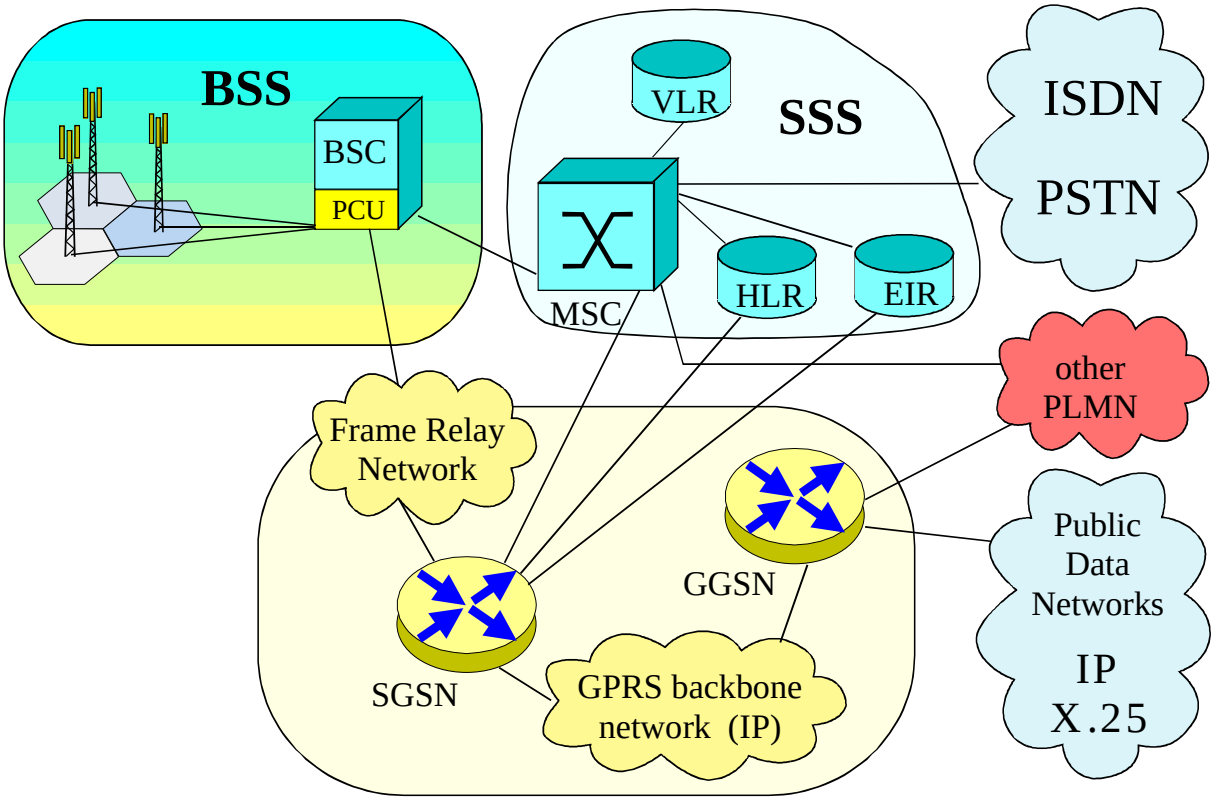
GPRS Overview

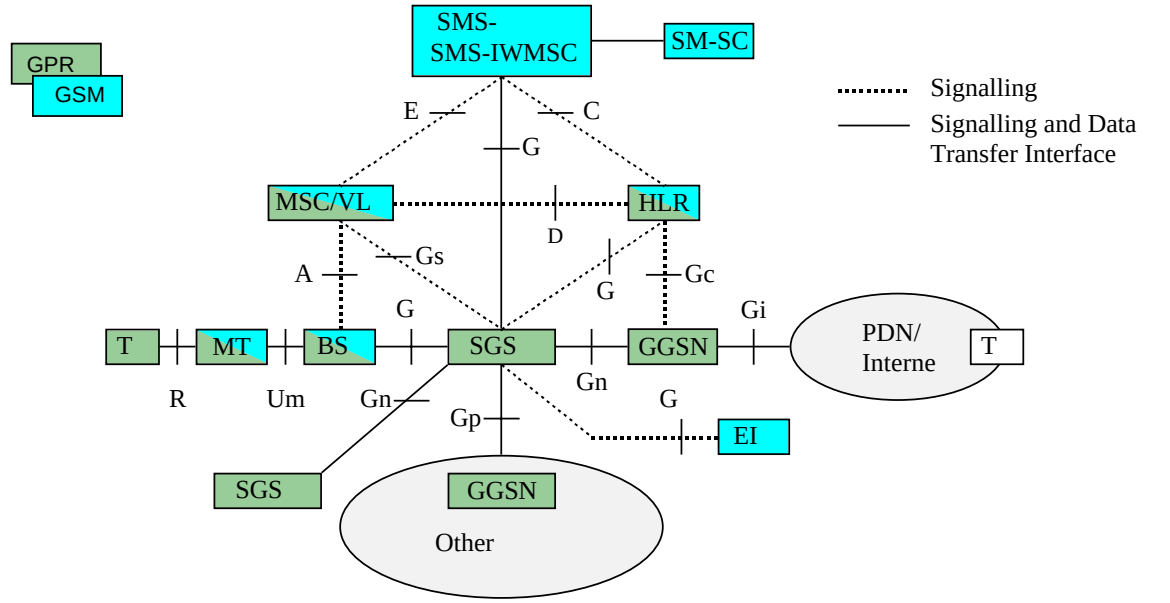
GPRS General Packet Radio Service

- A new service for economic data transmission in a GSM network
- A packet overlay network for data transmission
- GPRS allows new services, such as:
  - Email
  - Mobile Internet / Intranet
  - E-Commerce
  - Telemetry
  - Location Services (LCS)
- GPRS enables new market applications in the field of
  - Transportation: e.g. telematic services
  - Emergency Services: command & control
  - Field Services: job dispatch, issue and control
  - Utilities: meter reading

GSM - GPRS



GSM / GPRS Architecture and Interfaces



GGSN	Gateway GPRS Support Node	SGSN	Serving GPRS Support Node
MSC	Mobile-services Switching Centre	SM-SC	Short Message service Service Centre
MT	Mobile Termination	SMS-GMSC	Short Message Service Gateway MSC
PDN	Packet Data Network	SMS-IWMSC	Short Message Service Interworking MSC

GPRS Features

- Radio channels can be used either by GPRS or CS (circuit switched) Services
- GPRS radio channels are shared between multiple Mobile Stations
- GPRS provides higher bandwidth than GSM (up to 171,5 kbps)
- GPRS is economical for the network provider
  - Multiple Users on the same radio channel ➔ frequency economic
- GPRS is economical for the User
  - Billing according to the data volume, not for the holding time
  - The terminal can always be online

GPRS is the Bridge from 2nd Generation (GSM) to 3rd Generation (UMTS) Systems

GPRS Services

Service requester to Service receiver	Types of service request			
	Point to Point	Point to Multipoint	Point to Multipoint	IP
	Connection oriented and Connectionless	Multicast	Group Call	Multicast
From fixed to mobile	Supported	Supported	Supported	Supported
From mobile to mobile	Supported	Supported	Supported	Supported
From mobile to fixed	Supported (special: anonymous access to the network)	Not applicable	Supported (limited)	Supported

