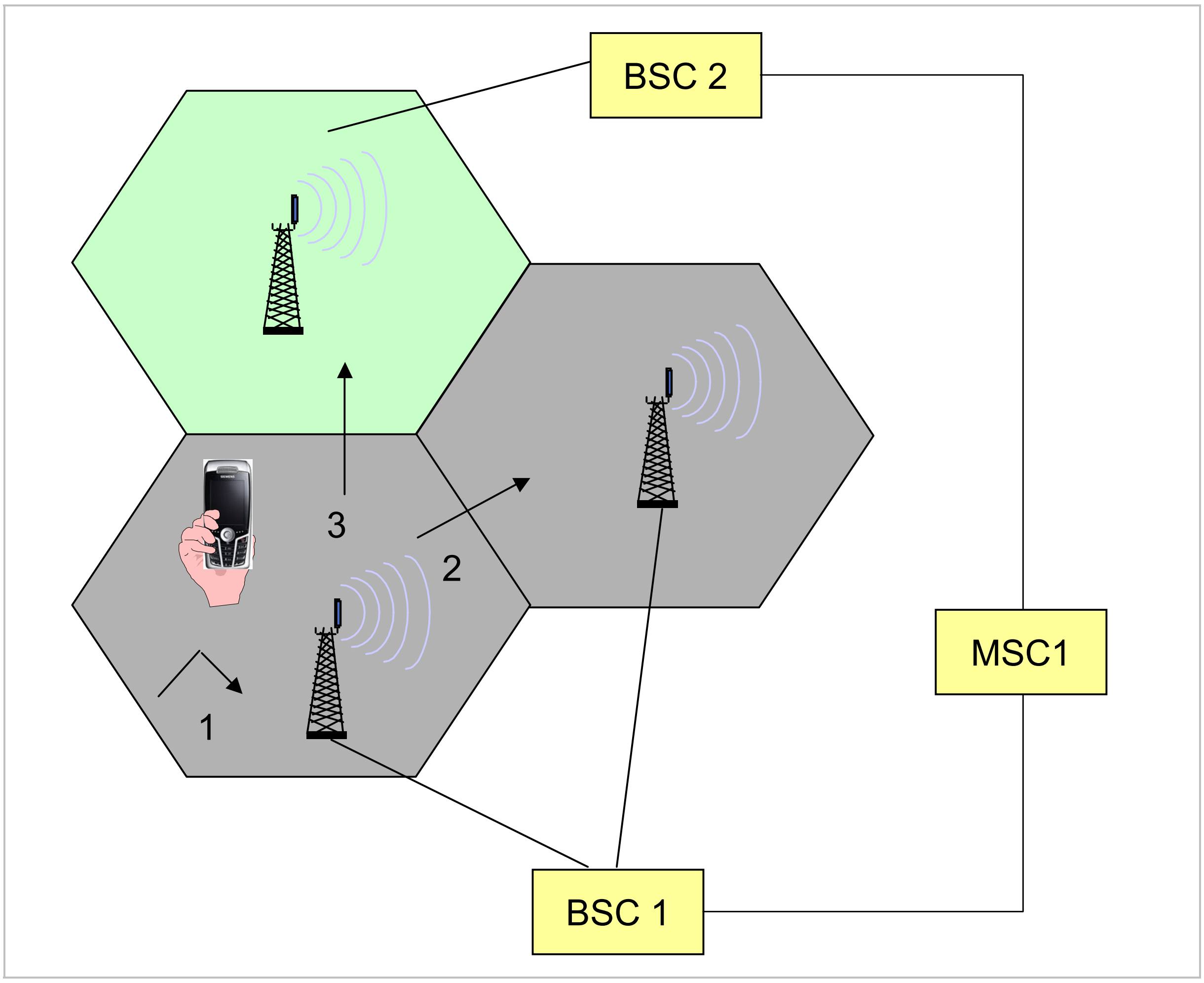
In addition, the following **network criteria** may be evaluated:

a) serving cell congestion (directed retry for call setup, HO due to BSS resource management criteria)

b) MS - BTS distance (in extended cells)

c) RX level and (optional, in addition) MS - BTS distance (in concentric cells)

The decision whether a handover is required for a call in progress derives from threshold comparisons that are applied to the respective (averaged) measurement results.



1	intracell handover
2	intercell handover – intra-BSC
3	intercell handover – inter-BSC

Fig. 33 Types of handovers

If an intercell handover is to be initiated, the power budget criterion is applied to set up a list of preferred handover target cells in a decreasing order of priority. This target cell list forms the basis for the final handover decisions made in the BSC or the MSC.

The measurement averaging processes, the threshold comparison processes as well as the target cell list compilation for each call in progress are performed by the BTS. The final handover decision and handover execution, however, are made by the BSC or MSC.

6.3.2 HO to UMTS

Calls started in the GSM system are handed over to the UMTS system when the user moves into the area with better UMTS coverage or the UMTS coverage only. In this case always the MSC is executing the HO.

The BSS initiates a handover to UMTS according due to **radio criteria** in one of the following reasons:

- Emergency Handover
- Better cell
- Sufficient UMTS coverage

In addition, the following **network criteria** may be evaluated:

- serving cell congestion (directed retry for call setup)

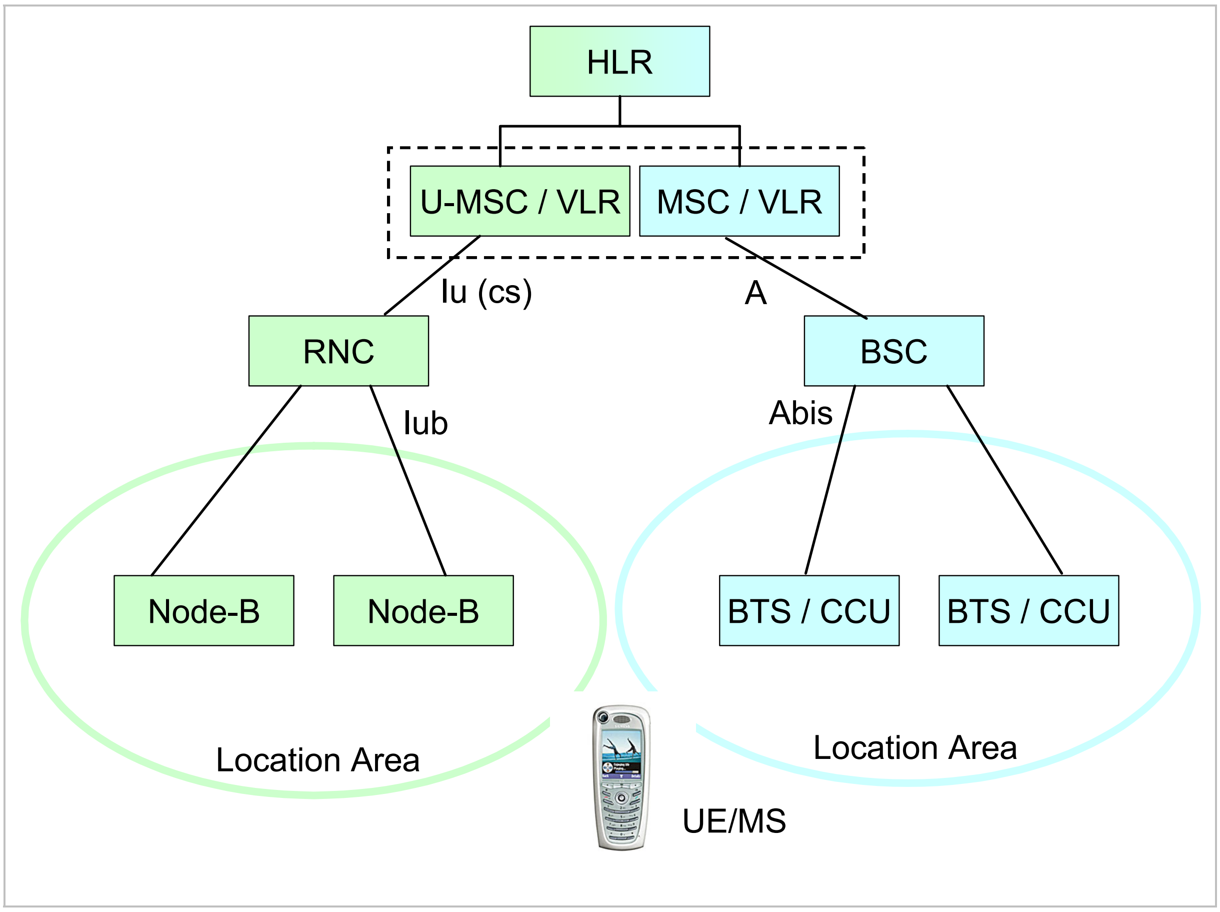


Fig. 34 Combined UMTS / GSM network architecture

6.4 Multiband operation

Multiband Operation means that the same network operator provides GSM services in both GSM900 and GSM1800 frequency bands.

Therefore, the operation of "dual band" MS as well as handover between cells belonging to different bands is also supported, with an appropriate management of the target cell list.

The transceiver equipment for both frequency bands is located in the same BTSE. This allows a network operator to use an already existing network infrastructure when expanding a GSM900 network with GSM1800 equipment and vice versa.

Multiband operation may even feature a "Common BCCH".

As an example a concentric BTS is configured. The inner area is the GSM1800 frequency and the outer area is the GSM 900 frequency. This BTS can be supplied with a single BCCH and offers carrier frequencies in both GSM900 and GSM1800 bands.

Another solution is to define a dual band standard cell that is also featuring the Common BCCH.

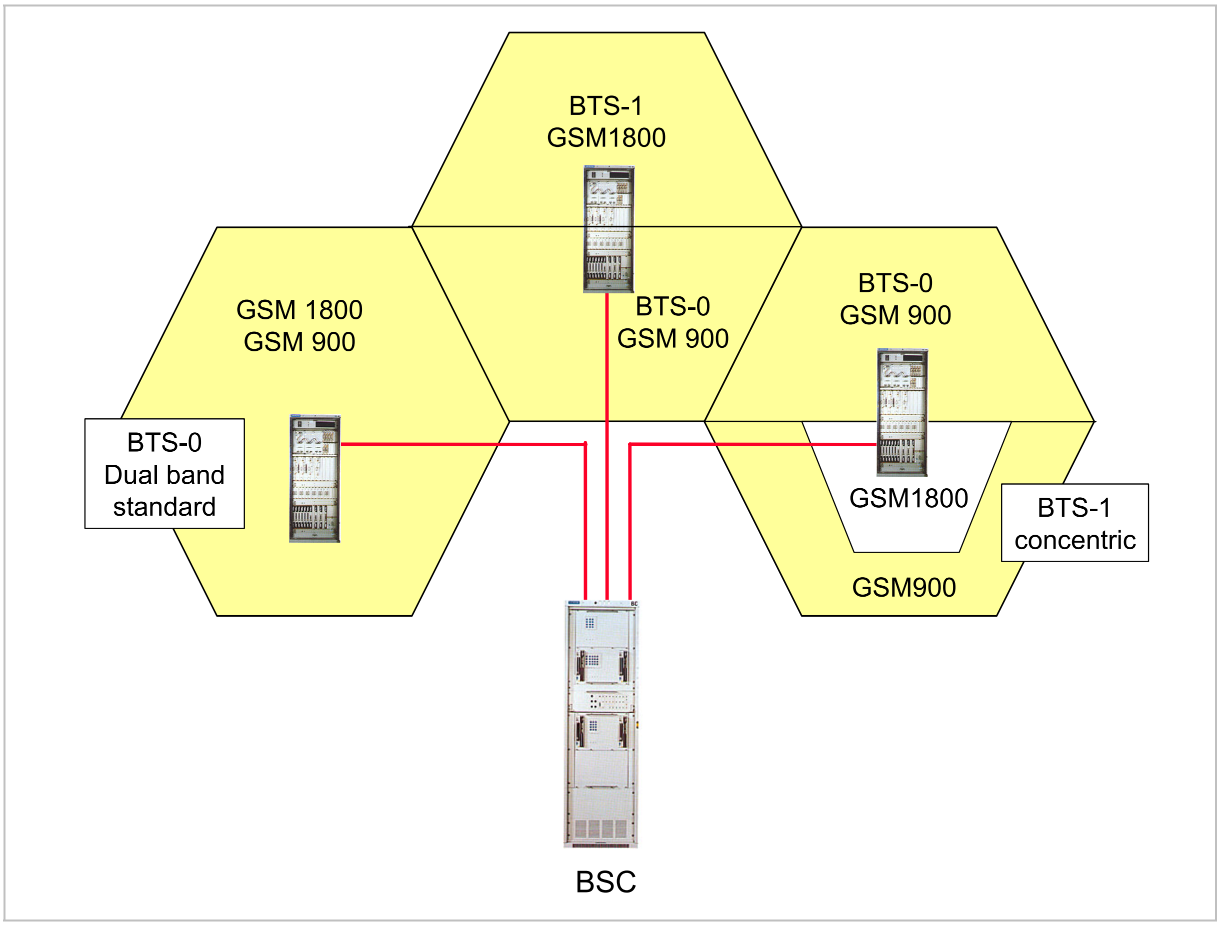


Fig. 35 Network with mixed cell configuration GSM900/ GSM1800

7 Data transmission in GSM phase 2+

To increase the data transmission rates, in GSM phase 2+ new bearer services with rates exceeding those of ISDN are defined:

