MAP - Mobile Application Part

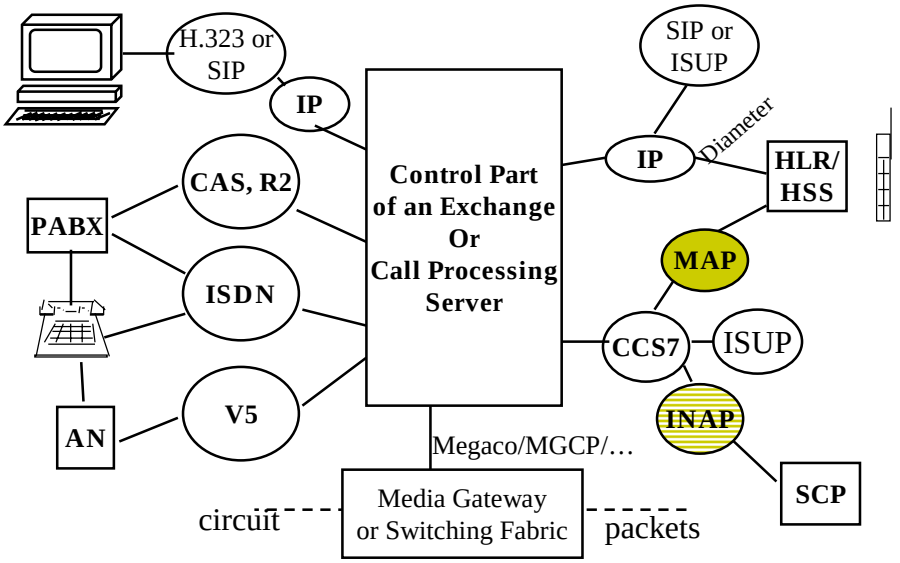
Mobility Management in GSM
GSM services

Short Message Service

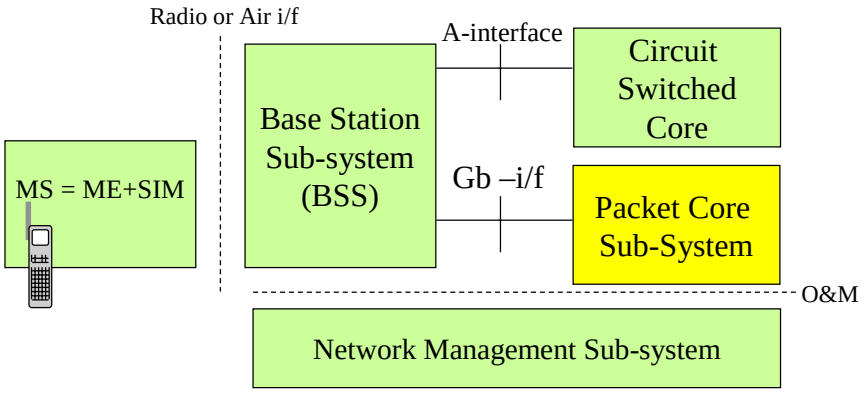
Support of GPRS

CAMEL = IN+GSM integration

Summary of course scope



GSM system consists of sub-systems



MS - Mobile Station
ME - Mobile Equipment
SIM - Subscriber Identity Module
BSS - Base Station Subsystem
HLR belongs to both CS and PS domains

Main differences cmp to wire-line networks
- air interface for the subscribers
- mobility and roaming of users

NB: the whole system is digital incl the ME.

Mobility Management in General

Comparison of solutions for CS and PS networks

Mobility requires logical subscriber numbers - are mapped dynamically to network topology bound routing numbers

- For most nodes it is enough to understand only the prefix of the routing number.
- Example: 10^9 subscribers, number length = 13 digits

Rough memory estimate for the analysis tree based on dialled digits (no separate routing numbers).
Tree is made of nodes of 64 octets. One node is used to analyse one dialled digit

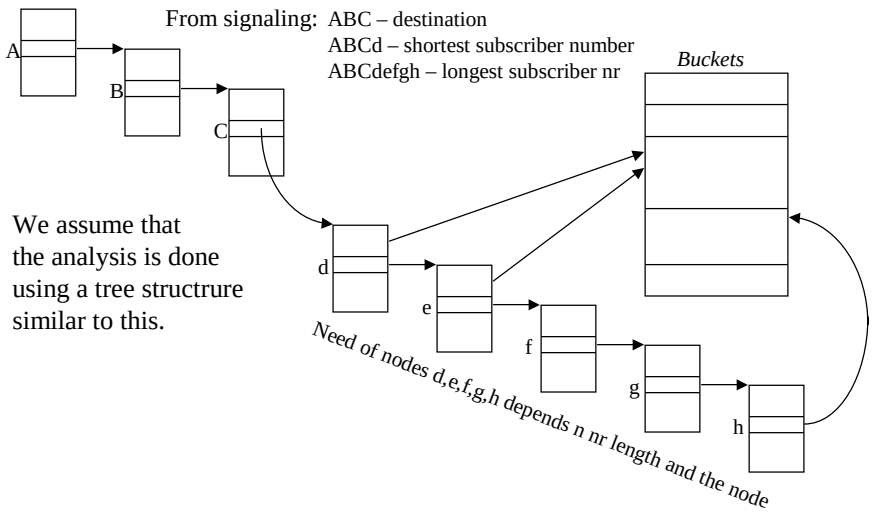
Use of numbering space: on average 5 values in each position are used

$$m^{13} = 10^9 \Rightarrow 13 \lg m = 9 \Rightarrow m = 4.92$$

Nrof nodes in the tree is (m is also the branching factor!)

$$1 + m + m^2 + \ldots m^{12} = \frac{m^{13} - 1}{m - 1} = 305 \text{ million}$$

Analysis tree links signaling to routing



Analysis tree calculus cont ...

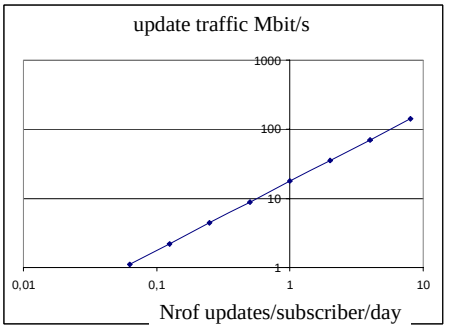
Memory requirement is 64 bytes * 305 * 10^6 = 19 Gb

- Need to be available for any calls: replication will be expensive!
- A single read with full number requires 13 memory references, is not a problem
- Maintaining replicas is the problem:

Assumptions:
- an update takes a 50 bytes msg
- all updates in 6 hours

NB:
- updates/subscriber may need to be done significantly more often.

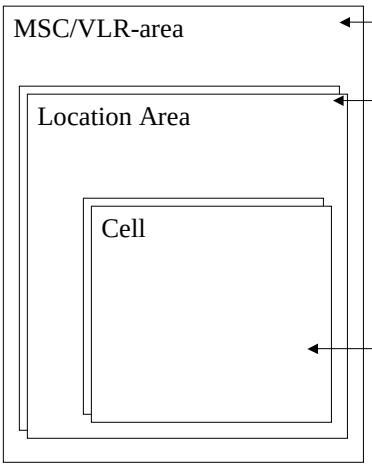
Problem needs to be partitioned!