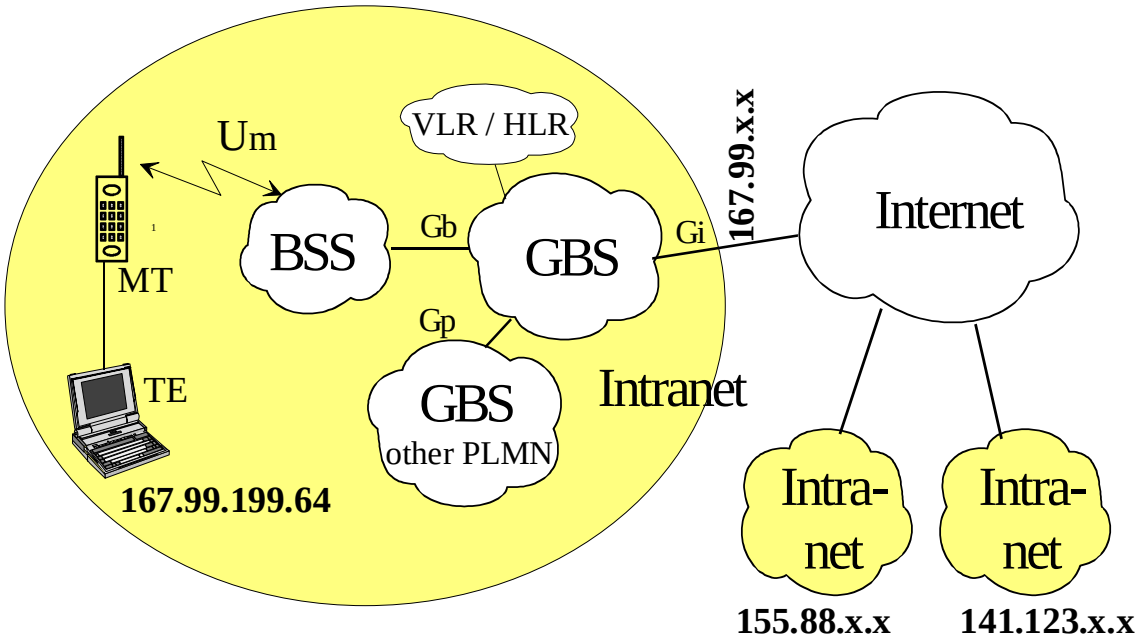
Point-To-Point Connectionless Network Service	PTP-CLNS	e.g. IP
Point-To-Point Connection Orientated Service	PTP-CONS	e.g. X.25
Point-To-Multipoint - Multicast	PTM–M	messages in a geographical area (SMS-CB)
Point-To-Multipoint - Group Call	PTM–G	a specified receiver group within a geographical area(s)
IP Multicast	IP-M	as defined in the IP protocol suite.

Capabilities of GPRS MS Classes

	Class A	Class B	Class C
simultaneous attach	yes	yes	no
simultaneous activation	yes	yes	no
simultaneous monitor	yes	yes	no
simultaneous invocation of a service	yes	limited	no
simultaneous traffic	yes	no	no
circuit switched and GPRS traffic	simultaneously	sequentially	no
selection of service (circuit/packet)	simultaneously	automatically	manually

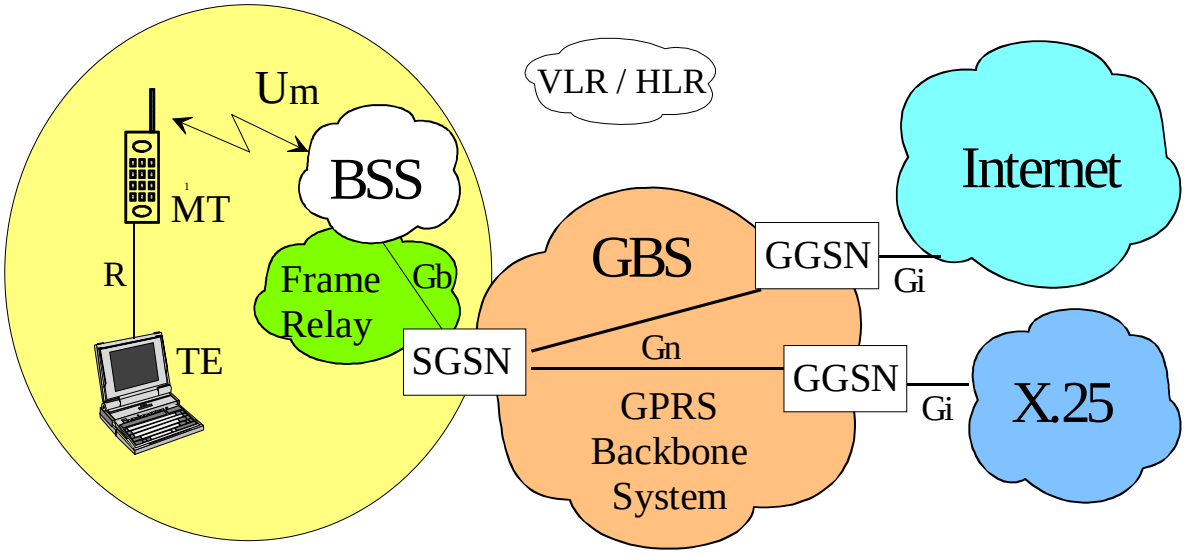
Class-A MS	normal GSM	AND	GPRS,	full simultaneous operation
Class-B MS	normal GSM	AND	GPRS,	simultaneous paging only
Class-C MS	normal GSM	OR	GPRS,	

GPRS: a subnet connected to the internet



BSS: Base Station Subsystem GBS GPRS Backbone System

Radio Network (BSS), GPRS Backbone (GBS) and Public Data Networks (PDN)

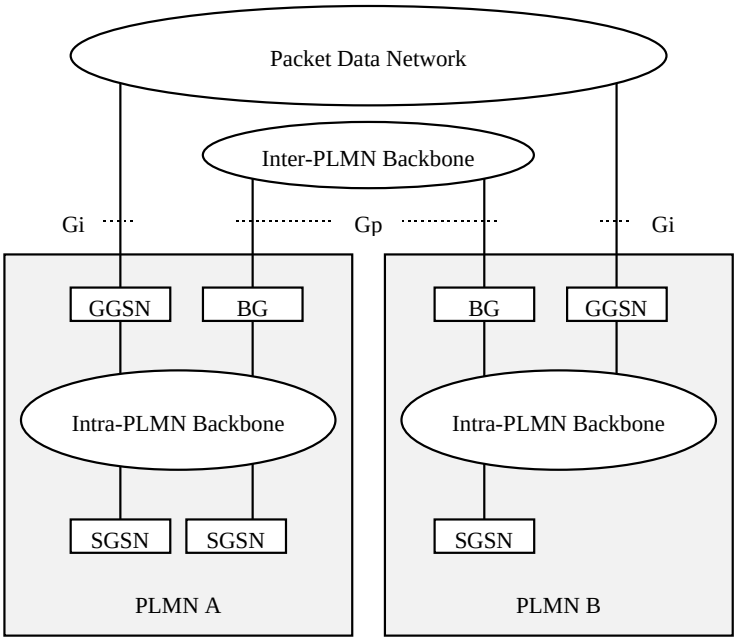


GGSN Gateway GPRS Support Node
Interface between the GPRS Backbone System (GBS) and Public Data Networks (IP, X.25, ..)
A GGSN may support only one Public Data Protocol PDP (e.g. IP) or several PDPs

SGSN Serving GPRS Support Node
Interface between the GSM Radio network (BSS) and the GPRS Backbone System (GBS)

GBS the GPRS Backbone System is an IP network

GPRS Backbone Networks



intra-PLMN backbone network:

- a private IP network (Sicherheit)
- interconnecting GSNs of the same PLMN
- for GPRS data and GPRS signalling only

inter-PLMN backbone network.