- High Speed Circuit Switched Data HSCSD
- General Packet Radio Service GPRS
- Enhanced Data Rates for GSM (Global) Evolution EDGE

High Speed Circuit Switched Data HSCSD

HSCSD (Rec. 02.34) is a circuit switched data service (only point-to-point) for applications with higher bandwidth demands and continuous data stream, e.g. video streaming or video telephony. The higher bandwidth is achieved by combining 1-8 physical channels for one subscriber. Additionally, the data transmission codec is changed such that a maximum of 14.4 kbit/s instead of 9.6 kbit/s is available per physical channel. Thus, HSCSD theoretically supports transmission rates up to 115.2 kbit/s. For implementing HSCSD, merely the GSM-PLMN software requires modification. More problematic is the high demand on (radio) resources.

General Packet Radio Service GPRS

With GPRS it is possible to combine 1-8 physical channels for one user, just as with HSCSD. Various new coding schemes with transmission rates of up to 21.4 kbit/s per physical channel enable theoretical transmission rates of up to 171.2 kbit/s. As opposed to HSCSD, GPRS is a packet-switched bearer service, meaning that several subscribers can use the same physical channel. GPRS is resource efficient for applications with a short-term need for high data rates ("bursty traffic" e.g. surfing the Internet, E-mail, ...). GPRS also enables point-to-multipoint transmission and volume-dependent charging. However, extensions of the GSM network and protocol architecture are required for GPRS implementation.

Enhanced Data rates for GSM Evolution EDGE

EDGE (Release`99) supports up to 69.2 kbit/s per physical channel by changing the GSM modulation procedure (8PSK instead of GMSK). Theoretically, transmission rates of up to 553.6 kbit/s (meeting 3G requirements) would be possible by combining up to 8 channels. A combination of GPRS and EDGE offers high bandwidth and highly economical frequency resource utilization at the same time.

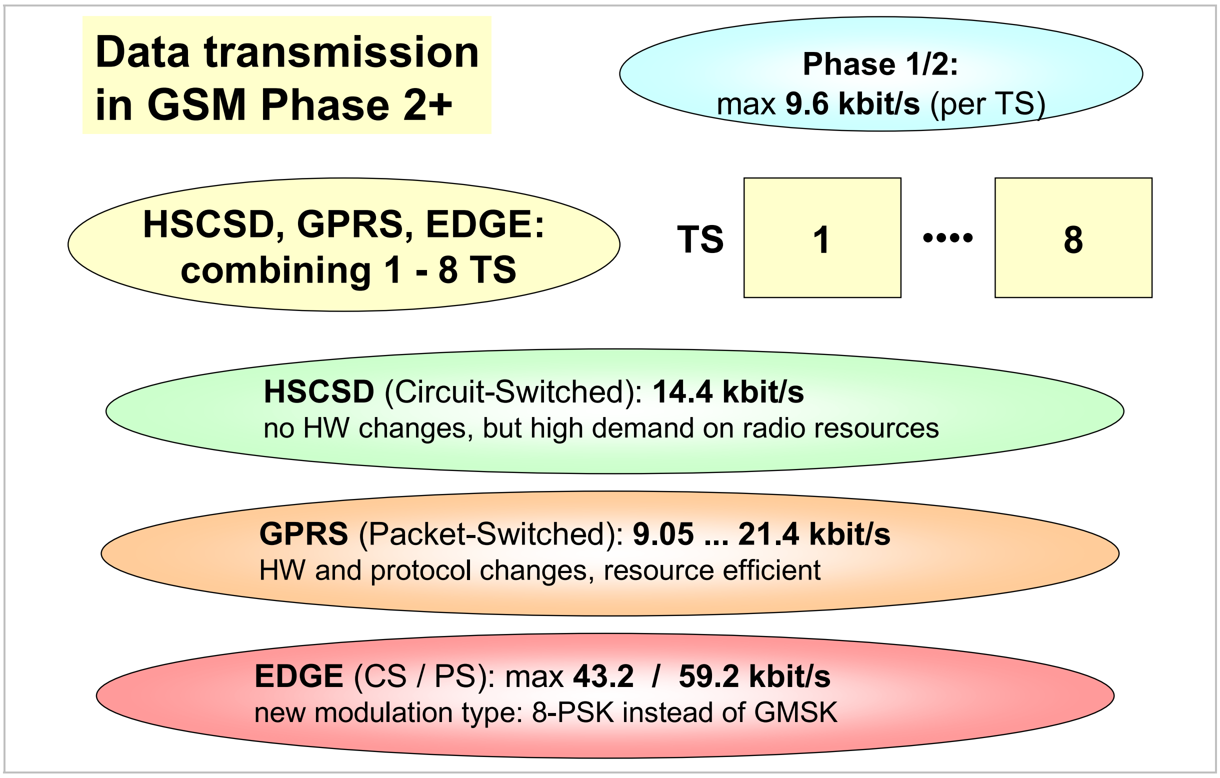


Fig. 36 Data transmission in Phase 2+

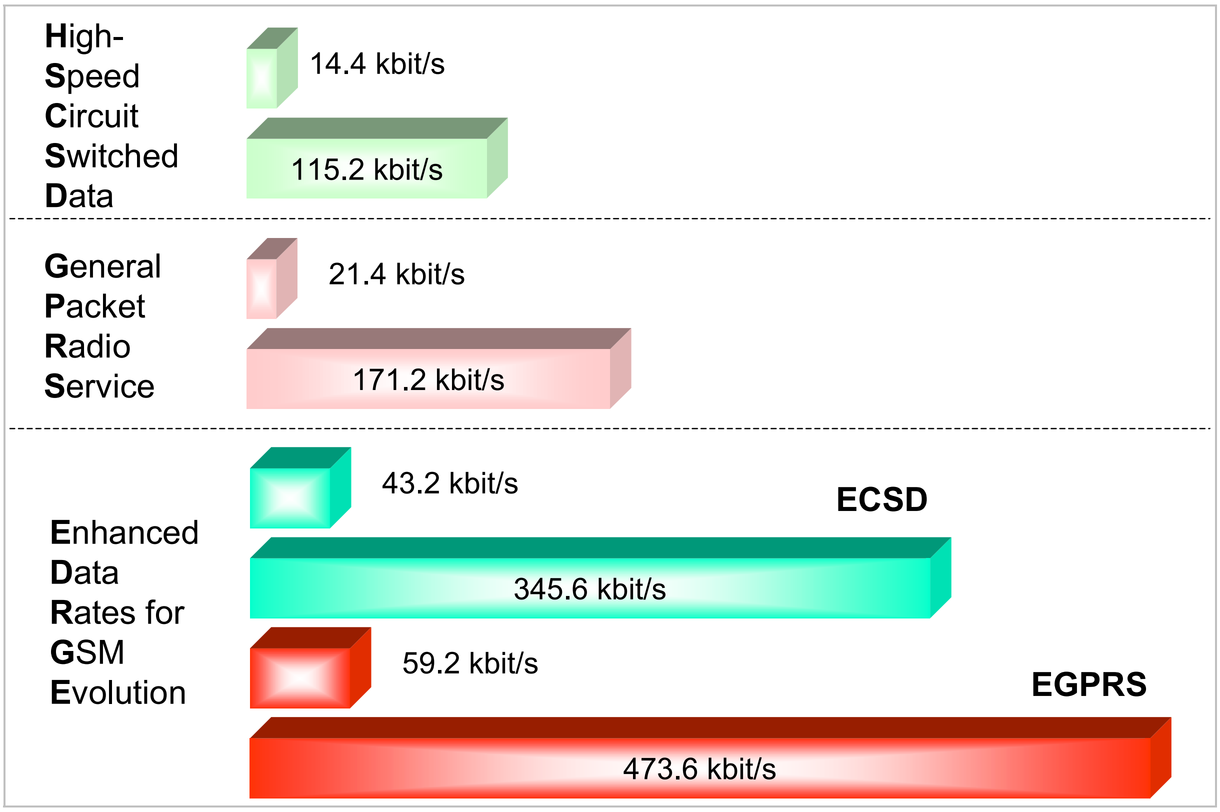


Fig. 37 Netto transmission rates for HSCSD, GPRS and EDGE

7.1 High Speed Circuit Switched Data HSCSD

High Speed Circuit Switched Data provides circuit switched data transmission using up to max. 8 TCH simultaneously.

HSCSD is particularly suited for real-time applications e.g. video communication.

High Speed Circuit Switched Data provides the following kinds of services:

14.4 kbit/s data (in a single time slot).

Transparent / Non-transparent services

For transparent HSCSD connections the BSC is not allowed to change the user data rate, but the BSC may modify the number of TCH used by the connection (in this case the data rate per TCH changes accordingly).

For non-transparent HSCSD connections the BSC is also allowed to change the user data rate (data compression on the air i/f, on fixed network side -to and from modem of internet provider - no compression at data rates 19.2 kbit/s, 38.4 kbit/s or 64 kbit/s in later versions).

Symmetric and pseudo-asymmetric services

In symmetric service the timeslot allocation for downlink and uplink is symmetric and the same data rates are used in downlink and uplink direction.

In pseudo-asymmetric service the timeslot allocation for downlink and uplink is symmetric but the data rate used in uplink direction is lower than in downlink direction.

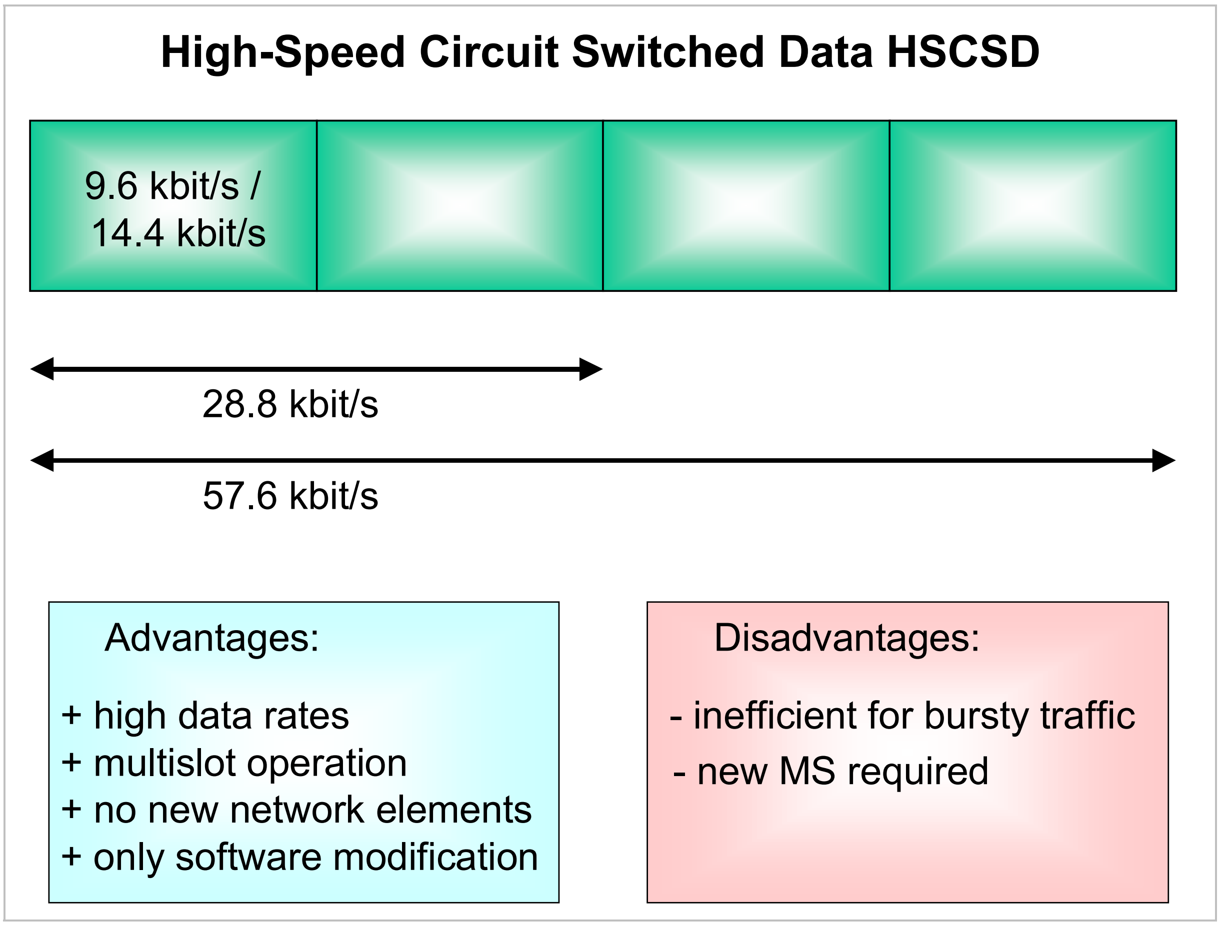


Fig. 38 High-speed circuit switched data - main features

The following conditions characterize an HSCSD connection:

- All n radio timeslots are located on the same TRX.
- The same frequency hopping sequence and training sequence is used.
- Only TCH/F are used.
- In symmetric configuration individual signal level and quality reporting for each channel is applied.
- For an asymmetric HSCSD configuration individual signal level and quality reporting is used for those channels, which have uplink SACCH associated with them.
- The quality measurements reported on the main channel are based on the worst quality measured on the main and the unidirectional downlink timeslots used.
- In both symmetric and asymmetric HSCSD configurations the neighbor cell measurements are reported on each uplink channel used.

Handovers

All TCH used in an HSCSD connection are handed over simultaneously. The BSC may modify the number of timeslots used for the connection and the channel coding when handing over the connection to the new channels.

All kinds of handovers are supported.

Flexible air resource allocation

The BSC is responsible for flexible air resource allocation. It may modify the number of TCH/F as well as the channel coding used for the connection. Reasons for the change of the resource allocation may be either a lack of radio resources, handover and/or maintenance of the service quality.

The change of the air resource allocation is done by the BSC using new service level upgrading and downgrading procedures.

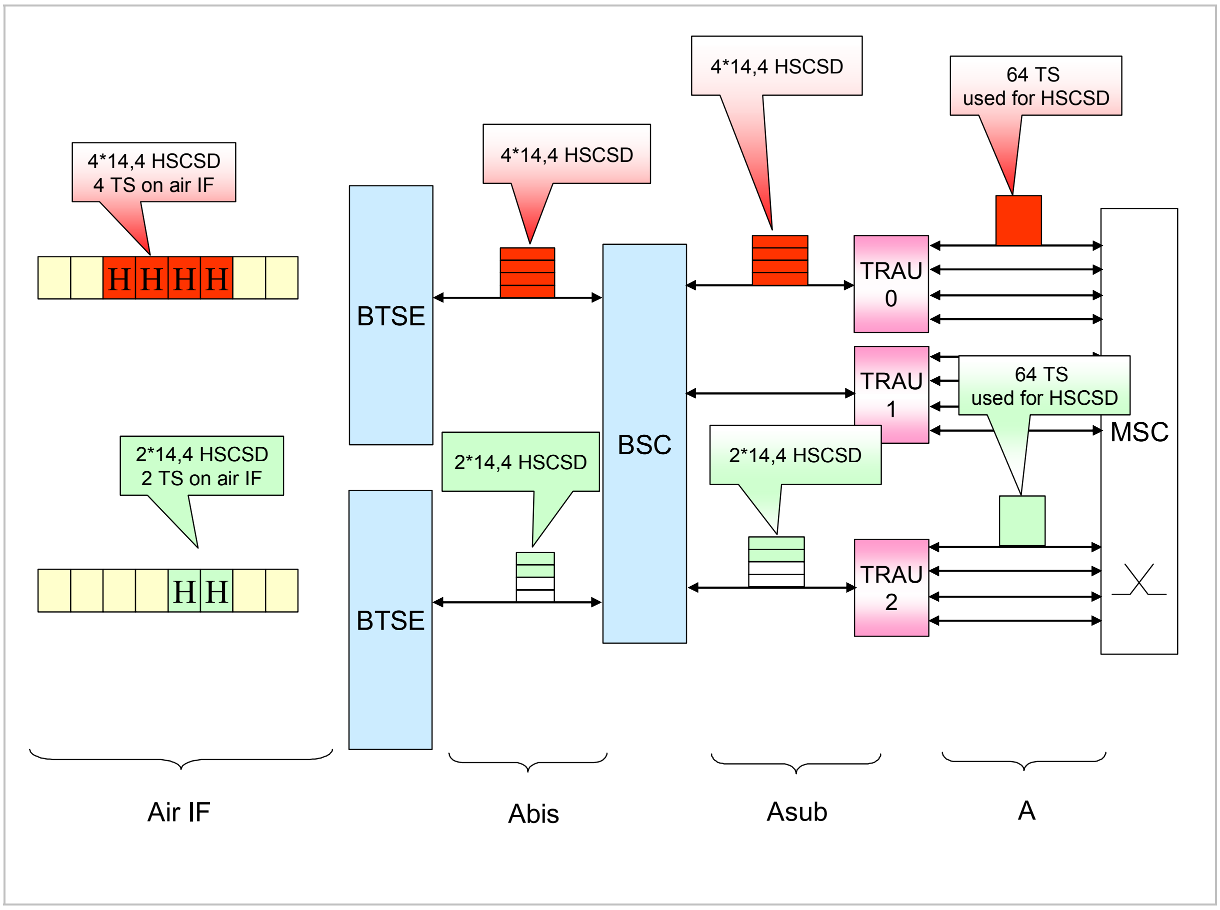


Fig. 39 HSCSD transmission examples

7.2 General Packet Radio Service GPRS

GPRS offers packet-switched data transmission but requires new network elements making up the packet-switched core network:

7.2.1 Core network elements

Serving GPRS Support Node SGSN is on the same hierarchic level as an MSC and handles functions comparable to a Visited MSC. For example Mobility Management; paging, tracing the location, it performs security functions, access control, routing/traffic management.

Gateway GPRS Support Node GGSN realizes functions comparable to those of a gateway MSC. For example performs interworking between a GSM PLMN and a packet data network PDN, contains the routing information or can inquire about location information from the HLR

Interfaces

New interfaces are defined for GPRS. The most important are:

- **Gb** - between an SGSN and a BSS; Gb allows the exchange of signaling and user data:
- **Gi** - between GPRS and an external packet data network PDN
- **Gn** - between two GPRS support nodes GSN within the same PLMN

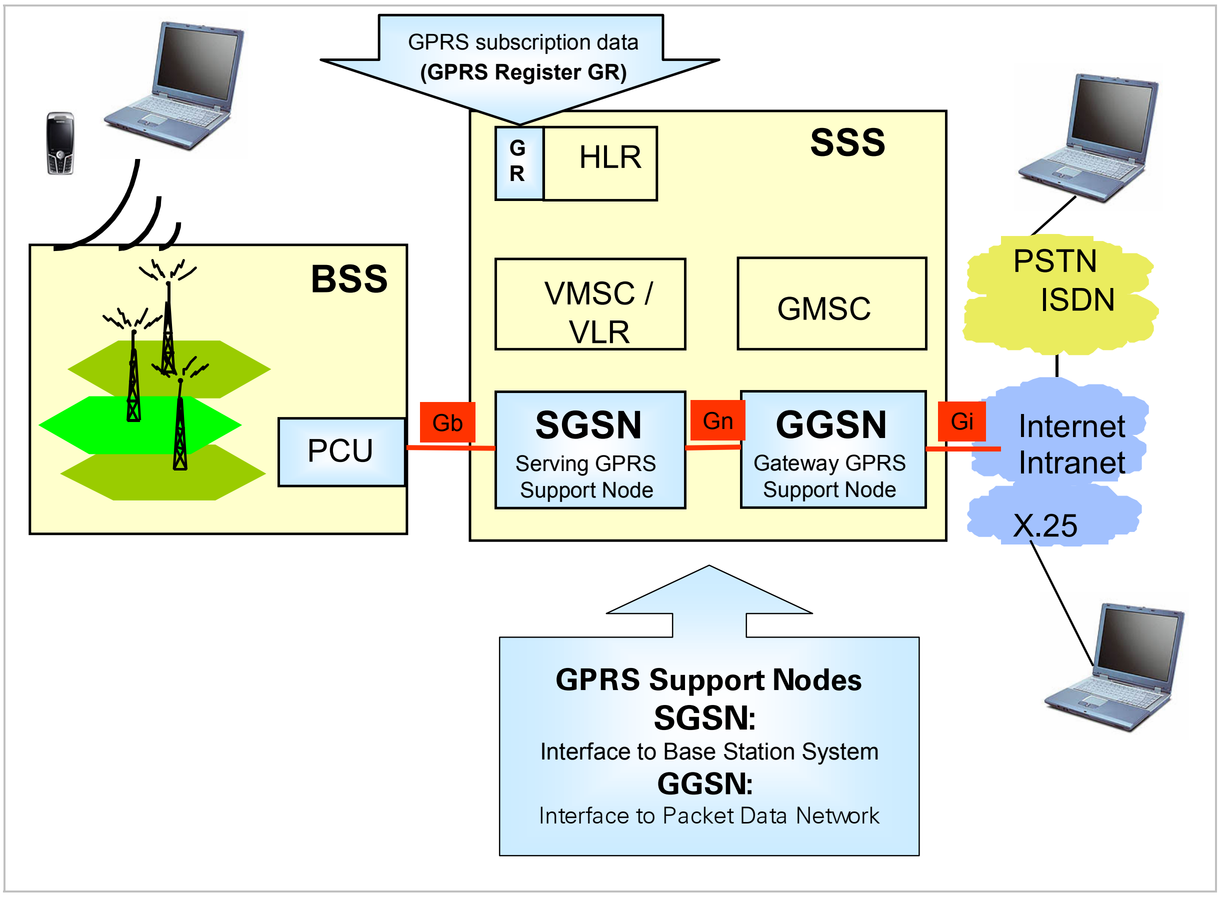


Fig. 40 Packet Switches in the Core Network

7.2.2 Radio network units

Packet Control Unit PCU

In the SBS, the PCU is realized by the PPXX module in the BSC. The PCU:

- manages GPRS radio channels (Radio Channel Management), e.g. power control, congestion control, broadcast control information
- allocates resources for UL and DL packet data transfer
- performs access control, e.g. access request and grants
- converts protocols (between interfaces Gb and Um).

In principle, the PCU may be placed in BTS, BSC or SGSN (GSM Rec. 03.60). Locating the PCU in the BSC is the most practical solution, however, used also for SBS.