In GSM the DB is partitioned by Operator and by Prefix of MSISDN nr

- An HLR per a few 100 000 subscribers
  - Operator code + prefix map to HLR
- Location area hierarchy decreases nrof updates
  - Not all location changes need be told to HLR
- MS-ISDN = “directory number” = what you dial is mapped to Mobile Subscriber Routing Number (MSRN) per call or per visit to another network

Location Area Hierarchy in GSM reduces the need for HLR updates



HLR knows MSC/VLR

Visitor Location Register (VLR) knows
- = a set of cells
- update once/6 min….24h and when power switched on/off etc.
- update need to be authenticated

In case of GPRS the SGSN knows the Routing Area = a subset of Location area.

Final location is found by paging:
- call is sent to all cells in LA
- MS receives in favorite cell
- cell with best connectivity is chosen

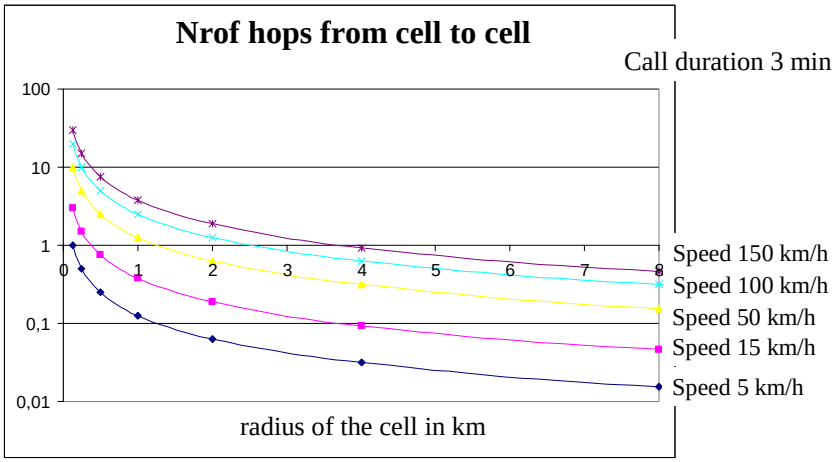
Rough calculus of location update traffic in an HLR with 200 000 subs

- 200 000 subscribers
- 1 update/5min/subscriber
- Rough estimate: let one update = 100 octets

Traffic = 200 000 * 100 * 8/(5*60) = 0,53Mbit/s.

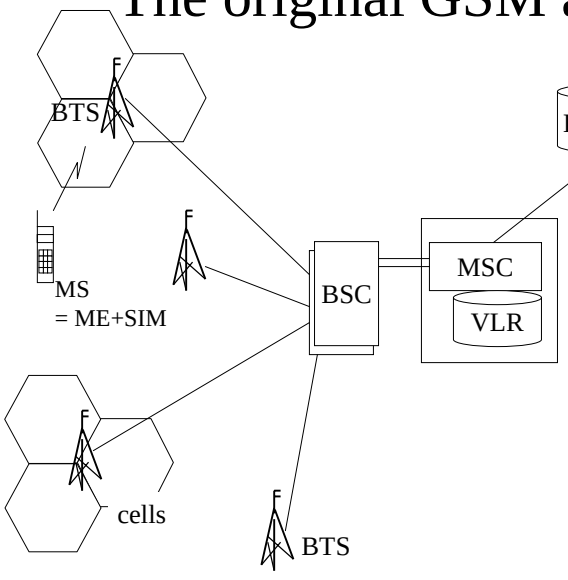
Can be transported on a single PCM-line (2 Mbit/s)!
→ Makes sense, is clearly feasible.

Nrof probable hops from cell to cell during a telephone call



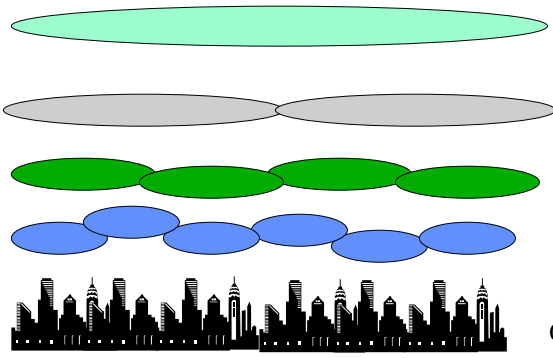
An architecture with less than one hop on average makes sense!

The original GSM architecture



HLR - Home Location Register (kotirekisteri)
AC - Authentication Center (Varmennekeskus)
EIR - Equipment Identity Register (laiterekisteri)
MSC - Mobile Switching Center (matkapuhelinkeskus)
VLR - Visitor location Register (vierailijarekisteri)
BSC - Base Station Controller (tukiasemaohjain)
BTS - Base Transceiver Station (tukiasema)

Multi-layer cell design increases radio network capacity



Cell selection tries to place fast moving MSs higher up in the hierarchy.

What if subscriber numbers are binary?

- Example: 10^9 subs, sub nr length is 128 bits

Rough memory estimate for analysis: Analysis tree is made of node of 64 octets, each for analysing 4 bits.

Usage of hexa code points:

$m^8 = 10^9 \Rightarrow 8 \lg m = 9 \Rightarrow m = 13.34$

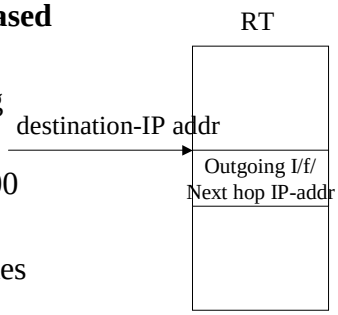
Nrof nodes in the tree is

$$1 + m + m^2 + \ldots m^7 = \frac{m^8 - 1}{m - 1} = 114 \text{ million}$$

⇨ *Result is of the same order of magnitude as for decadic numbers!*

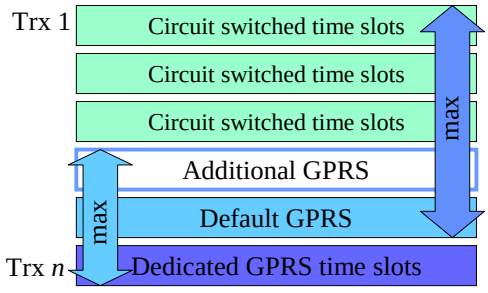
Background of mobility mgt for packet services terminals

- **Packet forwarding/packet is based on routing tables (RT).**
- Routers maintain RTs by routing protocols.
- Feasible size of the RT is 100 000 …300 000 entries =rows.
- Longest match search/packet takes many memory reads (<32).



- n x 100m users →provider addressing results feasible RT size
- search is based on address prefix not a full 32 bit address

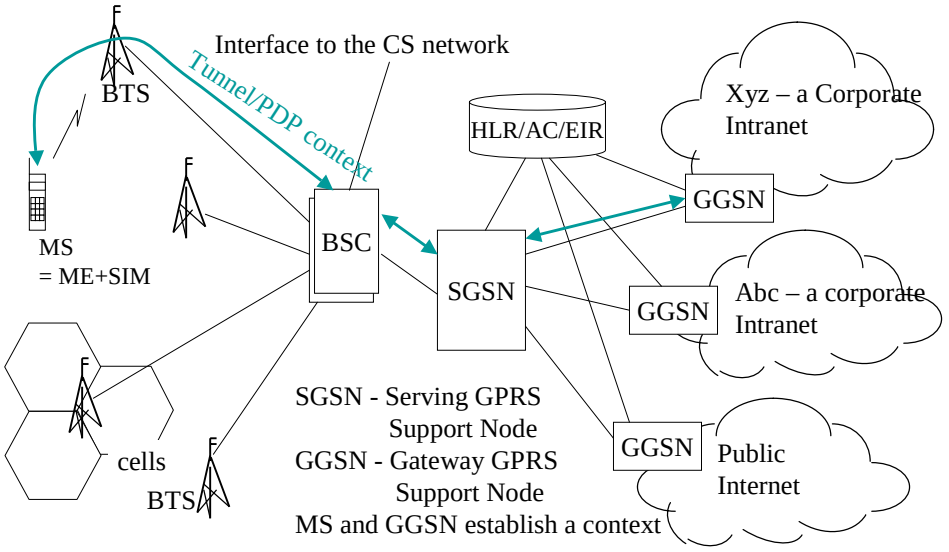
GPRS shares TRX timeslots with CS services in GSM