- interconnecting GSNs and intra-PLMN networks of different PLMNs
- Gp interface and Border Gateways

Function	MS	BSS	SGSN	GGSN	HLR
Network Access Control:					
Registration					X
Authentication and Authorisation	X		X		X
Admission Control	X	X	X		
Message Screening				X	
Packet Terminal Adaptation	X				
Charging Data Collection			X	X	
Packet Routeing & Transfer:					
Relay	X	X	X	X	
Routeing	X	X	X	X	
Address Translation and Mapping	X		X	X	
Encapsulation	X		X	X	
Compression	X		X		
Ciphering	X		X		X
Mobility Management:	X		X	X	X
Logical Link Management:					
Establishment, Maintenance, Release	X		X		
Radio Resource Management:					
Um Management	X	X			
Cell Selection	X	X			
Path Management		X	X		

GPRS:

Mapping of Functions to Logical Architecture

Data Rates in Mobile Communication Systems

Service	Data Rates (gross)	Remark
CSD: Circuit Switched Data in GSM	**9.6 Kbps** per time slot (**14.4** Kbps defined but not yet offered)	Data uses a voice channel
SMS: Short Message Service	**0.001 Kbps** to **0.1 Kbps** (160 Bytes per message)	Data travels only on control channels
CDPD: Cellular Digital Packet Data, in D- AMPS	**13.2 Kbps** uplink (reverse) **12.1 Kbps** downlink (forward)	Data uses idle voice channels. Voice has priority. No bundling of channels
HSCSD: High Speed Circuit Switched Data	**9,6 - 76.8 Kbps** (1-8 time slots, 9,6) **14,4 – 115,2 Kbps** (1-8 time slots, 14,4)	Multislot operation of CSD
GPRS: General Packet Radio Service	**9.05 Kbps** to **21.4 Kbps** per time slot => **171.2 Kbps** for 8- slot mobiles	Packet switched system. 4 Coding Schemes CS- 1 .. CS- 4
EGPRS: Enhanced GPRS, will be adapted for **IS- 136 HS** (North American TDMA)	**8.8 Kbps** with MCS- 1 up to **59.2 Kbps** with MCS- 8 per time slot, => **473.6 Kbps** for 8- slot mobiles	EDGE concept uses GMSK and 8- PSK. Smooth transition from GPRS. Link Adaptation and Incremental Redundancy.
EDGE Lite (now also called **EGDE compact**) **:** Is a special IS- 136 HS	Theoretically like EGPRS, but lower data rate due to tighter reuse	Uses 1 MHz of spectrum, i. e. 1/ 3 reuse must be applied. Control channels need synchronised network.
UMTS: Universal Mobile Telecommunication System	**2 Mbps** for in- house and Pico- cells. **384 Kbps** for outdoor or Macro- cells	CDMA with TDD and FDD mode.
BRAN: Broadband Radio Access Network	**25 Mbps .. 155 Mbps**	HIPERLAN, HIPER-ACCESS **25Mbps** HIPERLINK **155Mbps**

Coding parameters for standard GSM

	net bit rate	4 modified ISDN frames	adding 4 fill bits	Convolurtional coding r=1/2	puncturing 15/14
Bits per frame	192	240	244	488	456
Data Rate	9,6 kb/s	12 kb/s	12,2 kb/s	24,4 kb/s	22,8 kb/s

Coding parameters for GPRS

Scheme	Modu lation	Code rate	USF	Pre- coded USF	Radio Block excl. USF and BCS	BCS	Tail	Coded bits	Punctured bits	Data rate kb/s
CS-1	GMSK	1/2	3	3	181	40	4	456	0	9.05
CS-2	GMSK	≈2/3	3	6	268	16	4	588	132	13.4
CS-3	GMSK	≈3/4	3	6	312	16	4	676	220	15.6
CS-4	GMSK	1	3	12	428	16	-	456	-	21.4

Coding: ½ rate convolutional code (before puncturing) A radio block is transmitted within 20 ms.

Calculation of the Coding parameters for GPRS

Scheme	Code rate	Pre-coded USF	Radio Block excl. USF and BCS	BCS	Tail	Coded bits	Punctured bits	Data rate kb/s
CS-1	1/2	3	181	40	4	456	0	9.05
CS-2	≈2/3	6	268	16	4	588	132	13.4
CS-3	≈3/4	6	312	16	4	676	220	15.6
CS-4	1	12	428	16	-	456	-	21.4

1. Calculate Coded Bits:

For CS-1 to CS-3: 2 * (Pre-coded USF + Radio Block bits + BCS + Tail) = Coded bits

For CS-4 (no coding) (Pre-coded USF + Radio Block bits + BCS + Tail) = Coded bits

2. Calculate Transmitted Bits:

For CS-1 to CS-4: coded bits – punctured bits = transmitted bits = 456 bits

Gross bit rate: 22,8 kb/s = 456 bits / 20 ms (a block is transmitted in 20 ms)

Net bit rate: Radio Block bits / 20 ms Example: CS-2 286 net bits / 20 ms = 13.4 kb/s