Channel Codec Unit CCU

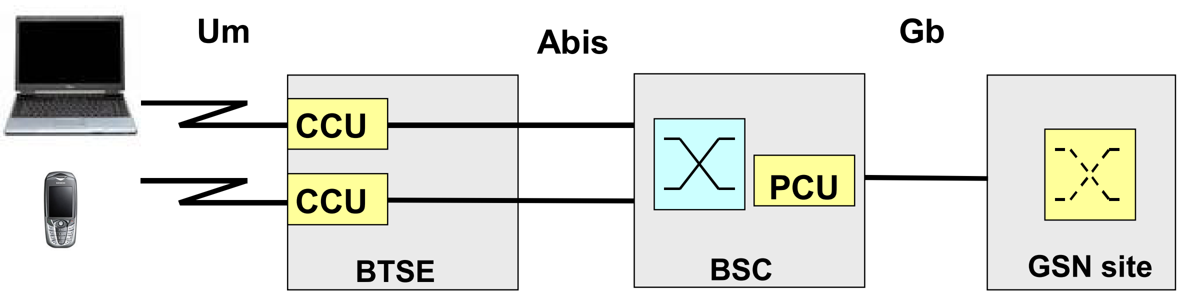
In the SBS the CCU is included in the Carrier Unit module of the BTSE. The CCU performs:

- Channel coding (including forward error correction FEC and interleaving) and
- Radio channel measurements (including received quality and signal level, timing advance measurements)

GPRS Mobile Station

A GPRS MS can work in three different operational modes. The operational mode depends on the service an MS is attached to (GPRS or GPRS and other GSM services) and on the mobile station’s capacity of handling GPRS and other GSM services simultaneously.

- "Class A" operational mode: The MS is attached to GPRS and other GSM services and the MS supports the simultaneous handling of GPRS and other GSM services.
- "**Class B**" operational mode: The MS is attached to GPRS and other GSM services, but the MS cannot handle them simultaneously.
- "Class C" operational mode: The MS is attached exclusively to GPRS services.



GPRS-MS:
- Class-A
- Class-B
- Class-C

CCU
- Channel Coding (FEC, interleaving,..)
- Radio Channel Measurement functions(received quality & signal level, TA,..)

PCU
- Channel Access Control functions
- Radio Channel Management (Power Control, Congestion Control,...)
- scheduling data transmission (UL/DL)
- protocol conversion (Gb<-->Um)

Fig. 41 PCU, CCU, MS

7.2.3 Radio interface

The tasks of layer 1 radio interface relate to the transmission of user and signaling data as well as to the measuring of receiver performance, cell selection, determination and updating of the delayed MS transmission (timing advance TA), power control and channel coding.

In packet switched traffic a main difference to circuit-switched services is that several mobile stations in parallel can use a physical channel and a packet data channel. This is named **multiplexing**.

On the other hand it is also possible for a mobile station to use more than one packet data channel at the same time, i.e. to **combine several physical channels** of one radio carrier. In principle, up to 8 packet data channels can be seized simultaneously.

The allocation can be done in two ways:

- Horizontal Allocation
- Vertical Allocation

In case of horizontal allocation strategy the MS are placed in separate timeslots. The advantage is that the MS get the maximum possible capacity.

In case of vertical allocation strategy several MS are multiplexed on the same timeslots. This leads to the advantage that the scare resources of the air interface are saved.

Distribution of the physical channels for various logical packet data channels is based on blocks of 4 normal bursts each, called **radio blocks.** This means that signaling and the packet data traffic of several mobile stations can be statistically multiplexed into one packet data channel.

UL and DL for GPRS packet data are assigned separately. Therefore the packet data channel can be seized asymmetrically.

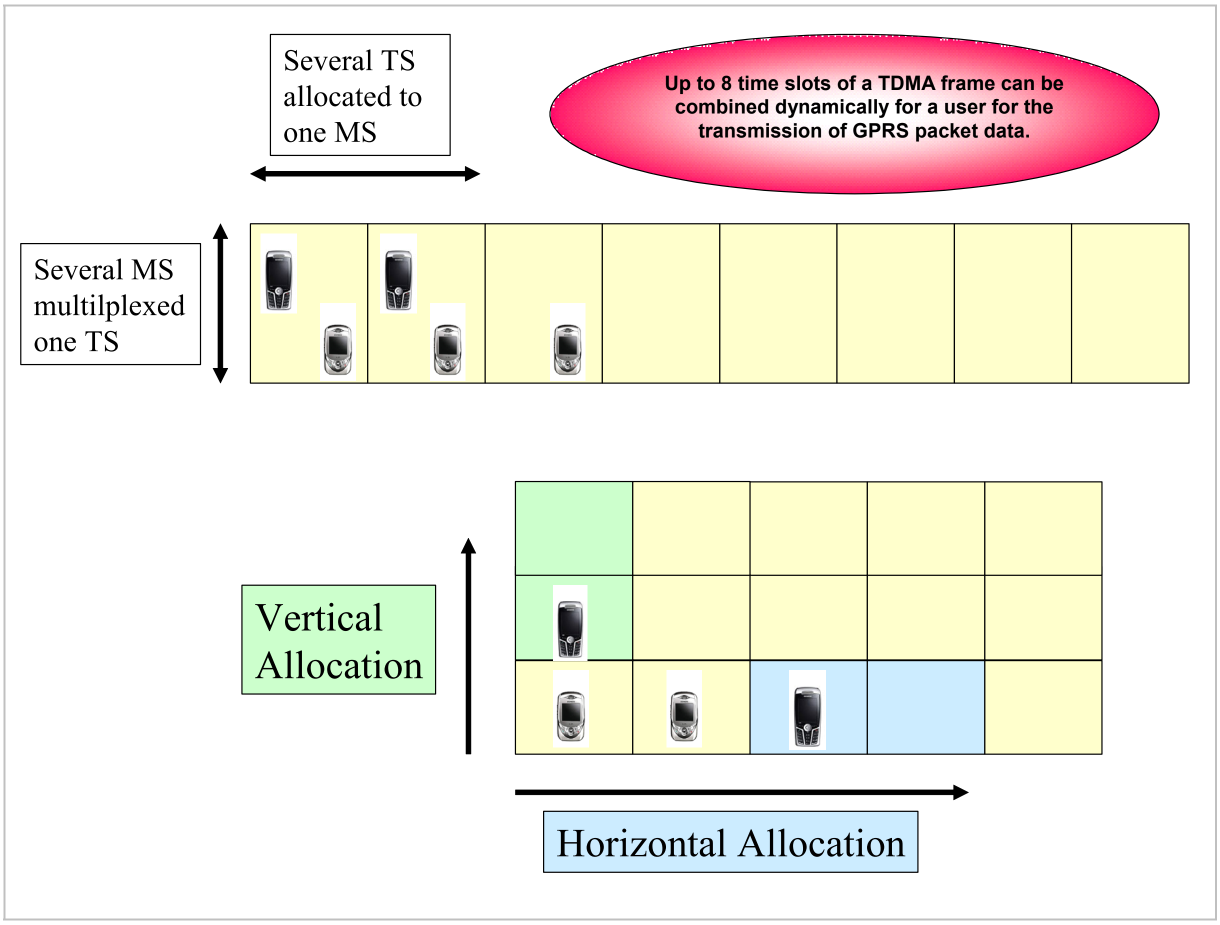


Fig. 42 Multiplexing and TS combining

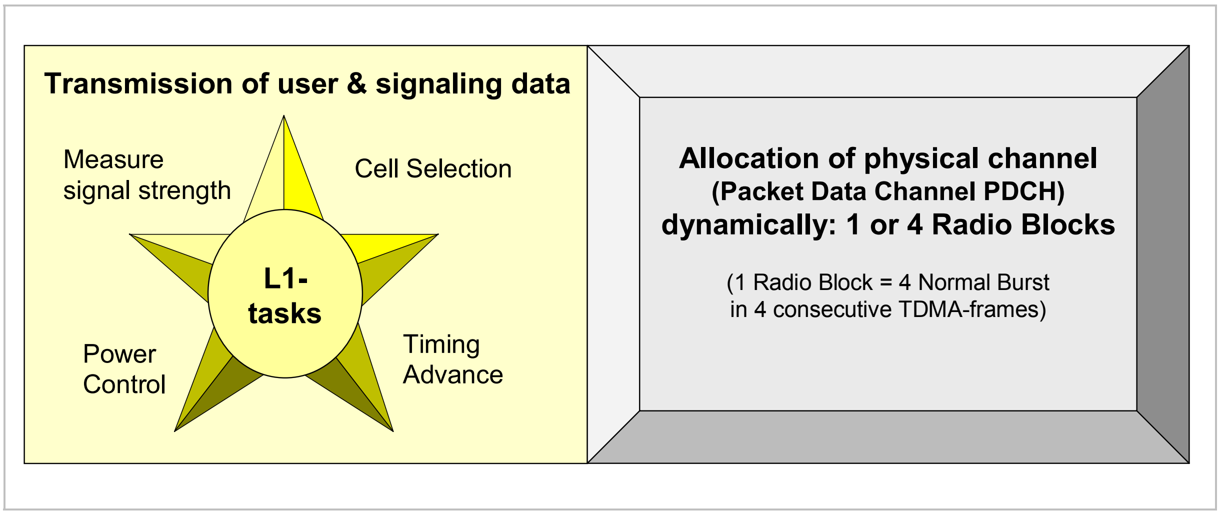


Fig. 43 Radio Interface

7.2.4 Channel coding

Channel coding is modified substantially for packet switched purposes (GSM Rec. 03.64). Channel coding starts with the division of digital information into transferable blocks. These radio blocks, i.e. the data to be transferred (prior to encoding) comprise:

- a header for the Medium Access Control MAC (MAC Header),
- signaling information (RLC/MAC Signaling Block) or user information (RLC Data Block) and
- a Block Check Sequence BCS.

The functional blocks (radio blocks) are protected by convolutional coding against loss of data. Usually, this means inserting redundancy.

Furthermore, channel coding includes a process of interleaving, i.e. re-arrangement in time. The convolutional radio blocks are interleaved to a specific number of bursts/burst blocks. In the case of GPRS, interleaving is carried out across four normal bursts in consecutive TDMA frames (and, respectively, to 8 burst blocks with 57 bit each).

Coding Schemes

New GPRS coding schemes - CS1 - CS4 - have been defined for the transmission of packet data traffic channel PDTCH (Rec. 03.64). Coding schemes can be assigned as a function of the quality of the radio interface. Normally, groups of 4 burst blocks each are coded together.

CS-1 makes use of the same coding scheme as specified for SDCCH (GSM Rec. 05.03). It consists of a half rate convolutional code for forward error correction FEC. CS-1 corresponds to a user data rate of 9.05 kbit/s.

CS-2 corresponds to a user data rate of 13.4 kbit/s, while

CS-3 corresponds to a user data rate of 15.6 kbit/s.

CS-2 and CS-3 represent punctured versions of the same half rate convolutional code as CS-1.

CS-4 has no redundancy in transmission (no FEC) and corresponds to a data rate of 21.4 kbit/s.