Each trx has 8 time slots, classified to:
- purely CS (telephony) use
- purely PS use (option)
- default packet traffic use (handovers may be used to keep these free of calls
-additional GPRS – may be used for packet traffic if there are no CS calls

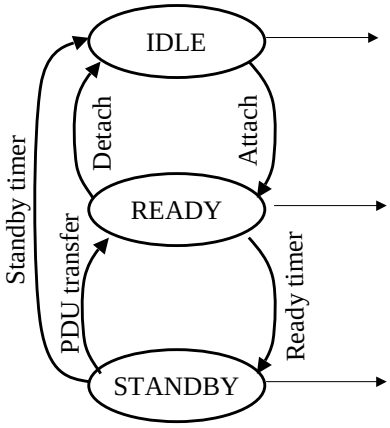
By setting the parameters between PS/CS services appropriately an elastic boundary is created between GPRS and CS services – QoS, Revenues and network usage need to be optimised.

SGSN takes care of mobility and GGSN is the interface node to other networks



GPRS mobility management states/ MS in MS and in SGSN

this is a bit simplified



Network does not follow MS location

User is active. Network follows the user with the accuracy of one cell

MS is online – but does not transfer packets. Network follows MS with the accuracy of a Routing Area:
cell < RA < location area. MS can be paged in the RA.

Mobility state model

Some GPRS key features

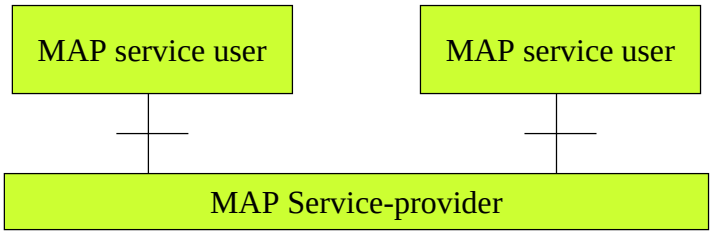
- GSM has two parallel MM systems: for CS and for PS serv
- GGSN allocates IP address for MS when MS needs it from the network GGSN is connected to.
  - GGSN = router from Internet and Intranet point of view
  - Several address allocation methods
- BSC-SGSN-GGSN (+HLR) network manages mobility using topology bound internal IP-addresses.
- In the tunnel MS - GGSN we have two IP networks on top of each other:
  - IP-based transport network: has its own DNS
  - and the “payload” network seen by users and applications.
  - Header overhead is high (>100 octets)

Summary

- Two different MM solutions: one for CS one for PS services
  - CS solution is centralised: GMSC always asks HLR where the MS is located
- It is not feasible to ask per packet for the location of the MS.
  - MM must be either adaptive or distributed.
  - Makes sense to limit paging to a smaller nrof cells

MAP

MAP works between MAP Service Users and MAP Service Providers

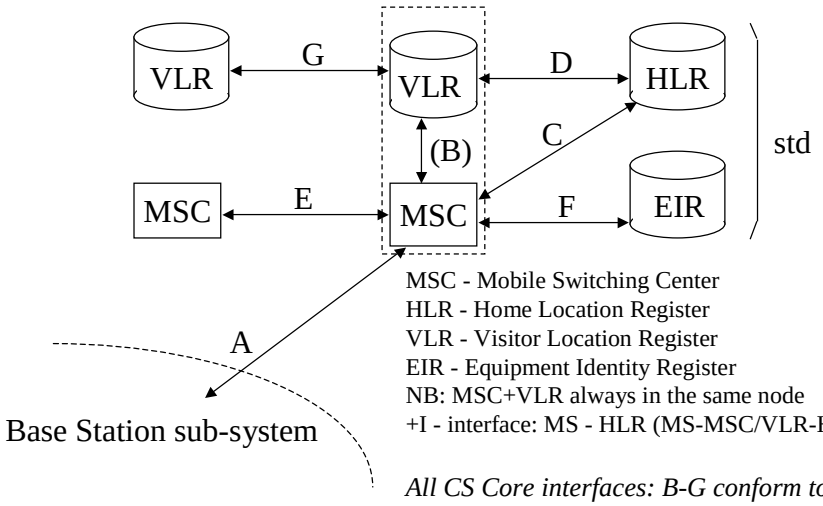


- MAP SUs and MAP SPs are network functions such as HLR, MSC etc

MAP is used by many network elements

EIR	Equipment Identity Register - usually integrated with HLR
GCR	Group Call Register
GGSN	Gateway GPRS Support Node - for interfacing to IP or other PD networks
GMLC	Gateway Mobile Location Center - for interfacing to Location Services
GMSC	Gateway MSC - for routing calls from visited network
gsmSCF	GSM Service Control Function - IN service control element
HLR	Home Location Register - the key database
MSC	Mobile services Switching Center
NPLR	Number Portability Location Center - for locating an HLR
SGSN	Serving GPRS Support Node - the "MSC/VLR" for PS services
SIWFS	Shared Interworking Function Server - for interfacing CS data services to IP or other PD networks
SMS GWMSC	SMS Gateway MSC - for terminating SMS routing
SMS IWMSC	SMS Interworking MSC - for originating SMS routing
USSDC	USSD Center - part of gsmSCF
VBS/VGCS Anchor MSC	Voice broadcast/group call service Anchor MSC - specified/not implemented
VBS/VGCS Relay MSC	Voice broadcast/group call service relay MSC - specified/not implemented
VLR	Visitor Location Register -in practice integrated with MSC
VMSC	Visited MSC

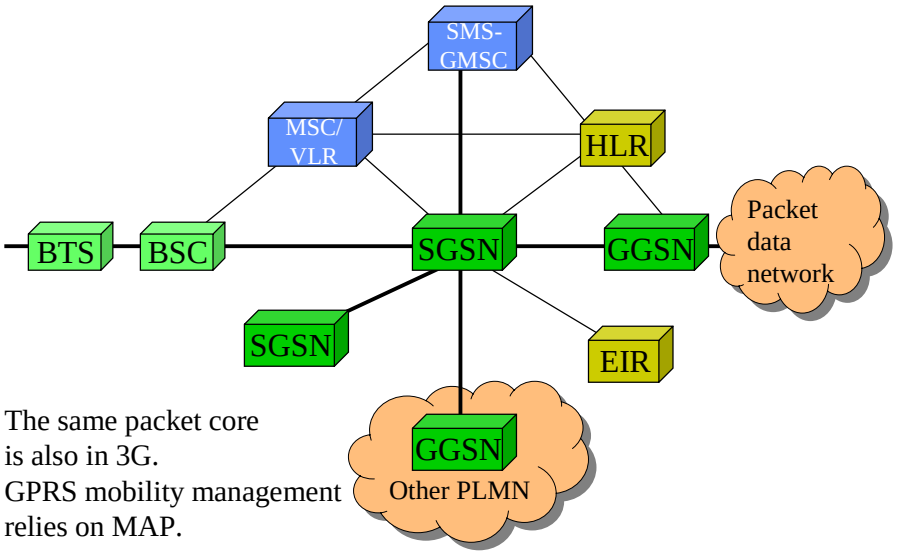
CS Core interfaces are



MSC - Mobile Switching Center
HLR - Home Location Register
VLR - Visitor Location Register
EIR - Equipment Identity Register
NB: MSC+VLR always in the same node
+I - interface: MS - HLR (MS-MSC/VLR-HLR)