Coding parameters for EGPRS

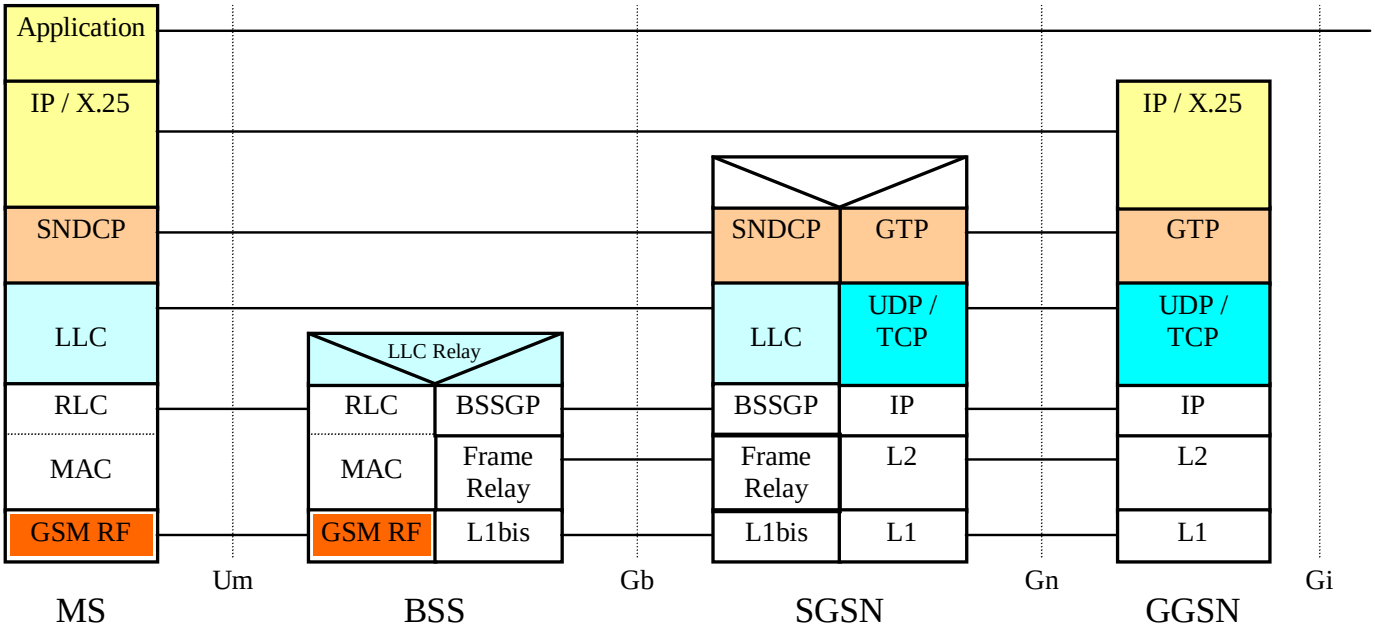
Scheme	Code rate	Header Code rate	Modulation	RLC blocks per Radio Block (20ms)	Raw Data within one Radio Block	Family	BCS	Tail payload	header CRC	Data rate kb/s
MCS-9	1.0	0.36	8PSK	2	2x592	A	2x12	2x6	8	59,2
MCS-8	0.92	0.36	8PSK	2	2x544	A	2x12	12	8	54,4
MCS-7	0.76	0.36	8PSK	2	2x448	B	2x12	12	8	44,8
MCS-6	0.49	1/3	8PSK	1	592 544+48	A	12	6	8	29,6 27,2
MCS-5	0.37	1/3	8PSK	1	448	B	12	6	8	22,4
MCS-4	1.0	0.53	GMSK	1	352	C	12	6	8	17,6
MCS-3	0.80	0.53	GMSK	1	296 272+24	A	12	6	8	14,8 13,6
MCS-2	0.66	0.53	GMSK	1	224	B	12	6	8	11,2
MCS-1	0.53	0.53	GMSK	1	176	C	12	6	8	8,8

+24, +48 = padding

Data Transmission: GSM, GPRS und EGPRS

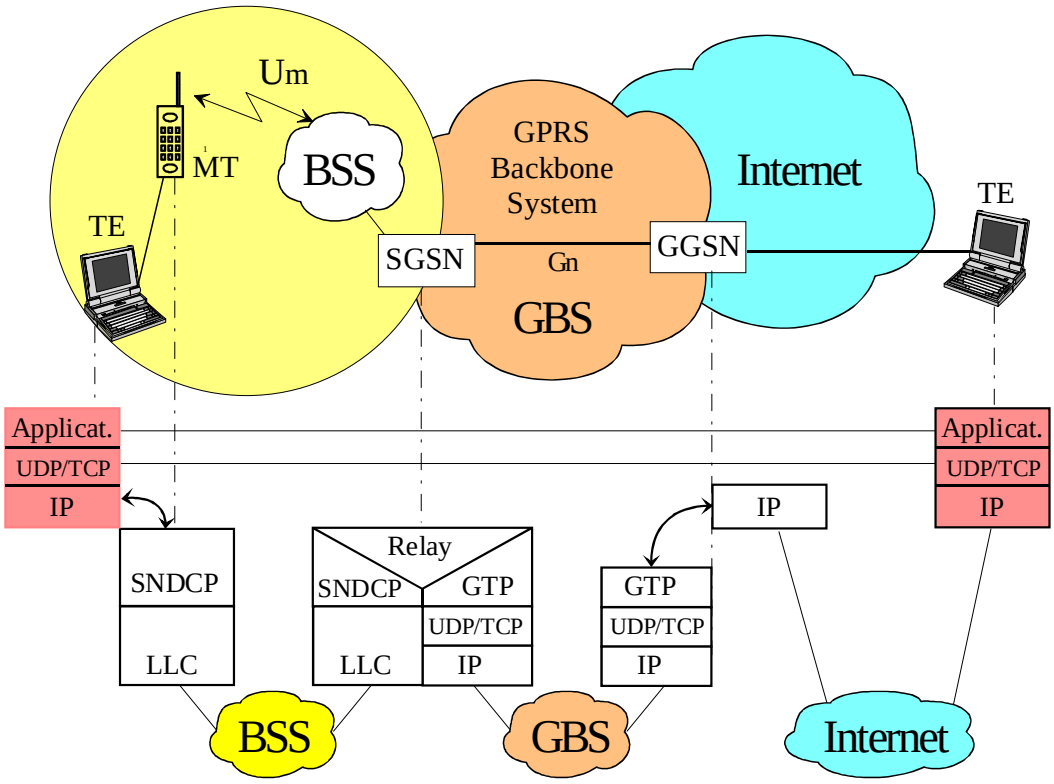
	Coding Scheme	Modulation	Data rate 1 Timeslot kb/s	Data rate 8 Timeslots kb/s
GSM		GMSK	9,6	n/a
GPRS	CS-1	GMSK	9,05	72,4
	CS-2	GMSK	13,4	107,2
	CS-3	GMSK	15,6	124,8
	CS-4	GMSK	21,4	171,2
EGPRS	MCS-1	GMSK	8,8	70,4
	MCS-2	GMSK	11,2	89,6
	MCS-3	GMSK	14,8	118,4
	MCS-4	GMSK	17,6	140,8
	MCS-5	8PSK	22,4	179,2
	MCS-6	8PSK	29,6	236,8
	MCS-7	8PSK	44,8	358,4
	MCS-8	8PSK	54,4	435,2
	MCS-9	8PSK	59,2	473,6

Higher Layer Protocols



BSS	Base Station Subsystem	MAC	Medium Access Control
GGSN	Gateway GPRS Support Node	RLC	Radio Link Control
GTP	GPRS Tunnelling Protocol	SGSN	Serving GPRS Support Node
LLC	Logical Link Control	SNDCP	Subnetwork Dependent Convergence Protocol

Tunnelling : SNDCP and GTP



Nodes:

SGSN Serving GPRS Support Node

GGSN Gateway GPRS Support Node

Tunnelling:

GTP GPRS Tunnelling Protocol

SNDCP Subnetwork Dependent Convergence Protocol

GTP : GPRS Tunneling Protocol SGSN ←→GGSN

Octets	Bits 8	7	6	5	4	3	2	1
1	Version			reserved				LFN
2	Message Type							
3-4	Length							
5-6	Sequence Number							
7-8	Flow Label							
9-10	LLC Frame Number							
11-12	reserved							
13-20	Tunnel Identifier TID							
	e.g. IP, X.25, ..							
	e.g. TCP / UDP							
	Application							

LFN LLC Frame Number flag: indicating wether the LFN is included in the GTP header

Message Type: is 255 for data (T-PDU), otherwise signalling

Length: the number of bytes in the GTP message (G-PDU)

Sequence Number:
data tunnelling: increasing number for tunnelled T-PDUs
Signalling: transaction identity