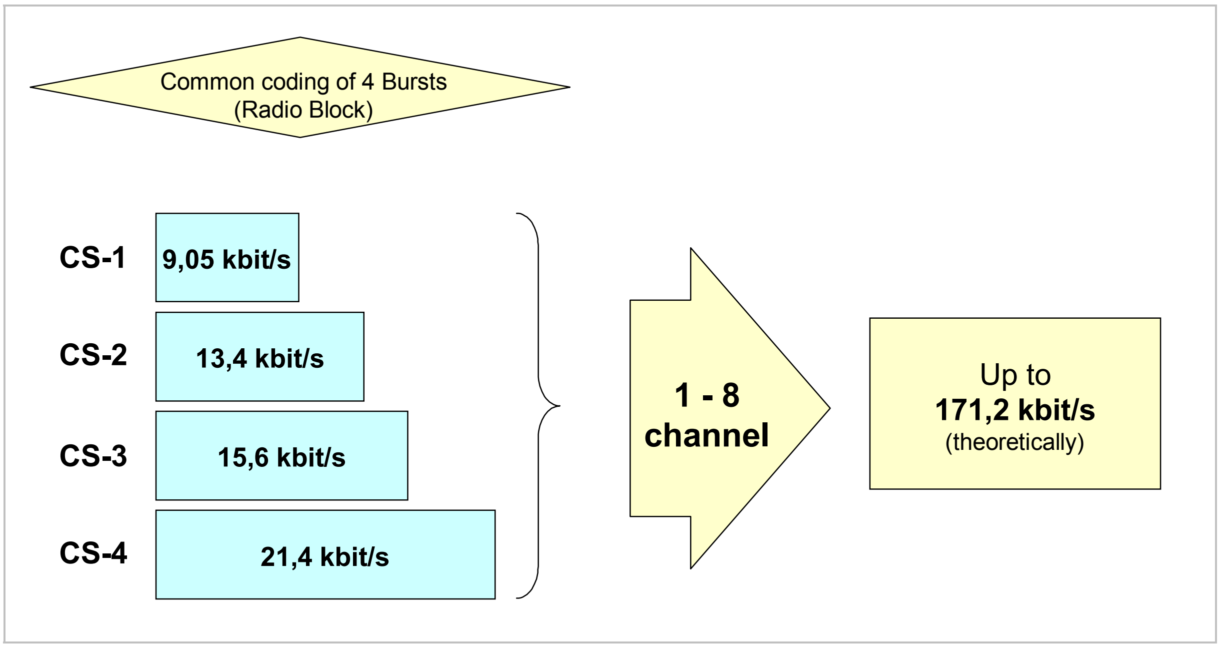


Fig. 44 Coding Schemes

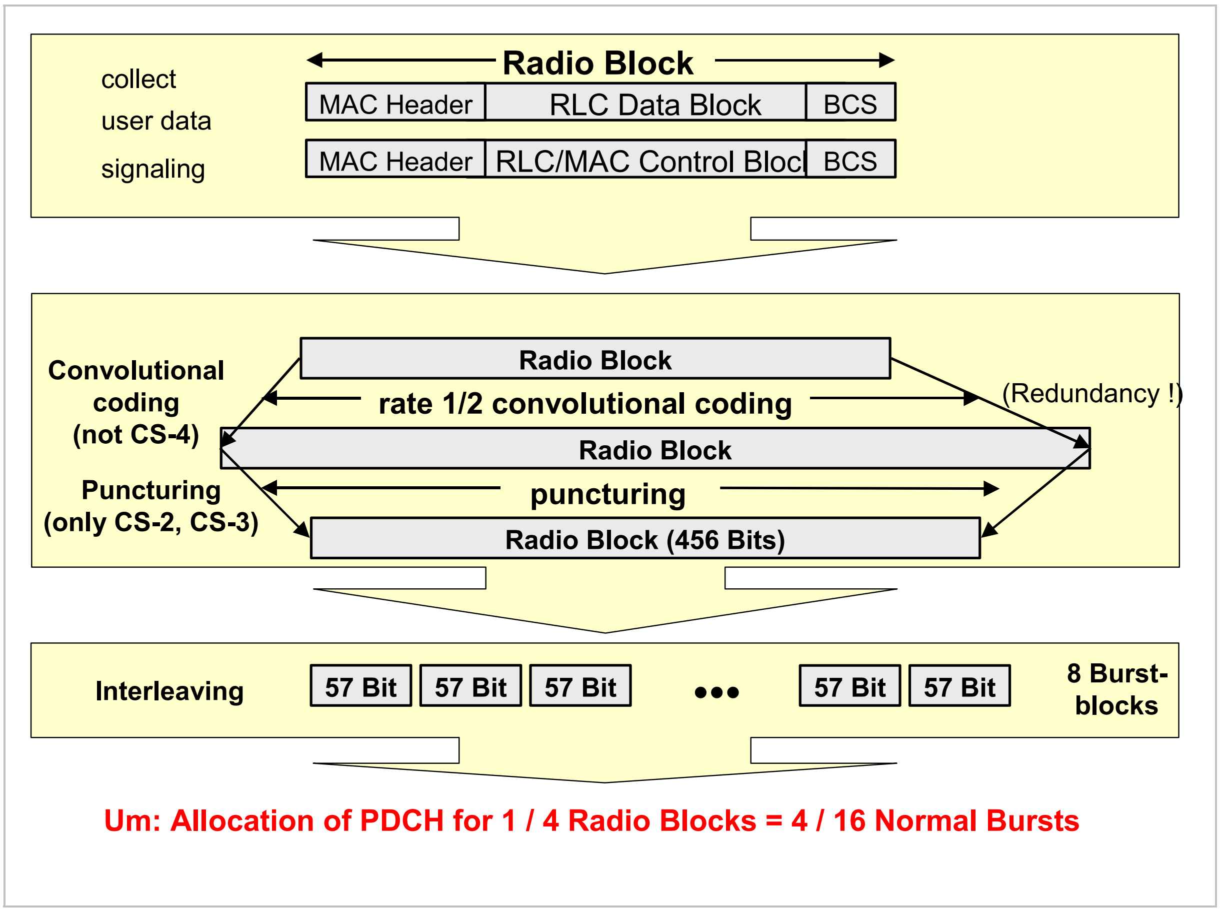


Fig. 45 Channel coding

7.3 Enhanced data rates for GSM evolution EDGE

EDGE (GSM 10.59, GSM 05.04,...) is an alternative concept to increase data transmission rates. As new coding schemes cannot significantly increase performance (GPRS uses 21.4 kbit/s net transmission rate with 22.8 kbit/s gross transmission rate), and no more than 8 timeslots are available on a carrier, EDGE changes the modulation used on the radio interface. In the same time interval, which it takes in "ordinary" GSM to send a bit, in EDGE a symbol representing 3 bits is transmitted.

EDGE nearly triples the data transmission rates (because of protocol overhead the factor is not exactly 3). Similar to HSCSD and GPRS, the new modulation technique is more sensitive to interference and therefore requires good radio conditions.

Since EDGE is based on a different concept, it can be used together with HSCSD and GPRS. The respective variants are called:

- **Enhanced Circuit Switched Data ECSD** and
- **Enhanced General Packet Radio Service EGPRS.**

In SBS up to this release the EGPRS is implemented.

A similar concept is used in the American market for enhancing the capabilities of the D-AMPS networks. The standardization of the UWC-136 HS system is done within the UWCC (Universal Wireless Communication Consortium), which closely cooperates with the ETSI in this regard.

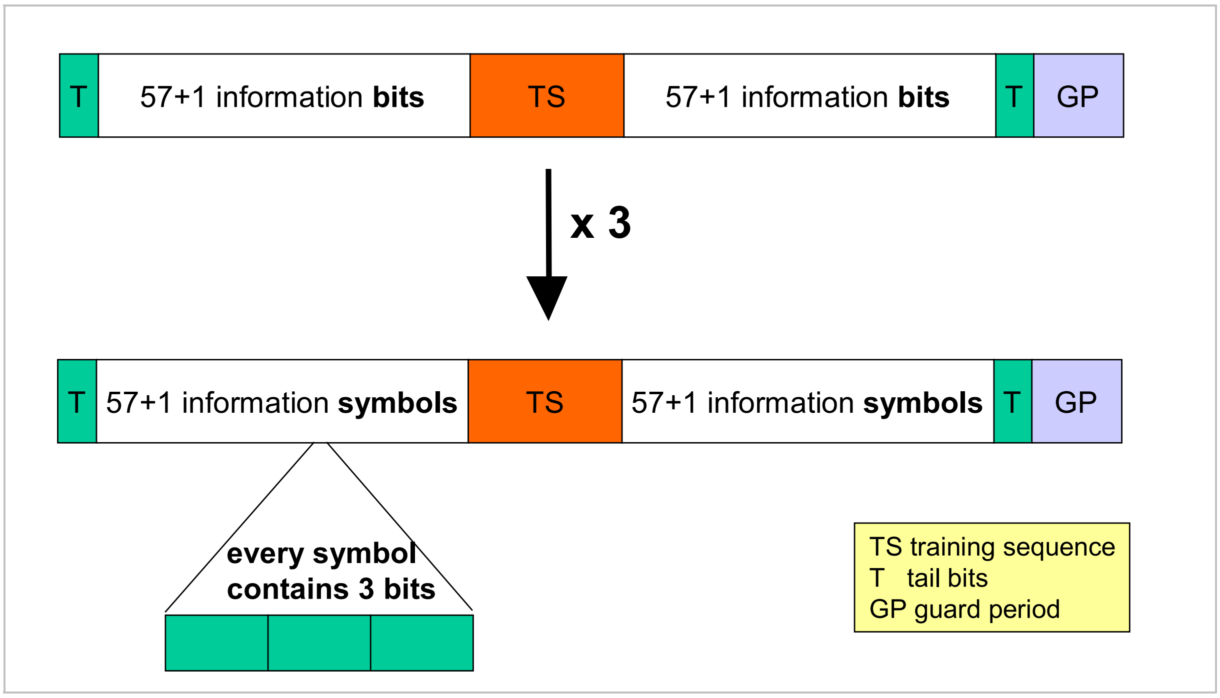


Fig. 46 Normal bursts in GSM (upper) and EDGE (lower)

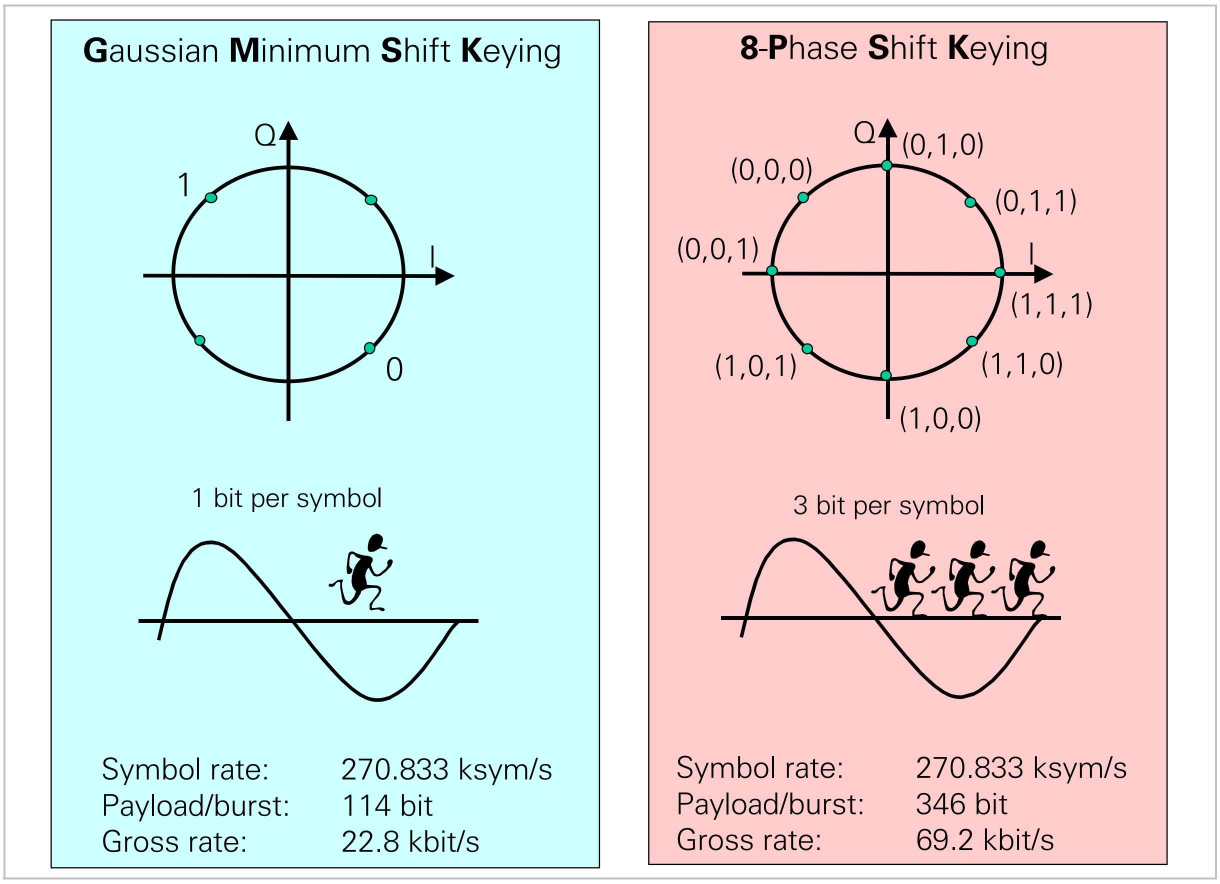


Fig. 47 Comparison of GSM modulation (left) and EDGE modulation (right)

E

7.3.1 Enhanced GPRS (EGPRS)

For Enhanced GPRS, the following main features are relevant:

- new coding schemes allow higher data transmission rates because of 8PSK modulation with different levels of protection by check bits,
- link quality control ensures an adaptation of data transmission rates depending on the condition of the air interface, i.e. in case of e.g. high interference level the data transmission rate is dynamically reduced to an optimum balance between speed and error correction capabilities, and

Channel Coding

9 new coding schemes have been developed for EGPRS:

Coding Scheme	Modu-lation	User data rate (kbit/s)	Code rate	Puncturing schemes	Useful bits	Family
CS-1	GMSK	9.05	0.50	--	181	--
CS-2	GMSK	13.4	0.66	--	268	--
CS-3	GMSK	15.6	0.75	--	312	--
CS-4	GMSK	21.4	1.00	--	428	--
MCS-1	GMSK	8.8	0.53	2	176	C
MCS-2	GMSK	11.2	0.66	2	224	B
MCS-3	GMSK	13.6	0.80	3	296	A (padding)
		14.8			272+24	
MCS-4	GMSK	17.6	1.00	3	352	C
MCS-5	8PSK	22.4	0.37	2	448	B
MCS-6	8PSK	27.2	0.49	2	592	A (padding)
		29.6			544+48	
MCS-7	8PSK	44.8	0.76	3	2*448	B
MCS-8	8PSK	54.4	0.92	3	2*544	A
MCS-9	8PSK	59.2	1.00	3	2*592	A

Logical Channels

The logical channels, which can be used with EGPRS, are the same as for "ordinary" GPRS.