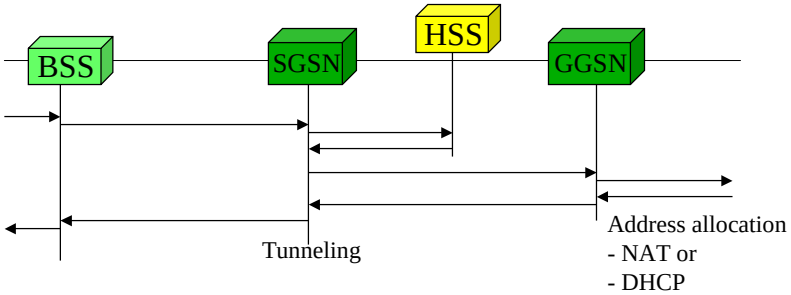
All CS Core interfaces: B-G conform to the MAP protocol

GSM/GPRS Core Network



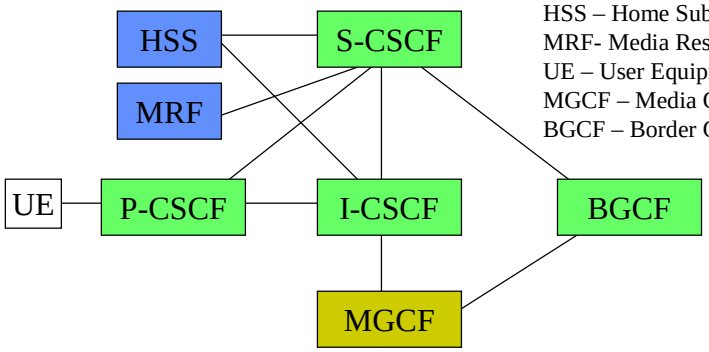
The same packet core
is also in 3G.
GPRS mobility management
relies on MAP.

To get on-line a GPRS device needs to create a PDP Context



PDP context = Packet Data Protocol Context
- PDP = IP or X.25
- SGSN requests HSS for access authorization and to find the GGSN based on the so called APN name. An MS can be connected to several IP-networks thru different GGSNs.
- The GGSN allocates an IP address from the IP-network it is connected to. Result is that the MS has an IP address that it can use to communicate using the Internet Protocol. We say that a PDP context has been created.

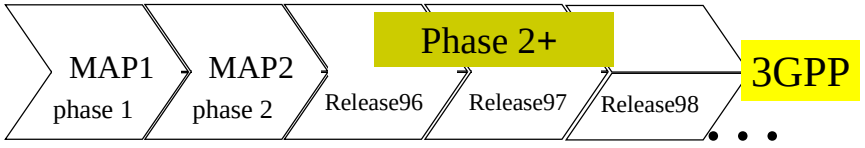
IP Multimedia System in 3G



HSS – Home Subscriber Server
MRF- Media Resource Function
UE – User Equipment
MGCF – Media Gateway Control
BGCF – Border Gateway Control

- MM subsystem works on top of the packet core.
- CSCF – Call Session Control Function processes signaling and controls the MM services.

Milestones in MAP development



- In phase 2+ … versioning is per operation package.
- This supports the idea of deploying small sets of features at a time in the network.
- If a remote system does not understand the newest tricks, *fall-back negotiation* restores operation on the level of the previous version.
- Release98 3GPP TS 09.02 V7.11.0 in www.3gpp.org (03-2002), ETSI →3GPP
- Later releases have small improvements (not discussed here)
  - Release99: 3GPP TS 29.002 V3.15.0 (2002-12),
  - Release 4: 3GPP TS 29.002 V4.10.0 (2002-12), Release 5, Rel 6: 29002-630 etc…

MAP -operations can be mapped to interfaces

I/f	Elements	Mobility management	O&M	Call handling	Supple-mentary services	Short messages	Sum
B	MSC - VLR	12	1	4	1	2	20
C	GMSC - HLR			1			1
D	VLR - HLR	9	3	1	10	1	24
E	MSC - MSC	5					5
F	MSC - EIR	1					1
G	VLR - VLR	1				1	2
	HLR - SMSGW					3	3
	MSC - SMSGW					1	1
Sum		28	4	6	11	8	57

The table corresponds to MAPv2

MAP -operations in Release98/ETSI/3GPP

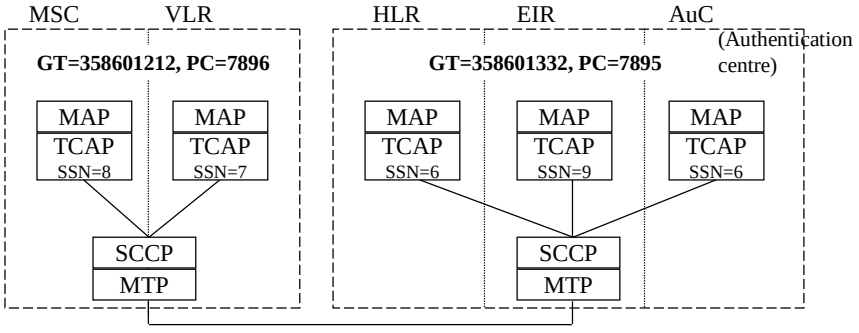
i/f	Elements	Mobility Manage-ment	O&M	Call Handling	Supple-mentary Services	Short Messages	PDP Context	Location Services	Sum
B	MSC - VLR	14	2		13	3			**32**
C	GMSC - HLR			1		2			**3**
D	HLR - VLR	9	2	4	12	1			**28**
E	MSC - MSC	5		1					**6**
F	MSC - EIR	1							**1**
G	VLR - VLR	1							**1**
J	HLR- gsmSCF	1			3				**4**
L	MSC - gsmSCF				1				**1**
C	SMSGW - HLR					2			**2**
	MSC - SMSGW					2			**2**
	VBS/VGCS Anchor MSC - VBS/VGCS Relay MSC			4					**4**
I	VBS/VGCS aMSC - GCR	Vendor specific							**0**
K	vMSC - SIWFS			2					**2**
Gr	SGSN - HLR	6							**6**
Gc	GGSN - HLR						3		**3**
Gd	SGSN - SMSGW					2			**2**
Gf	SGSN - EIR	1							**1**
Gb	SGSN - BSS	Not discussed on this course - not a MAP interface							**0**
Gs	SGSN - MSC/VLR	optional - not a MAP interface							**0**
	GMSC - NPLR			1					**1**
Lh	GMLC - HLR							1	**1**
Lg	GMLC - MSC							2	**2**
	use cases	**38**	**4**	**13**	**29**	**12**	**3**	**3**	**102**

The table corresponds to MAPv2+ Release98 (3GPP) This lecture does not discuss MSC-VLR interface operations nor O&M –operations, nor location services, nor Group Calls.