Flow Label: identifies a GTP flow

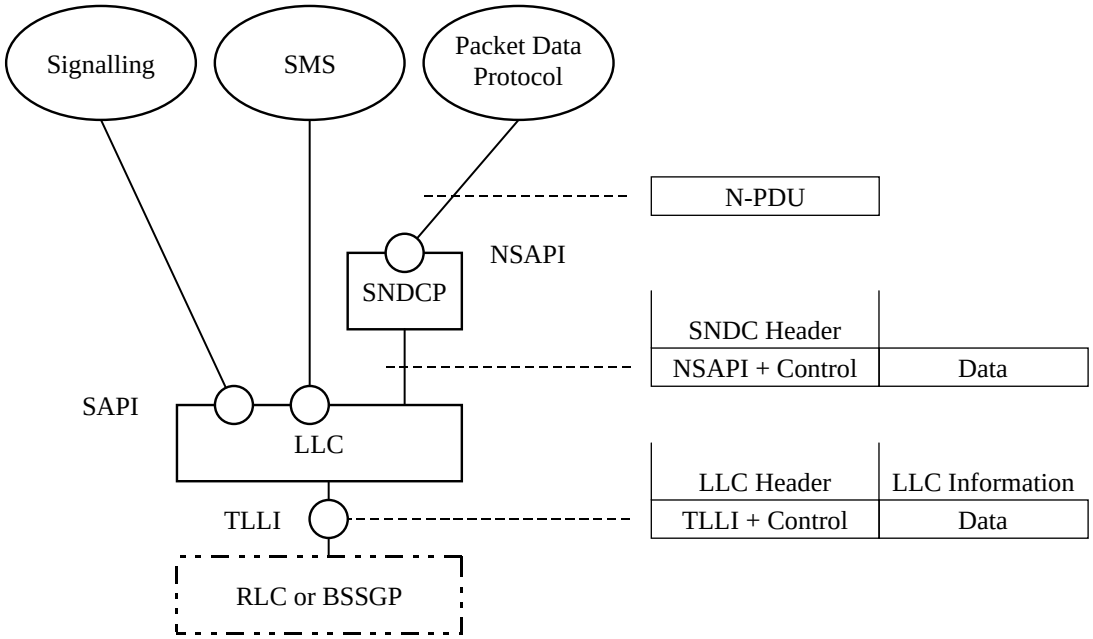
LLC Frame Number: used during inter-SGSN routing update to co-ordinate LLC data transmission between the MS and the SGSN

TID: Tunnel Identifier = IMSI + NSAPI (e.g. IP-address) uniquely identifies a single PDP context

Connectionless: UDP for IP-tunnelling

Connectionoriented: TCP for X.25-tunnelling

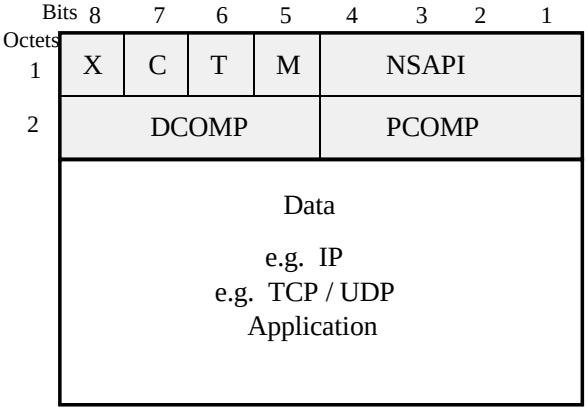
SNDCP : Subnetwork Dependent Convergence Protocol and LLC : Logical Link Control



TLLI	Temporary Logical Link Identity	Identifier for a logical connection between MS and SGSN (like TMSI)
NSAPI	Service Access Point Identifier	Mobility Management (signalling), SMS and up to 4 network layer protocols

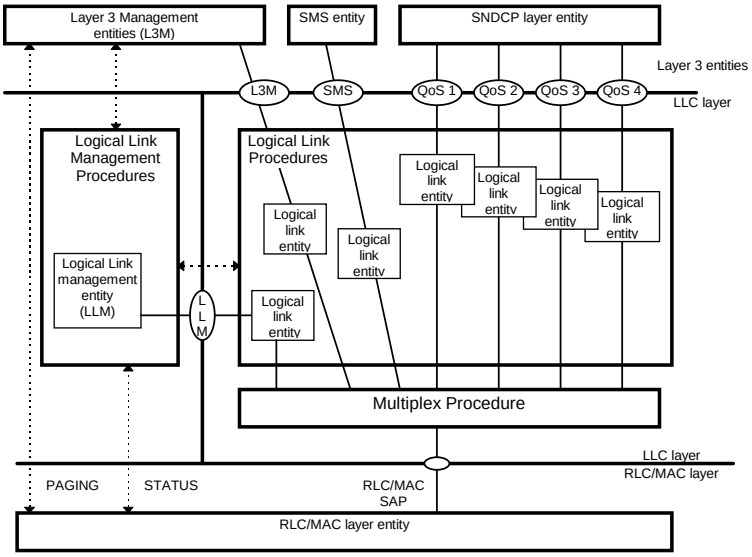
SNDCP : Subnetwork Dependent Convergence Protocol

- TCP / IP header compression
- User Data Compression (V.42 bis)
- Segmentation



X	Spare Bit
C	Compression Indicator
T	Type of SN-PDU: SN-data or SN-unit-data
M	More data bit (segmentation)
NSAPI	Network layer Service Access Point Identifier
DCOMP	Data COMPression negotiation and execution
PCOMP	Protocol control information COMPression negotiation and execution

LLC : Logical Link Control



LLC provides:
- acknowledged and unacknowledged data transfers
- high/low-priority data transfers
- data confidentiality (ciphering function)
- user identity confidentiality (TLLI)

SAPI:
- GPRS Mobility Management,
- Short_Message_Service,
- up to 4 networl layer protocols

L3M	LLC to GPRS Mobility Management SAP
LSMS	LLC to SMS service access point
GRR	GPRS Radio Resources service access point
BSSGP	BSS GPRS Protocol (BSS to SGSN)
RLC	Radio Link Control (MS to BSS)
MAC	Medium Access Control

If MS moves (cell change), links are maintained in same SGSN, re-established after SGSN change

Packet Data Protocol: PDP Context Activation

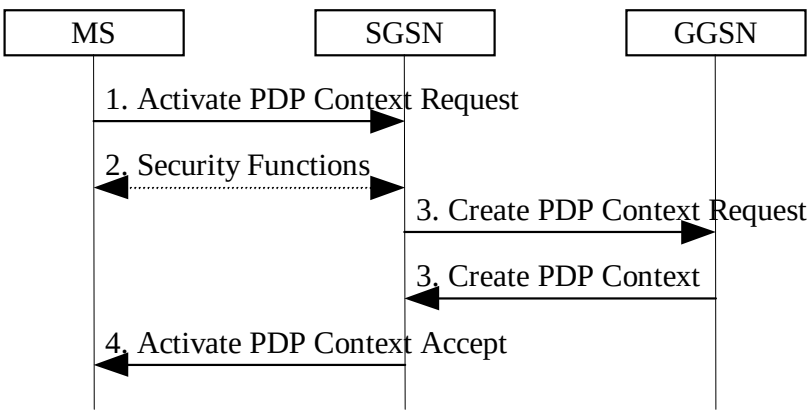
Static and Dynamic PDP Addresses (Packet Data Protocol e.g. IP, X.25)

- the HPLMN operator assigns a PDP address (IP) permanently to the MS (static PDP address);
- the HPLMN operator assigns a PDP address to the MS when a PDP context is activated (dynamic HPLMN PDP address); or
- the VPLMN operator assigns a PDP address to the MS when a PDP context is activated (dynamic VPLMN PDP address).