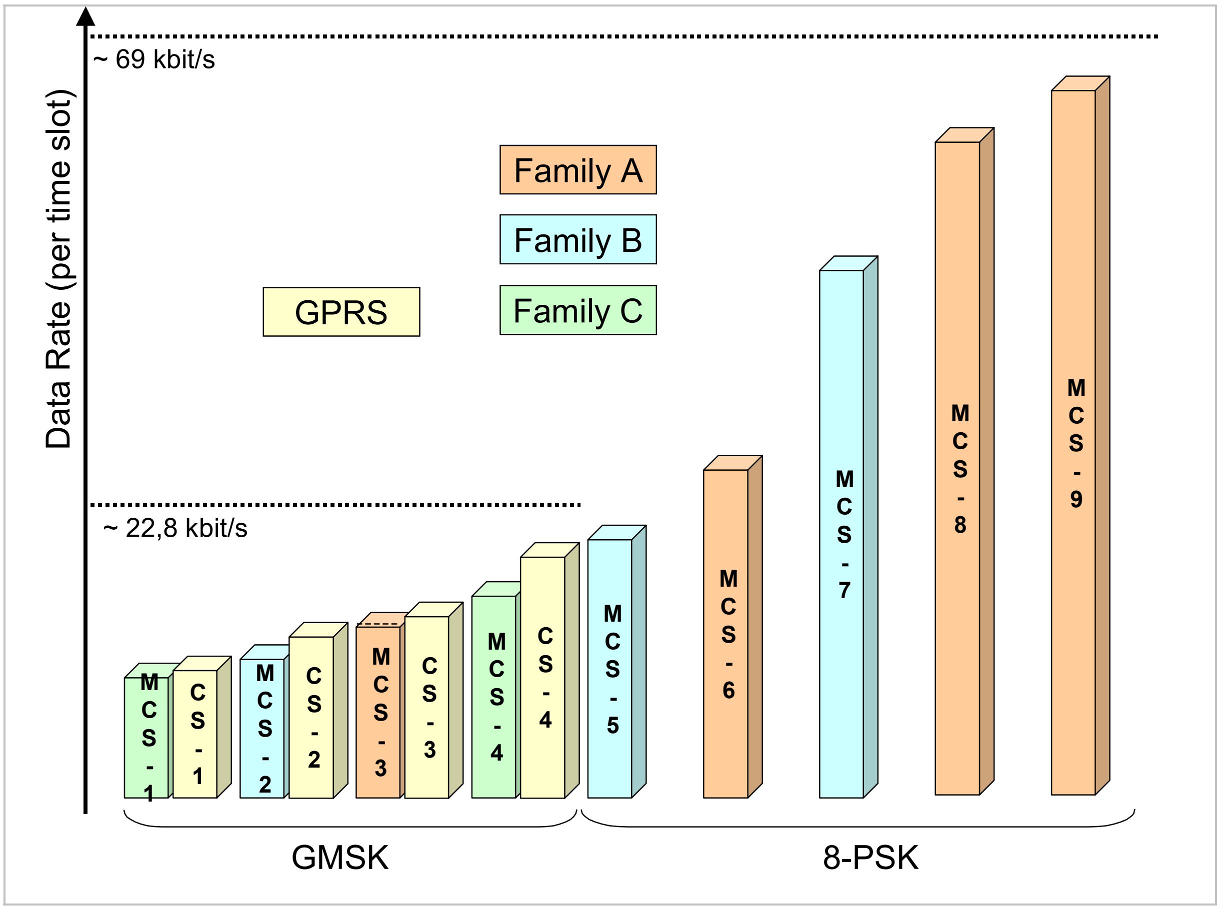


Fig. 48 EGPRS Coding Schemes

7.3.2 Link adaptation

Link adaptation is based on the MS measurements of the bit error rate. Depending on the number of bit errors a quality level is determined and reported to the base station system. The base station system decides, based on this quality level, whether a change of the coding scheme increases the performance and informs the MS about the new coding scheme to be used.

An example of the achievable data rates in dependence of the Modulation and Coding Scheme MCS used and the Carrier/Interference ratio is shown in the figure below (GSM 900, TU50, without frequency hopping).

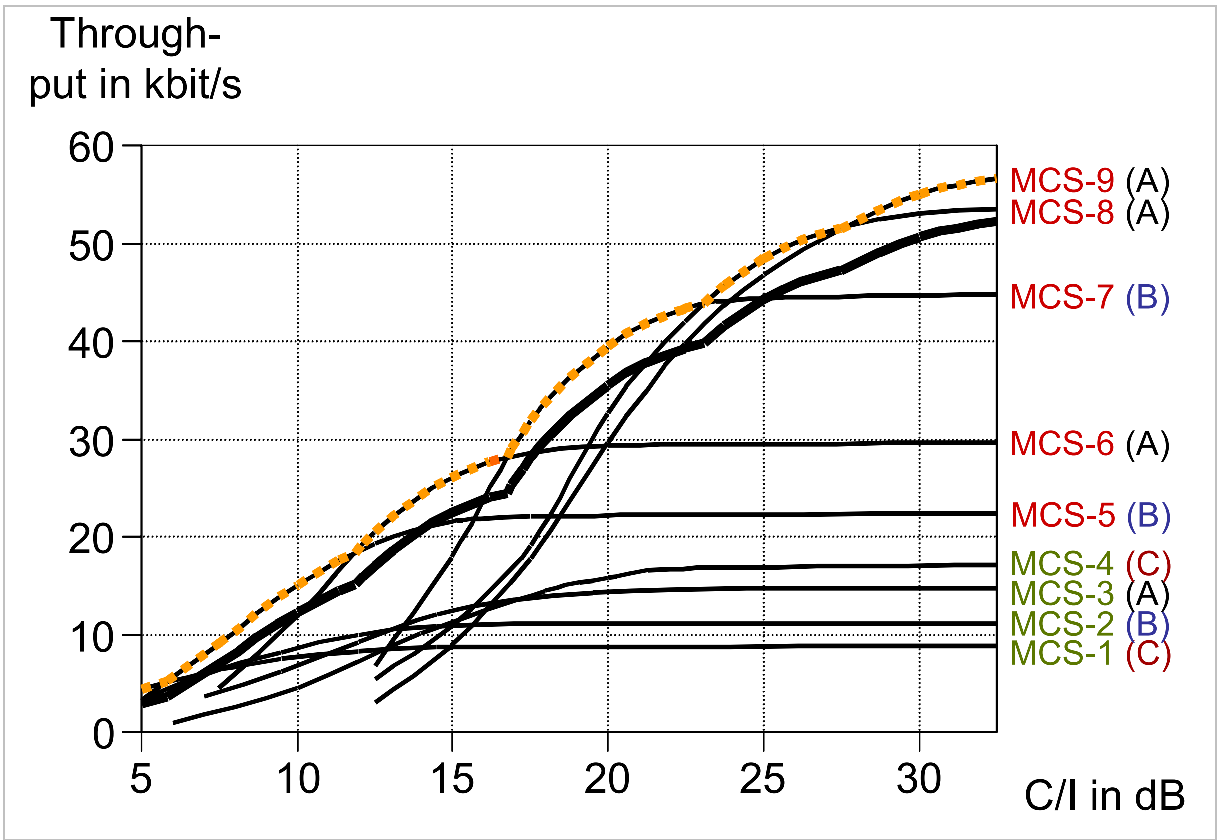


Fig. 49 Link adaptation

7.3.3 Architecture

The EGPRS architecture includes an EDGE capable GSM mobile station (MS), which is connected via the air interface (Um) to the E-CU that supplies EDGE functionality.

The packet switched traffic output from the E-CU in the BTS is transmitted to the Packet Control Unit (PCU) of the BSC from where it is routed to the GPRS backbone.

BSS Configuration with EDGE

The BTSE can be equipped with Edge capable carrier units featuring the new 8-PSK modulation technique and/or "normal" carrier units (G- CUs) supporting GMSK modulation. In the BTSone EDGE is not supported.

To reach the high data rates that are foreseen by the MCS, it is necessary to support Concatenated PCU frames. This requires peripheral processors for packet switched traffic handling providing the Packet Control Unit functionality of the Type "PPXX" modules.

The FAAS (Flexible Abis allocation Strategy) feature guarantees the higher capacity requirement on Abis. This is realized by the BR7.0 software and higher.

Edge Mobile Station

Two classes of mobile stations are provided. One class of mobile station is able to apply the 8PSK modulation in both the uplink and the downlink directions, which means that they support advanced facilities and capabilities. The other class applies 8PSK modulation in the downlink direction and GMSK modulation in the uplink direction.