Upgrade from MAP -1997

- NB:
  - a service may be confirmed or non-confirmed in the previous tables
  - a service can appear on several rows – e.g. for many services VLR is the relay point between HLR and MSC
  - The table gives a feeling of what MAP is used for. (I believe the service use case count is 98% accurate)
- New services: Location Services, GPRS, IN, New Supplemetary Services, Group Calling
  - added complexity
  - the spec (Rel 6) is approximately 1200 pages...

Addressing MAP messages



GT formats:

IMSI	MCC	+	MNC	+	MSIN
MSISDN	CC	+	NDC	+	SN
Hybrid	CC	+	NDC	+	MSIN

GT - Global Title
PC - Point Code
MCC - Mobile Country Code
CC - Country Code
MNC - Mobile Network Code
NDC - National Destination Code
MSIN - Mobile Subscriber Identity Number
SN - Subscriber Number

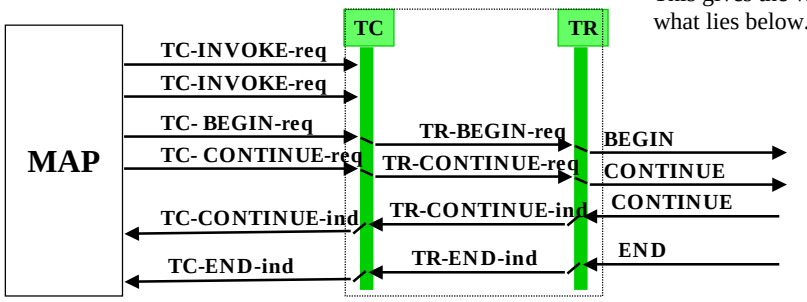
Common MAP services

• MAP-OPEN service • MAP-CLOSE service	• For establishing and clearing MAP dialogues btw peer-MAP service users
• MAP-DELIMETER service	• access to functions below the application layer
• MAP-U-ABORT service • MAP-P-ABORT service	• for reporting abnormal situations
• MAP-NOTICE service	• Notification from the Provider not affecting state of the dialogue

These are used by the application on top of MAP. So, this is the view from above.

MAP uses the structured dialogue provided by TCAP

This gives the view what lies below.



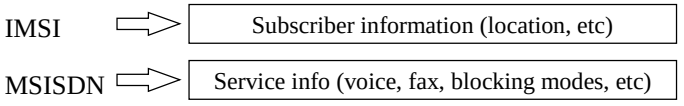
- **Begin causes a *transaction identifier* to be reserved.**
- **The remote system can either continue the transaction or close it.**
- **Continue - messages are exchanged in a full-duplex mode.**
- **Closing options:**
  - **based on pre-arrangement independently**
  - **normally by the End-message or "abnormally" by an Abort message**

Mobility management is the most important feature in MAP

MM can be broken down into the following:

- Location management
- Handover MSC-MSC during a call
  - handover is supported on many levels - also BSSAP (A- i/f protocol) is needed, but we do not cover that here
- Authentication and security
- IMEI - mobile equipment id queries
- Subscriber management
- Fault recovery (we skip this)

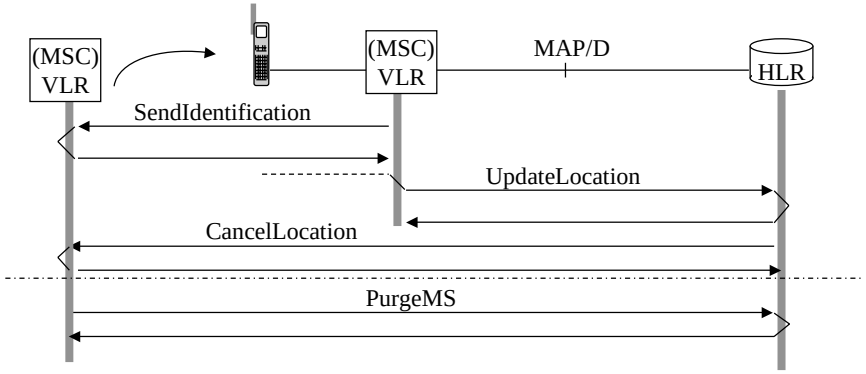
Home Location Register - HLR - contains subscriber and service information



In a mobile terminated call, the right HLR can be found based on *leading digits of MSISDN* or if *free numbering within the operator network* is supported, a Global Title (MSISDN is embedded in the GT in SCCP) translation needs to be done first e.g. in a specific network element.

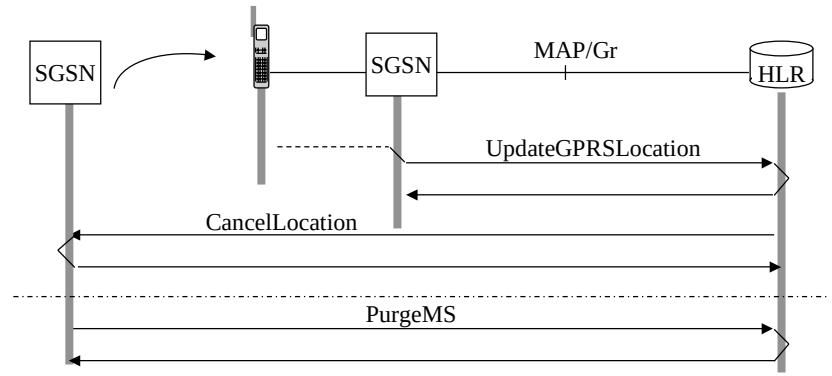
Release98 HLR database has
- location information (VLR number)
- basic telecommunications services subscription information
- service restrictions (e.g. roaming limitations)
- supplementary service parameters
- GPRS subscription data and routeing information: e.g. APN – Access Point Name pointing to the PDN user is allowed to connect to.

Location management maintains the location of the MSs in the HLR



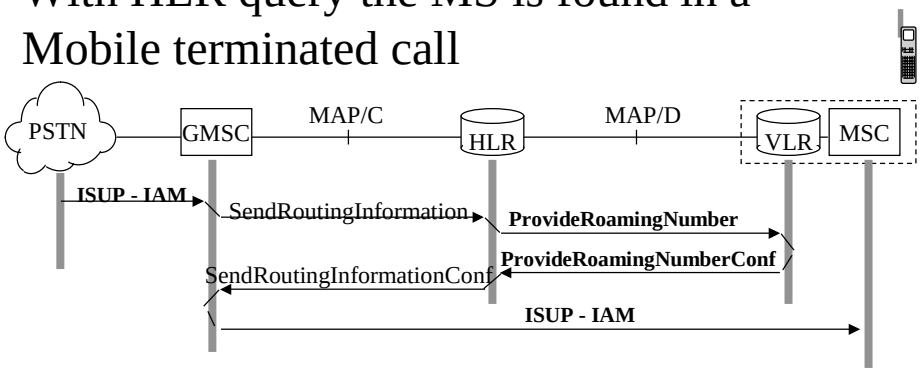
- **SendIdentification requests MS info (IMSI, authentication) from the previous VLR.**
- **UpdateLocation updates the new location with the accuracy of a VLR area**
- **With PurgeMS VLR tells to HLR that MS is unreachable (independent of the previous sequence).**

Location management maintains the location of the GPRS MSs in the SGSN and HLR



- **SendIdentification requests MS info (IMSI, authentication) from the previous SGSN.**
- **UpdateLocation updates the new location with the accuracy of a SGSN area**
- **With PurgeMS SGSN tells to HLR that MS is unreachable.**