Type of address is defined by the HPLMN operator;
Mobile Terminating context activation requires a static PDP address
The GGSN allocates and releases the dynamic PDP address.

Mobile Originated (MO)
PDP Context Activation Procedure

- The MS requests a dynamic PDP address(1); the MS selects a NSAPI and may include a GGSN address.
- The SGSN performs security functions and selects a suitable GGSN
- The GGSN binds the PDP context with the external PDP network.

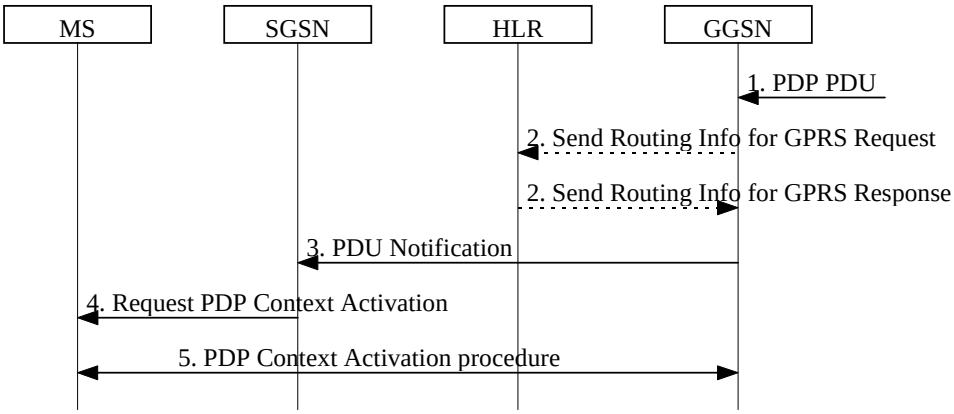


Network-Requested PDP Context Activation Procedure (MT)

Mobile Terminating context activation requires a static PDP address

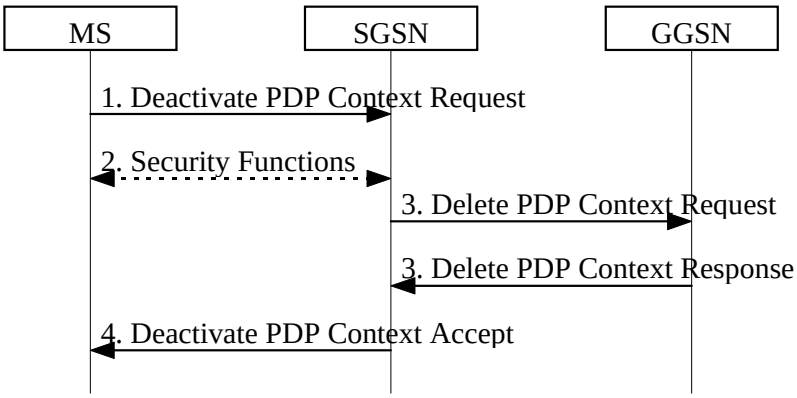
Unnecessary enquires to the HLR can be avoided by:

- Mobile Detached Flag for GPRS in GGSN, SGSN, and HLR
- The GGSN may reject PDP PDUs after a previous unsuccessful delivery attempt.
- The GGSN may store the address of the SGSN with which the GGSN established the last PDP context.



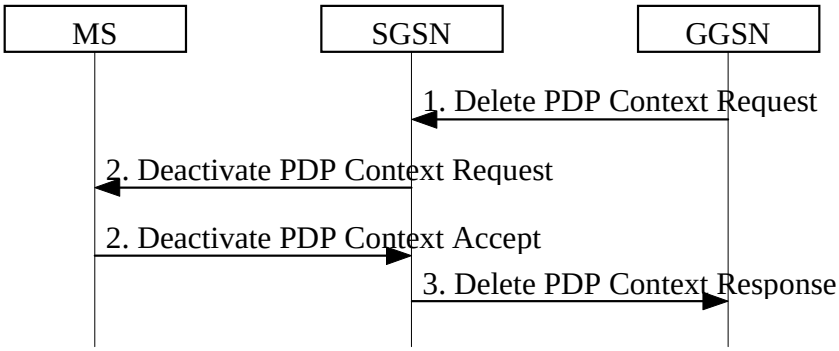
4) The SGSN requests the MS to activate the indicated PDP context.
5) The PDP context is activated by the MS

PDP Context Deactivation Procedure

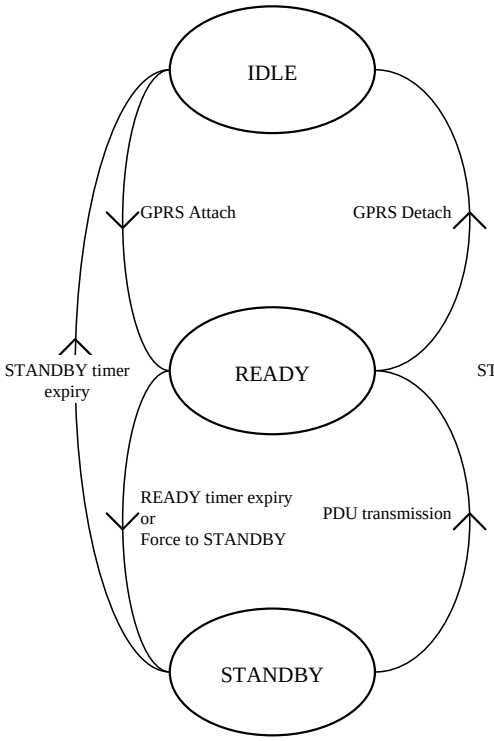


Initiated by the MS

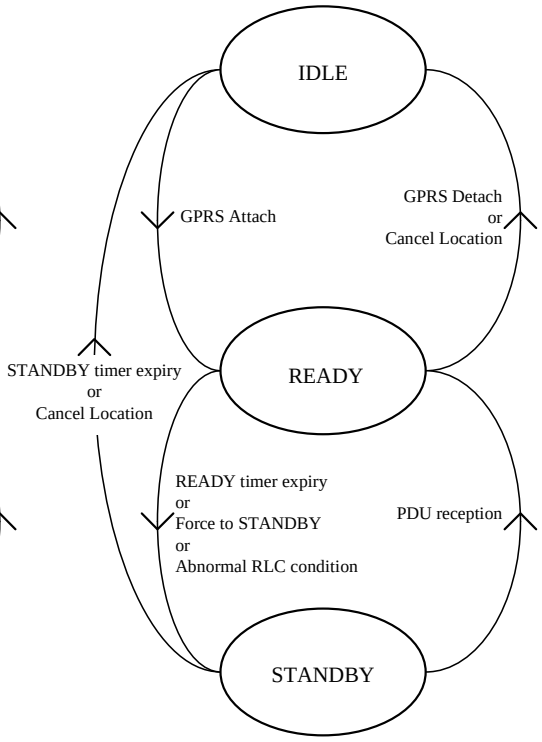
Initiated by GGSN



Mobility Management



MM State Model of MS



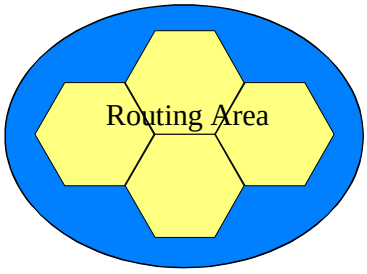
MM State Model of SGSN

Not GPRS attached
No active PDP context

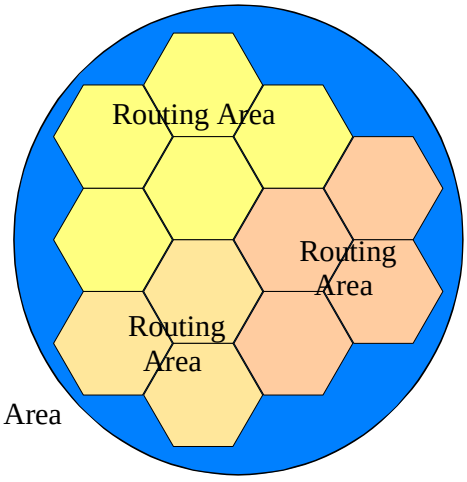
GPRS attached :
authenticated,
TLLI assigned
SMM context active
PDP context activation is possible
Data Transmission, if PDP context active