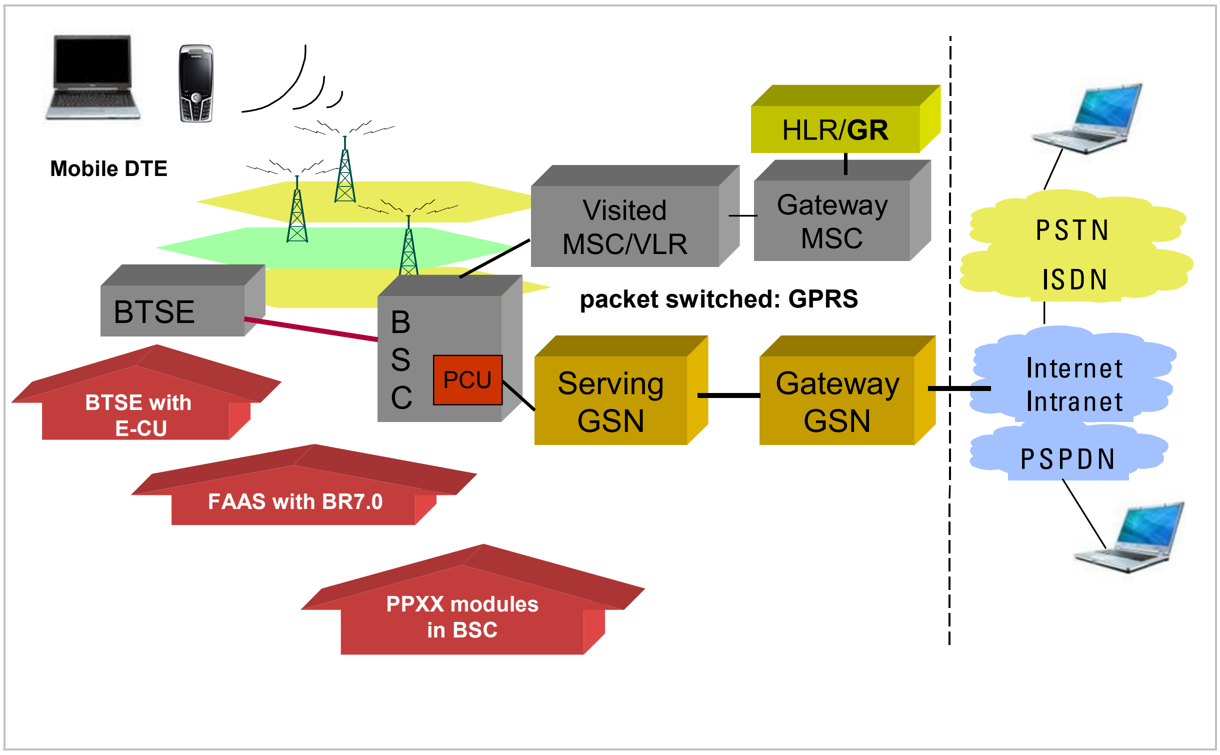


Fig. 50 Changes in Existing Network Infrastructure

8 Location services

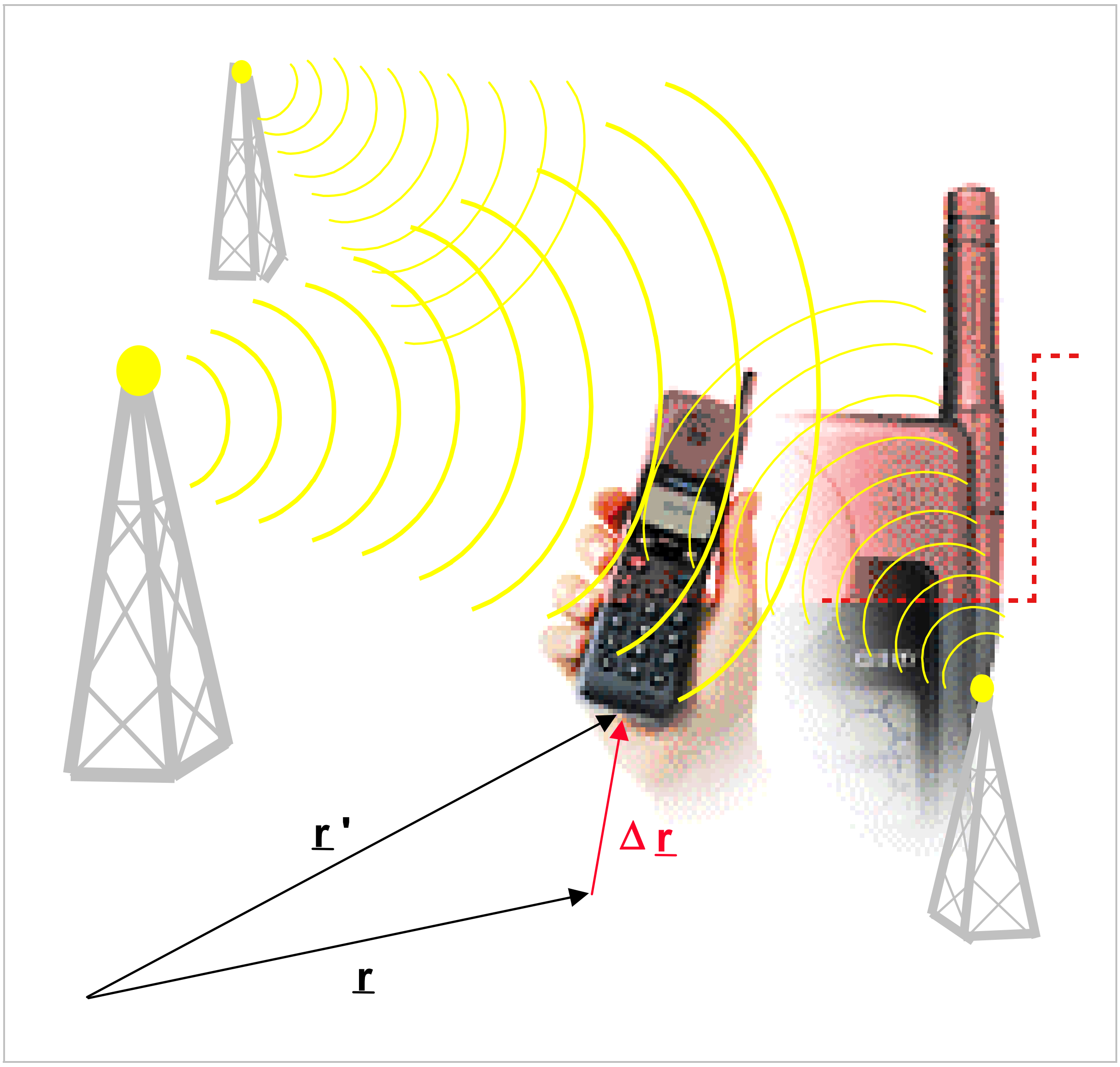


Fig. 51 Location Services

Location Services (LCS) offer the opportunity to deploy new value added services based on the known position of the mobile station. Among these services are

- Location dependent billing (e.g. home zone),
- Safety services (e.g. emergency calls, localization of vehicles),
- Tracking services (e.g. fleet management, navigation),
- Information services (e.g. tourist information, restaurant finder).

Beside offering commercial benefits, LCS are driven by regulatory requirements (US Federal Communication Commission requires location of emergency calls by end of 2001).

Location Services (LCS) provide MS positions to location applications ("LCS clients"). To describe the position of the MS universal latitude and longitude are used according to a defined geodetic reference system (e. g. WGS 084 coordinates Reference System).

8.1 Architecture

The new network entities are:

Serving Mobile Location Center (SMLC)

- manages the overall coordination and scheduling of resources required to perform MS positioning in a PLMN
- determines the positioning method to be used based on the QoS, the network capabilities and the MS location capabilities
- calculates the final location estimate and accuracy and it in a location response to a requesting Gateway Mobile Location Center (GMLC)
- there may be more than one SMLC in one PLMN

Gateway Mobile Location Center (GMLC)

- supports access to the LCS by external applications (e.g. via TCP/IP) or from other PLMN
- stores LCS subscription information on a per-LCS-client basis. This is used when receiving an LCS request to identify the requesting LCS client and to authorize it to use the specified request
- requests info from HLR about the MS to be located
- manages subscriber privacy
- receives the final location estimate and determines whether they satisfy the requested QoS (retry, reject)
- generates LCS related charging and billing rates

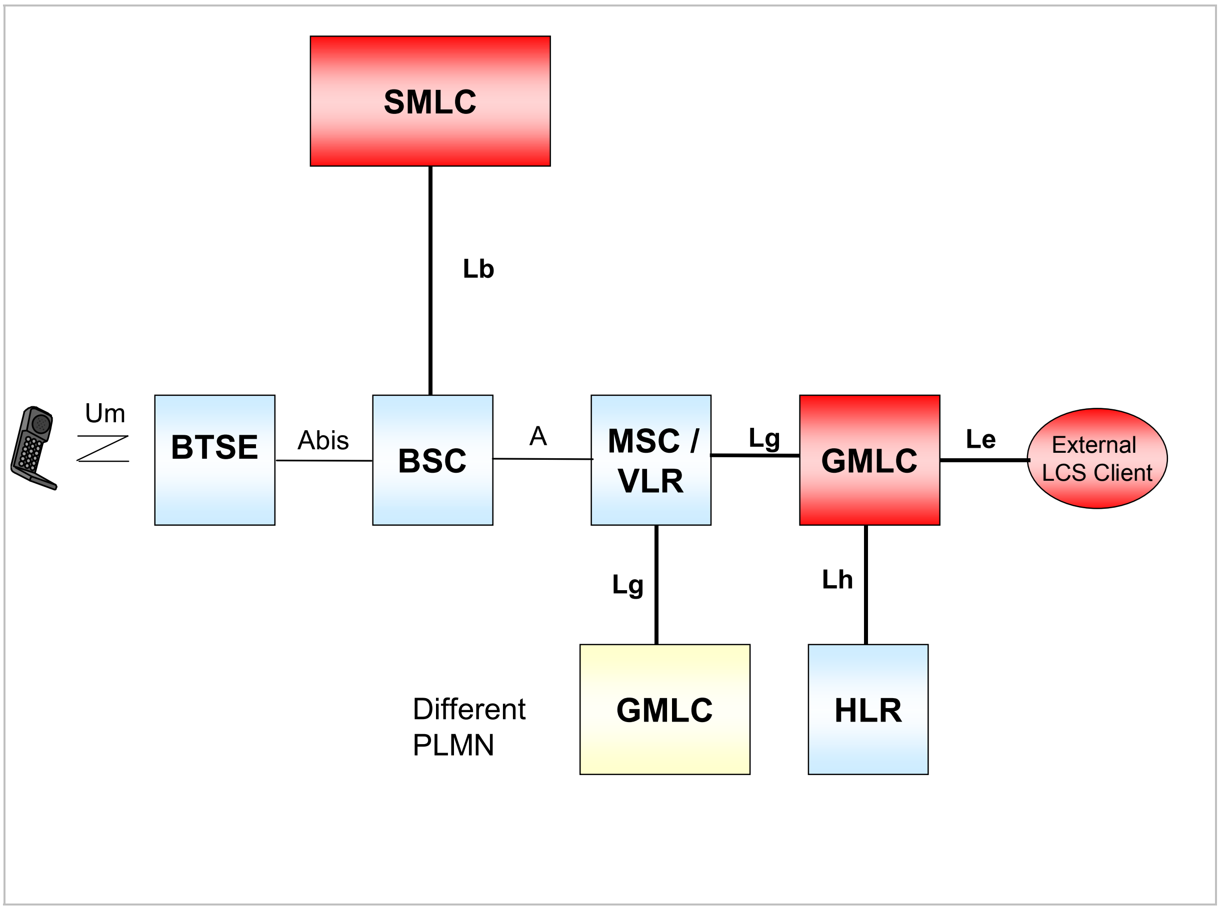


Fig. 52 LCS network architecture

8.2 Positioning methods

The positioning methods introduced are

- (Enhanced) Cell-ID/Timing Advance
- Enhanced Observed Time Difference (E-OTD)
- Time/Angle of Arrival (TOA/AOA)
- (Uplink) Time Difference of Arrival (U-TDOA)
- Assisted-Global Positioning System GPS (A-GPS)

The accuracy of some of the positioning methods depend on cell size, shape and cell planning.

SMLC positioning functions

The Common PRCF (Positioning Radio Coordination Function) determines the positioning method to be used (CITA, E-CITA, A-GPS …) and manages the resources required by the chosen method.

The E-CITA PCF calculates position received from the E-CITA PRCF (including collection of the required prediction data from the SMLC database) and returns back the calculated location estimate.

As examples two important methods (E-CITA and A-GPS) are described in more detail in the following.

	CI	CI/TA	E-CI/TA	E-OTD	U-TDOA	A-GPS
Accuracy [m]	10-30,000	~500	100 - 200	50 - 125	50 - 125	5 – 75
Fix Time	3s	5s	5s	5s	5s	5-10s
Impact on handset	None	None	None	Yes **(SW)**	None	Yes **(GPS chip, antenna)**
Impact on network	None	SMLC	SMLC	SMLC + LMUs	SMLC + LMUs	3GPP: SMLC + **Reference network** OMA SUPL: LSU

Fig. 53 Comparison of Positioning Methods

8.2.1 Enhanced CITA

The basic location information in cellular network is the actual Cell ID of the serving cell. Combining to this information the Timing Advance value of the MS, the CITA method is realized. The E-CITA is a positioning method that uses the CITA enhanced by a comparison of predicted receive levels and measured receive levels.

In GSM every MS that is in dedicated mode measures and reports continuously the actual radio conditions to the network. These reports contain information about reception power levels (RXLEV) of the serving cell and up to six neighboring cells.

To realize this method the SMLC has to be filled with prediction power level data. In case of a positioning request, the SMLC will compute the location by matching the measured data with the prediction data.

The output of the SMLC is shape, for example a point on the surface of the earth with an uncertainty circle.

Beside the position, the algorithm is able to estimate the positioning error described by an uncertainty circle or ellipse for a given confidence level.