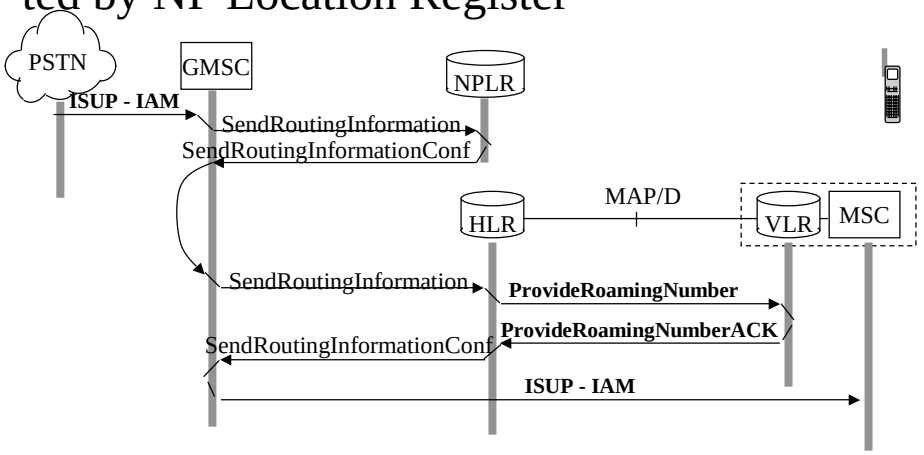
With HLR query the MS is found in a Mobile terminated call



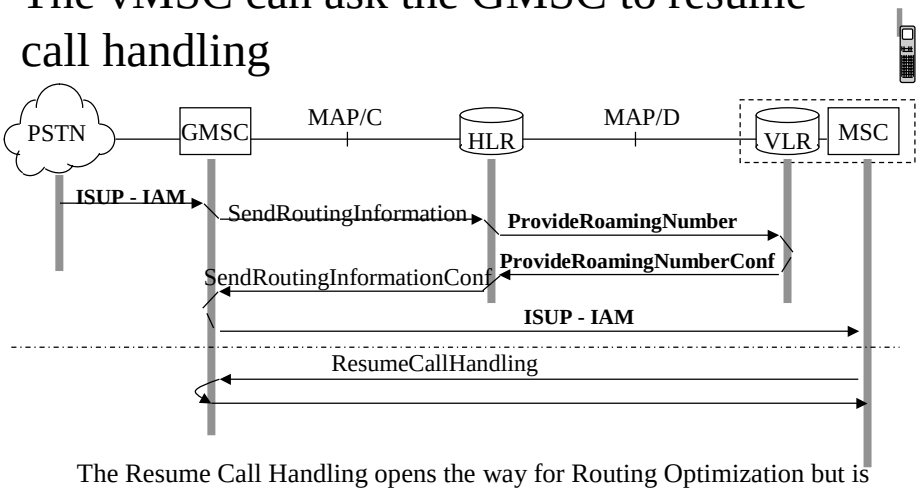
MSRN - Mobile Subscriber Roaming Number

- conforms to E.164 format (any exchange can pass along the number)
- each MSC has a limited range of MSRNs
- MSRN has a validity timeout
- MSRN may be allocated on a call by call basis or for the duration of a visit

GSM Number Portability can be implemented by NP Location Register



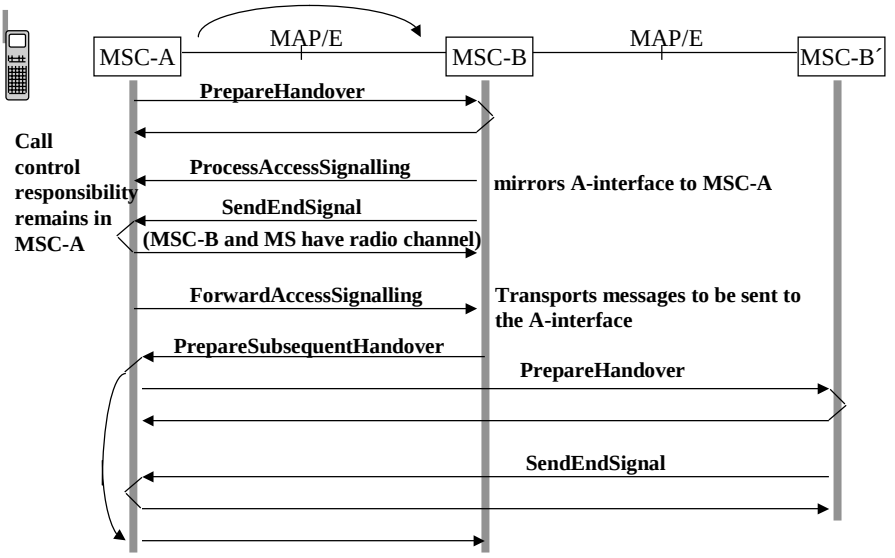
The vMSC can ask the GMSC to resume call handling



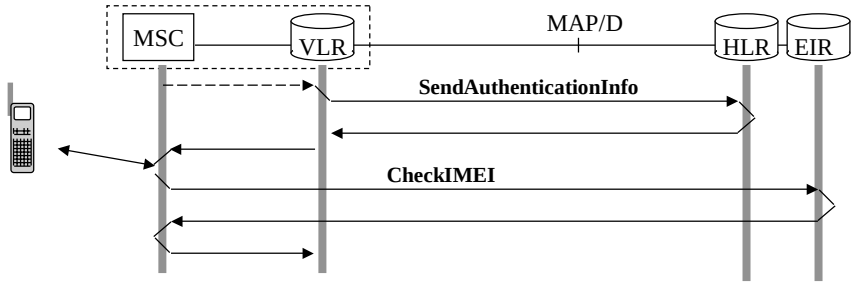
The Resume Call Handling opens the way for Routing Optimization but is not used:

- calls are normally always routed through the Home Network due to charging reasons.

Handover from MSC to MSC

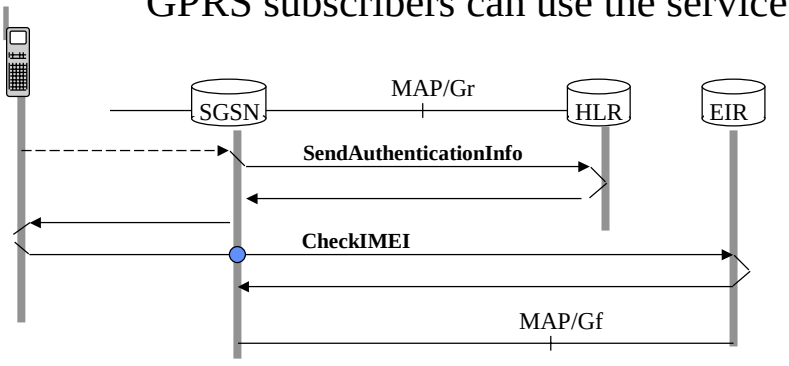


Security operations ensure that only authorized subscribers can use the service



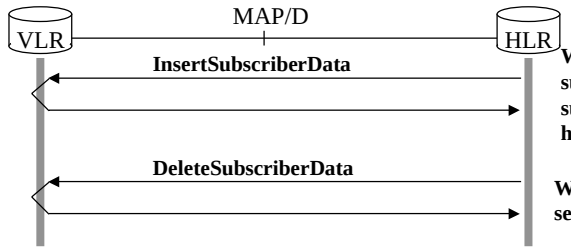
Black list of suspect stolen phones ensures that stolen equipment can not be used for long

Security operations ensure that only authorized GPRS subscribers can use the service



If SGSN does not have the IMEI, it asks it from the MS. After authentication a PDP context can be established for packet transfer.