GPRS attached
Receive Pagings
Periodic RA update

Location Area ➔ Routing Area



Location Area



Location Area

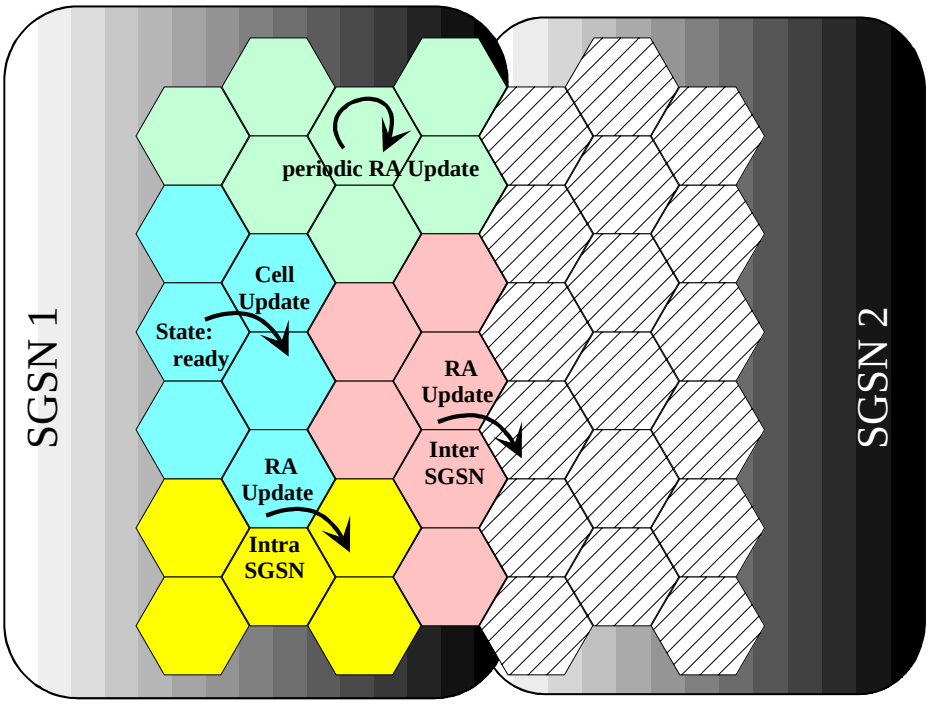
Routing Area = one or several cells

A Routing Area cannot span over several Location Areas

A Location Area can contain one or several Routing Areas

A Routing Area is served by one SGSN

Location Management Function



No Handover by the network:
Cell selection by MS instead

new cell inside the current RA:
Cell Update Procedure if MS is in READY state

new cell in new RA:
Routing Area Update

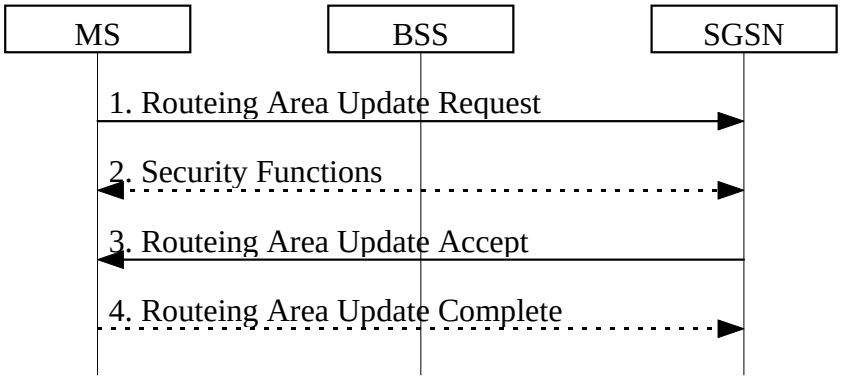
periodic RA update timer has expired:
Routing Area Update

Cell Update Procedure:
send any LLC frame containing the MS identity

RAI: Routing Area Identifier = LAI + RAC = MCC + MNC + LAC + RAC

LAI: Location Area Identifier RAC: Routing Area Code

Intra SGSN Routing Area Update Procedure



1) Routing Area Update Request: old TLLI, old RAI, new RAI, new CI,

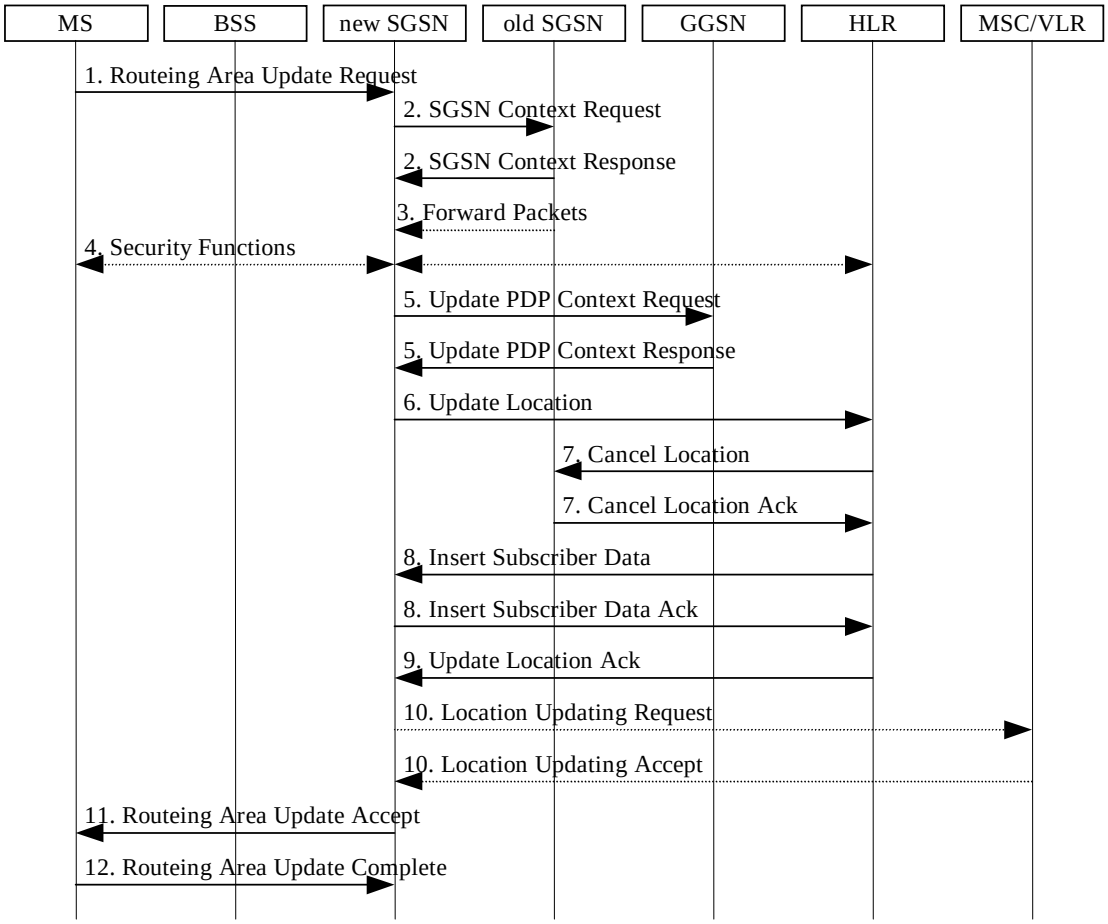
2) Security functions may be executed.