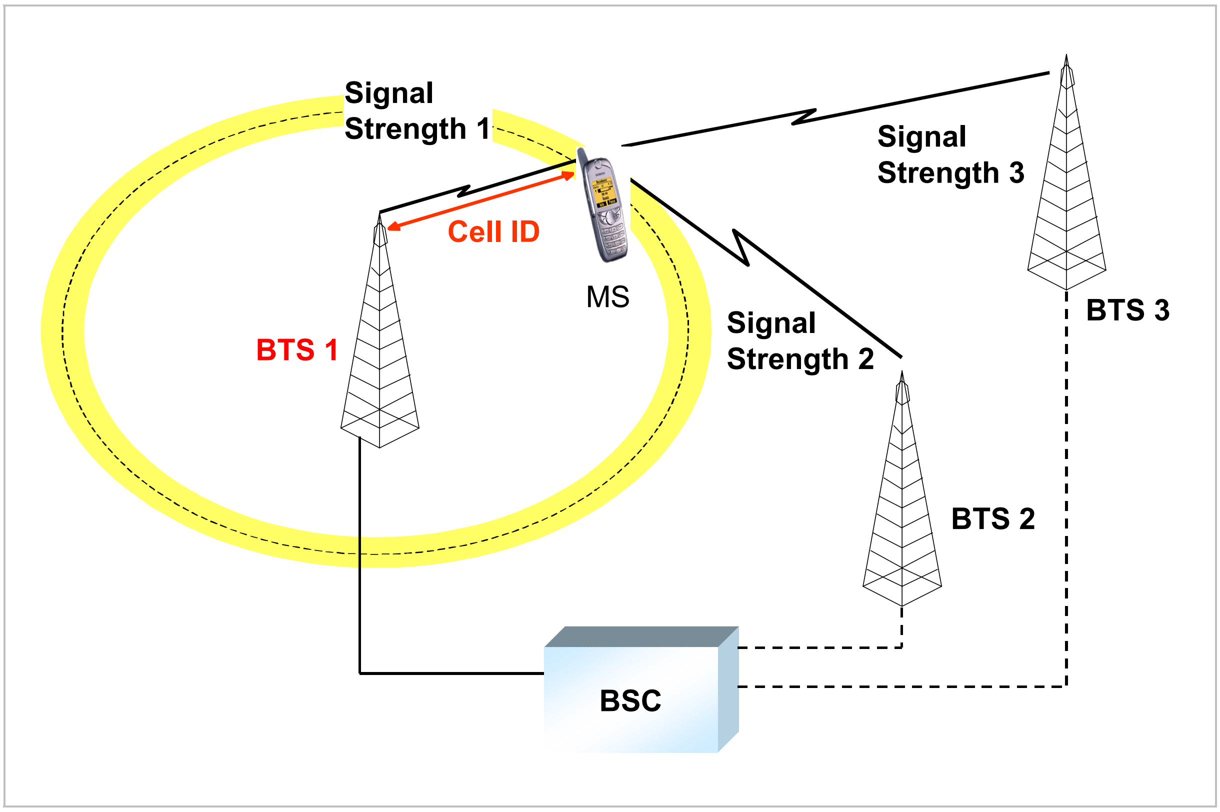


Fig. 54 MS measurements

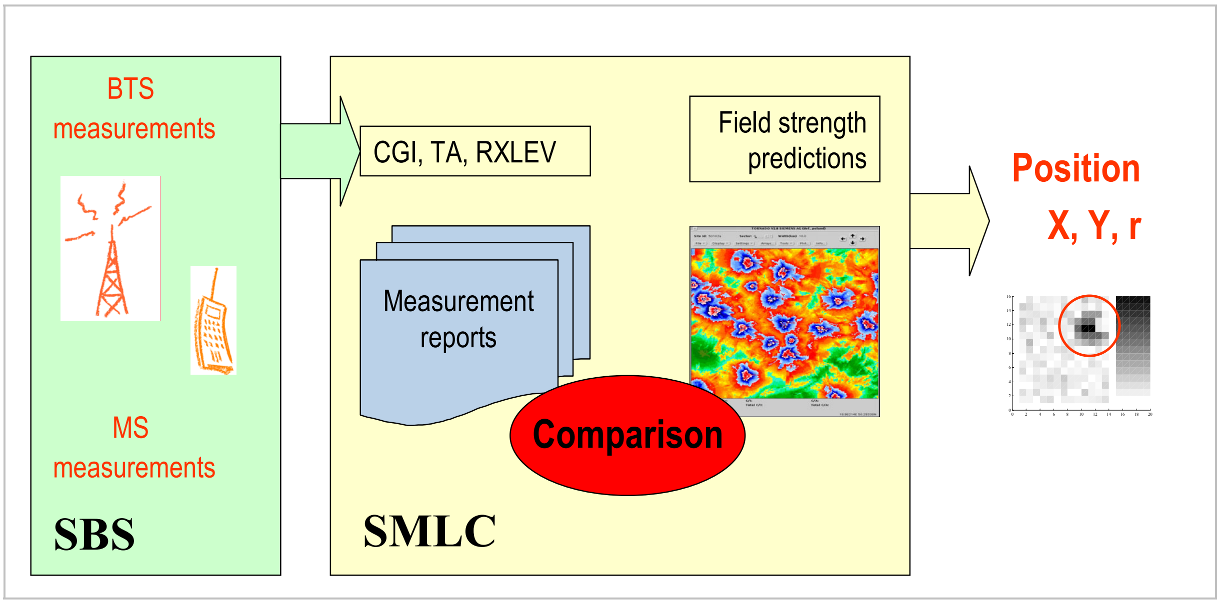


Fig. 55 Location estimation

8.2.2 Assisted GPS

Conventional GPS is a known solution for positioning. In case of using the GPS method in mobile networks the large time to first fix, low sensitivity (no coverage indoors or in urban canyons), and excessive battery consumption are the disadvantages. To overcome these drawbacks, network assisted GPS (A-GPS) is used.

The basic idea behind network assisted GPS (A-GPS) is that the GPS receiving system is distributed:

- MS with GPS receiver
- Reference GPS network

The GPS reference network consists of GPS receiving stations, tracking all GPS satellites at all times. This data is used to model the satellite orbits and clocks well into the future. The MS obtains this so called assistance data from the radio network. It consists of a list of visible satellites to facilitate the acquisition of the satellites signals for the MS.

The MS measures only the times of arrival (called “pseudoranges”) which enables a lower signal level. Therefore the A-GPS method requires a handset with integrated GPS receiver.

The Siemens mobile A-GPS functionality is integrated into the SMLC. The SMLC is determining the position with use of the GPS data. In the SMLC the A-GPS positioning method can be provided along with other lower accuracy positioning methods like CITA and E-CITA.

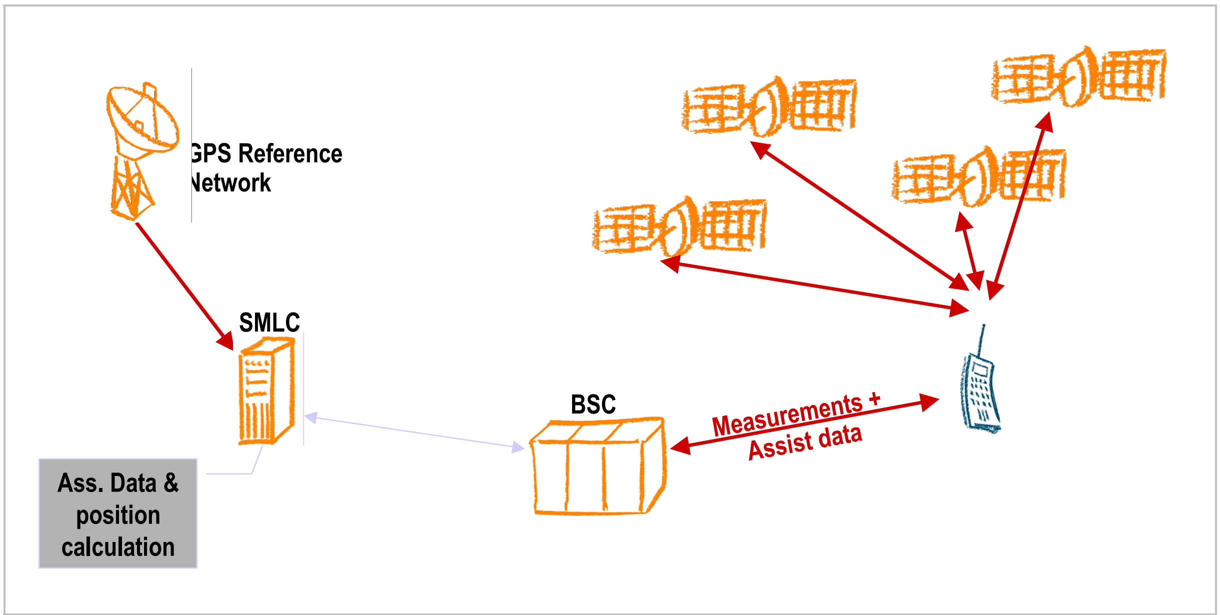


Fig. 56 MS measurements and assistance data

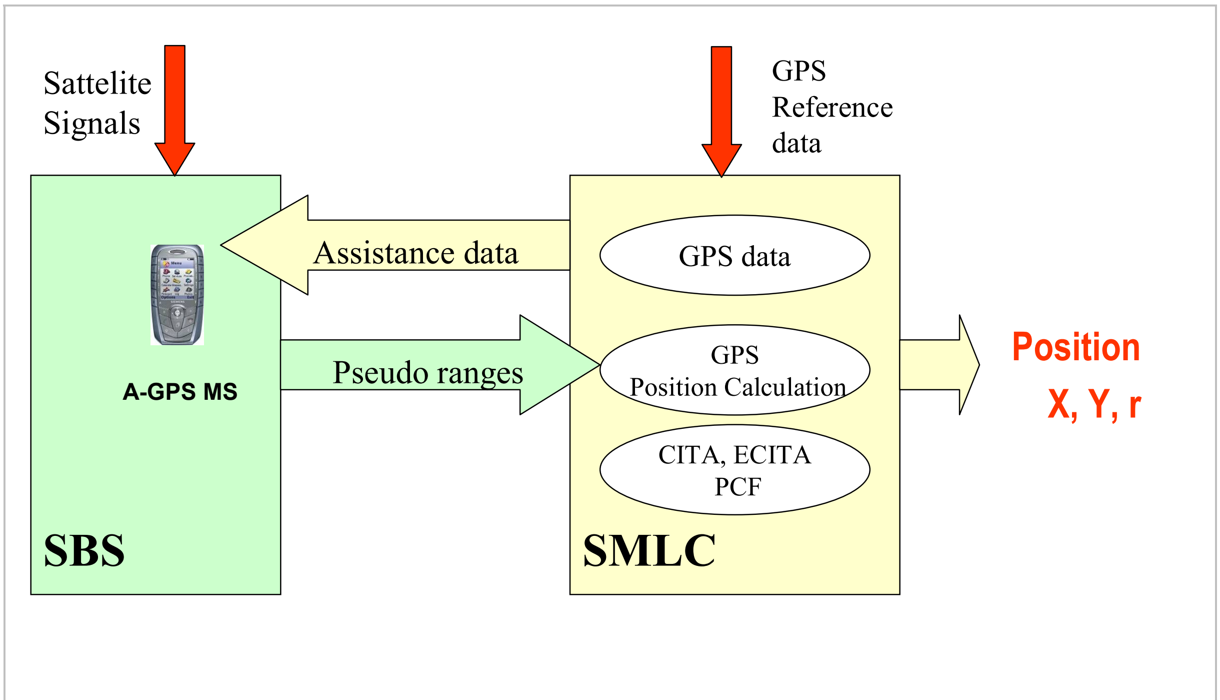


Fig. 57 Location estimation

9 Exercises

- What means GSM?
- What means PLMN?
- What are the major subsystems in a PLMN?
- Which subsystem is responsible for monitoring of the BSS and SSS?
- List the major functions of the network components of the BSS
- Name the most important interfaces defined by GSM?
- What is a radio cell?
- What influences the size of a radio cell and what is the maximum size of a radio cell in GSM900?
- Find out the correlation between the guard period of an access burst and the maximum size of a GSM cell.
- What is the frequency range for GSM900 (extended band)?
- How many radio frequency carriers are available in GSM900?
- Can a cell have more than one RFC?
- What is meant by TDMA, FDMA, and FDD?
- What type of burst is used for traffic channels?
- Which manual provides background information on SBS features?
- Where do you find information on the BS240 commissioning procedure?
- Why is power control performed?
- What is the name for operating TRX of different bands in the same cell?
- What does HSCSD stand for?
- What are transparent and non-transparent modes of operation?
- What are the differences between GPRS and HSCSD?
- What is the (theoretical) maximum data rate for GPRS?
- How many logical channels are used in GPRS?
- Explain the difference between GMSK and 8-PSK.
- Name the main differences between HSCSD, GPRS and ECSD, EGPRS.
- What is Link Adaptation?
- Which methods are used for Location Services? What are their main differences?