Subscriber management takes care of the subscriber data in the VLR

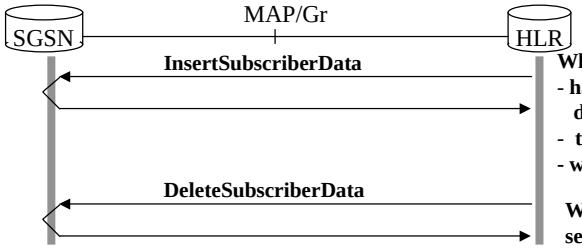


When the operator or the subscriber have changed any of subscriber data. When location has been updated.

When a basic or a supplementary service is cancelled.

With these operations all information residing in the VLR, can be manipulated, when the HLR has the master copy of the information. (HLR does not have some detailed location info…)

Subscriber management takes care of the subscriber data in the SGSN



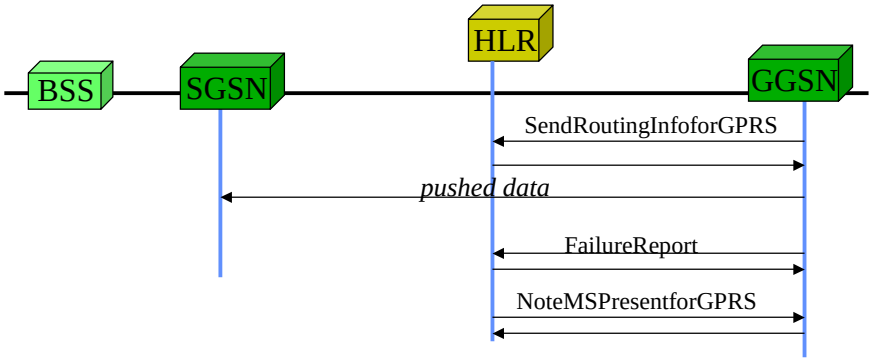
When the operator or the subscriber
- have changed any of subscriber data (e.g. barring).
- the mode has changed
- when location is updated.

When a basic or a supplementary service is cancelled.

With these operations all information residing in the SGSN, can be manipulated, when the HLR has the master copy of the information. (HLR does not have some detailed location info…)

There are 3 types of MS: (a) simultaneous CS + PS services,
(b) Alternate CS/PS services and (c) GPRS only. Type b has two modes.

Network Requested PDP Context Activation facilitates data push



PDP context is Packet Data Protocol Context, includes a ”virtual connection” from MS to GGSN in an IP-tunnel.

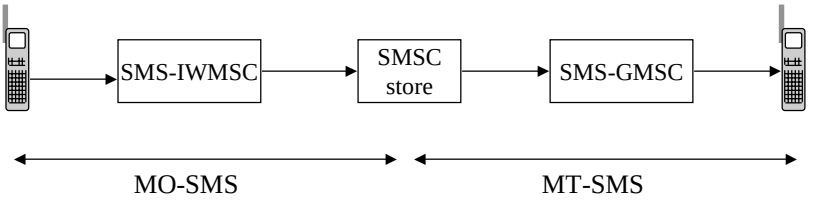
Supplementary service operations are passed from MS via MSC/VLR to HLR

MS --> MSC/VLR --> HLR

RegisterSS	Activation of call forwarding
EraseSS	Switching off supplementary services
ActivateSS	Activation of call blocking
DeactivateSS	Deactivation of supplementary services
InterrogateSS	Interrogation of supplementary service settings
RegisterPassword	Password setting for SS

GetPassword	Password query to MS
USSD operations	Unstructured SS data transport

Short Message Service

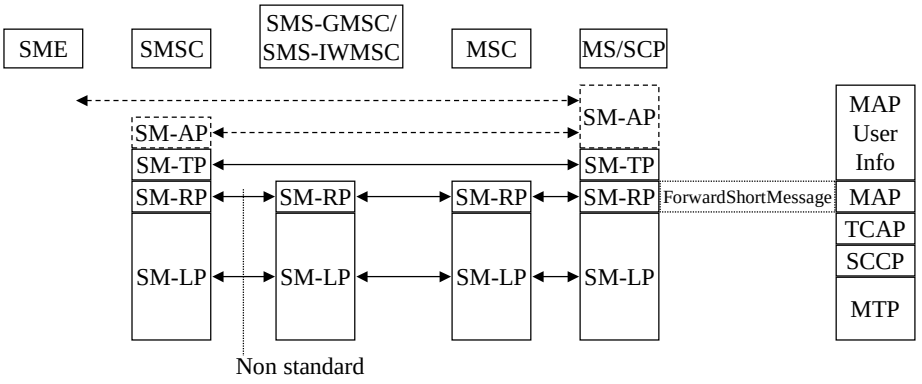


SMSC - Short Message Service Center (or SC - Service Center)
SMS-GMSC - Short message Gateway MSC, issuer of routing information query to HLR in MT-SMS
SMS-IWMSC - Short message Inter-working MSC, routing MSC in MO-SMS service
SMS-GW = SMS-IWMSC + SMS-GMSC

MO - Mobile Originated
MT - Mobile Terminated

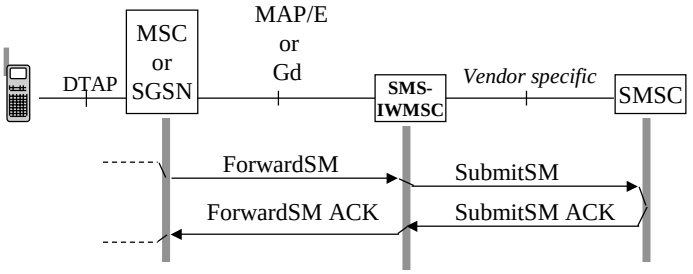
SMSC - HLR operations:
- MS short message buffer full
- MS reachability
- successful delivery of message

Short message transport protocol stack



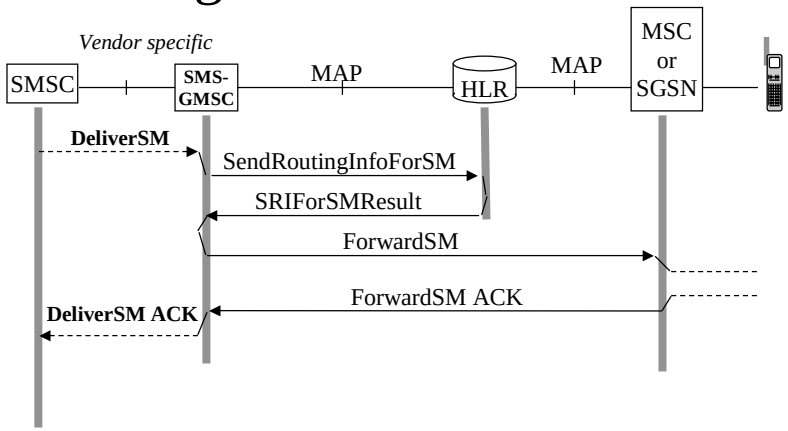
SME - Short Message Entity
SM-LP - Short Message Link Protocol
SM-RP - Short Message Relay Protocol
SM-TP - Short Message Transfer Protocol
SM-AP - Short Message Application Protocol

Messages in MO-SMS service



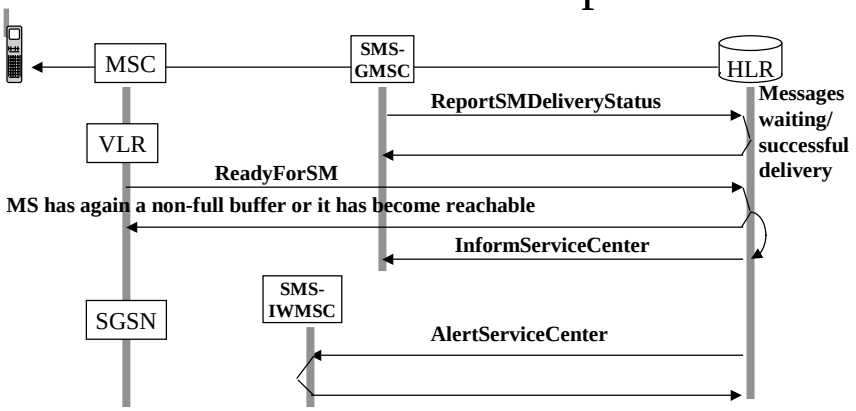
Traditionally serving MSC send short messages to the SMS Interworking MSC. Alternatively, GPRS side can do the same: SGSN sends SMS instead of sMSC.