3) the SGSN updates the MM context for the MS. A new TLLI may be allocated.

4) Only if TLLI was changed

TLLI = Temporary Logical Link Identity, identifies an LLC connection

Routing Area Update Request messages is sent unciphered (inter-SGSN routing)

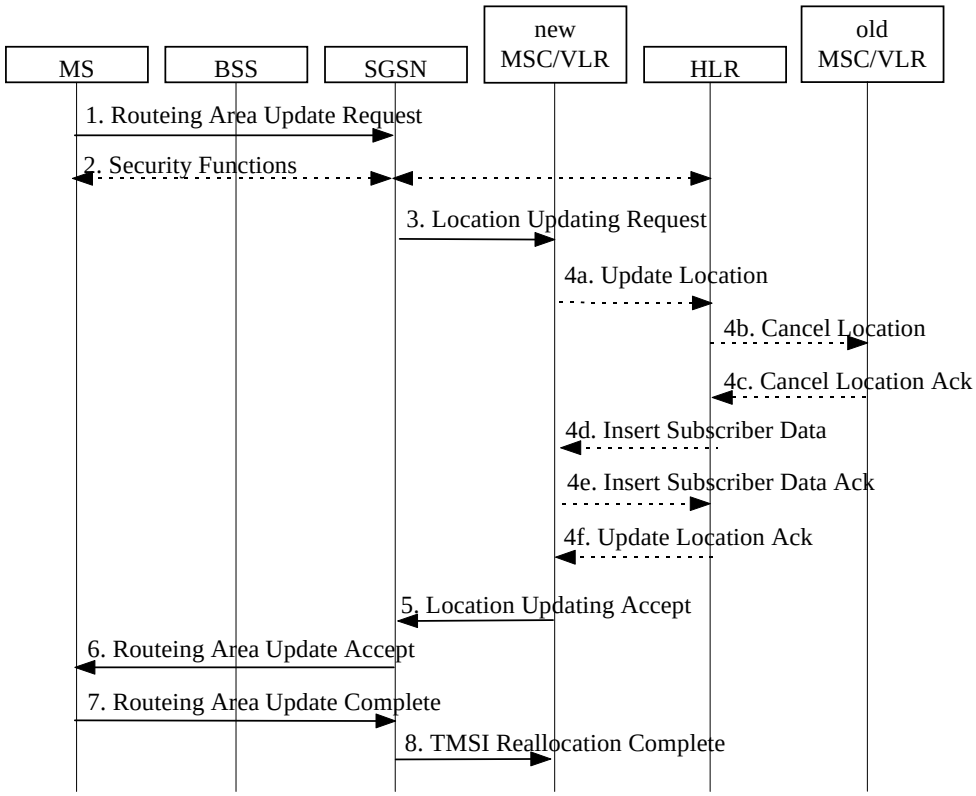


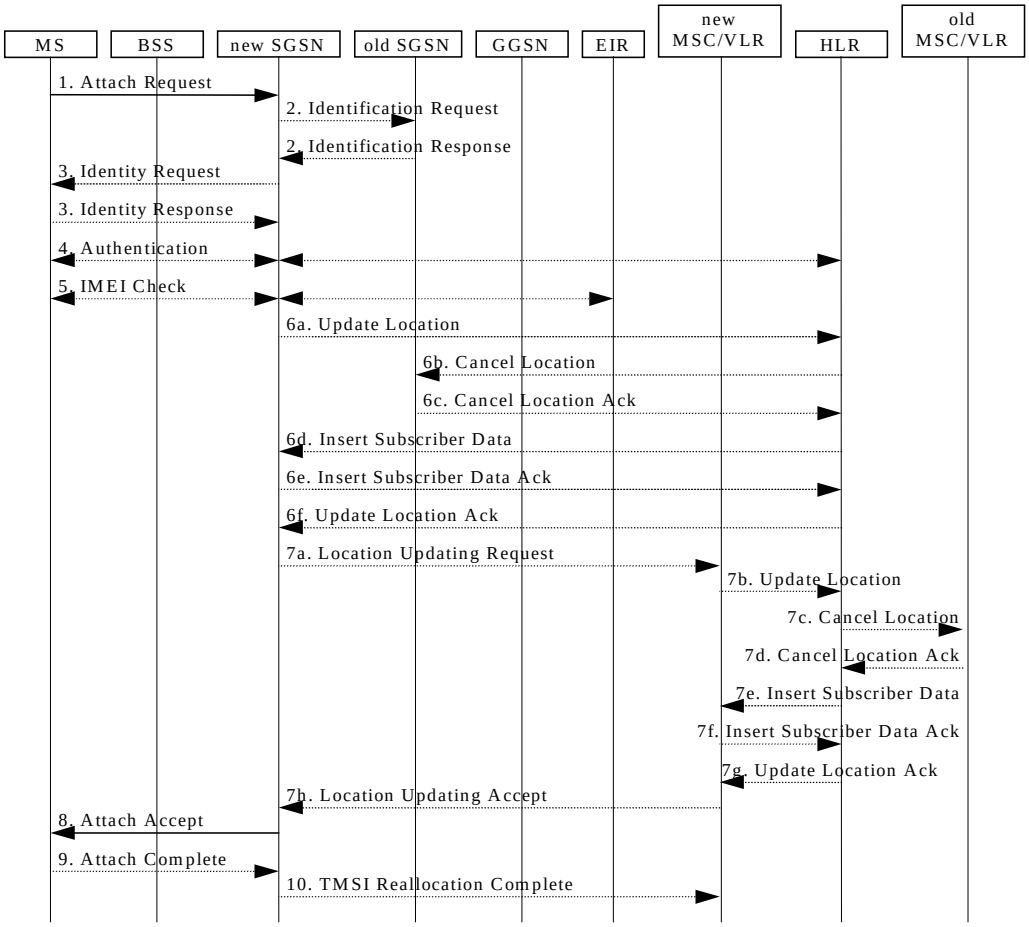
Mobility Management

Inter SGSN Routing Area Update Procedure

Mobility Management

Combined RA / LA update procedure (intra SGSN RA update)





Mobility Management:

Combined IMSI / GPRS Attach Procedure

Combined Routing Area RA and Location Area Update