Messages in MT-SMS service



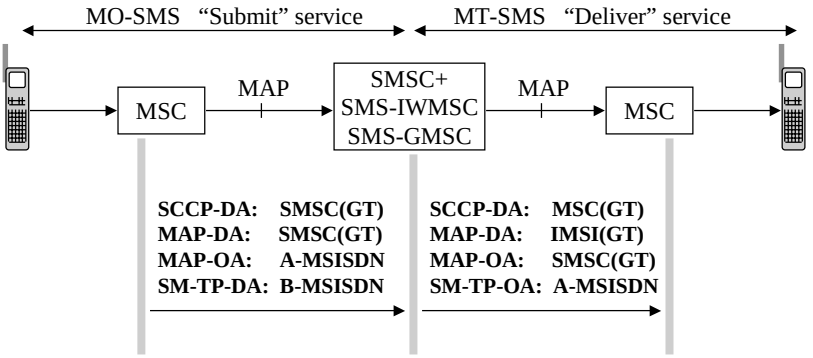
The SMS can be delivered either by a serving MSC or the SGSN thru GPRS servce.

Status information is kept in HLR



- **SM destination subscriber can tell the network, that its SM buffer is full or that the subscriber has become unreachable. HLR stores the status.**
- **When Status is good for receiving, VLR or SGSN gets the info and sends it to HLR.**
- **HLR informs those SMSCs that have reported themselves onto the waiting list.**

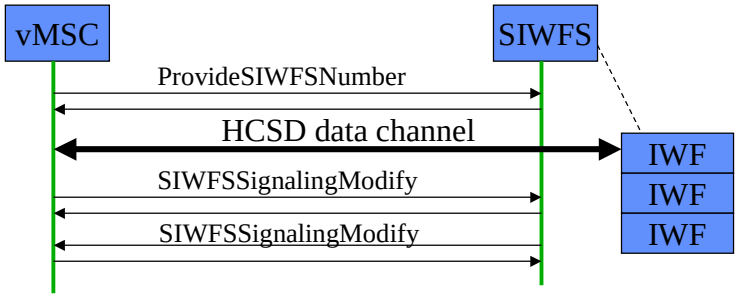
Addressing of Short messages



SMSC gets the IMSI of the B subscriber and the address of the VMSC by SRIForSM operation from the HLR.

NB: Addresses are on three protocol layers!

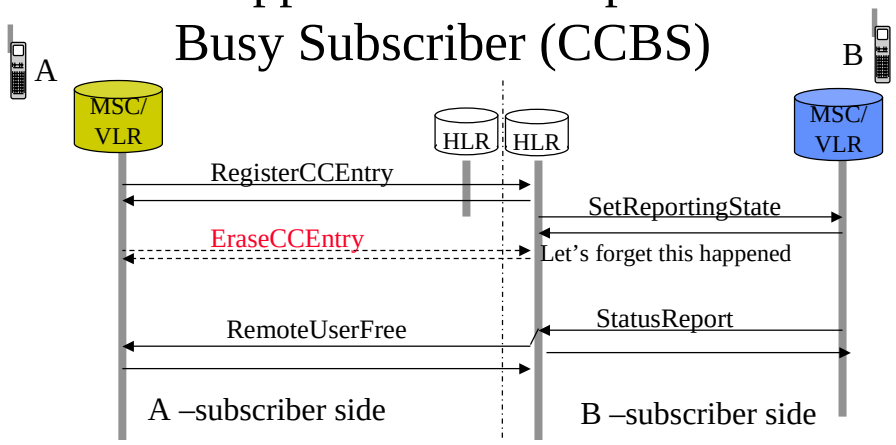
Shared IWF Server provides access to a PDN for CS data services



Signaling modify can e.g. modify number of time slots used for HSCSD

Compare this to what MGCP does!

GSM supports Call Completion to Busy Subscriber (CCBS)



A calls, when B is busy, A registers that he/she wants to know when B becomes free. HLR sets the reporting state to B's VLR. When B becomes free, new status is reported to HLR. HLR tells A's VLR/MSC that B is now free and call can be completed so that A pays normally. There is a CCBS protocol (HLR-HLR) also …

USSD - Unstructured Supplementary Service Data transports SS data between MS and the network

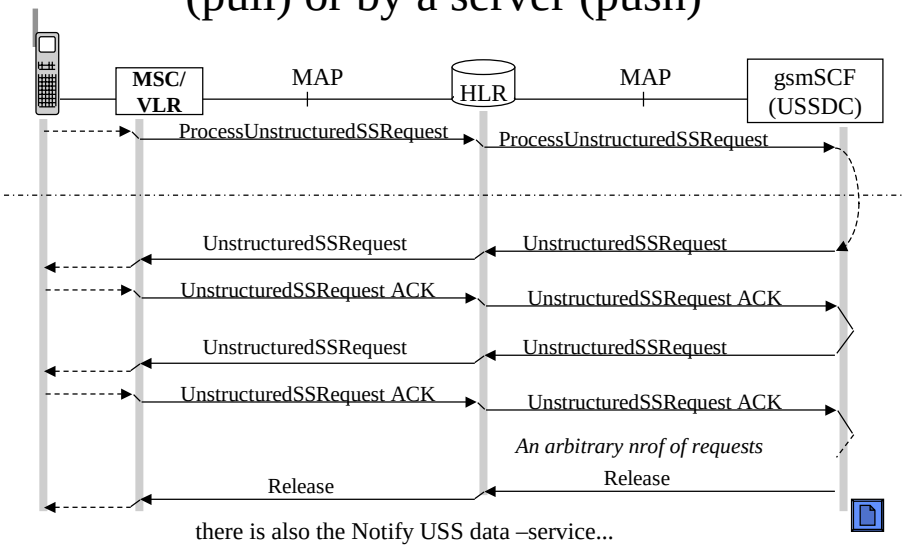
- Network destinations can be e.g.
  - MSC, VLR, HLR
  - HLR-> SCP, WWW-server
- Data is in “ascii”(cmp DTMF)
- E.g. WAP - Wireless Application Protocol can in principle use the USSD service
- a latecomer among features

USSD uses the structured dialogue of TCAP

- Dialogue is connection oriented
- A Dialogue has an identity
- Are independent of calls
- Message length is 80 octets, having max 91 Ascii characters a´ 7-bits

DCS - Data Coding Scheme

USSD dialogue can be initiated by MS (pull) or by a server (push)

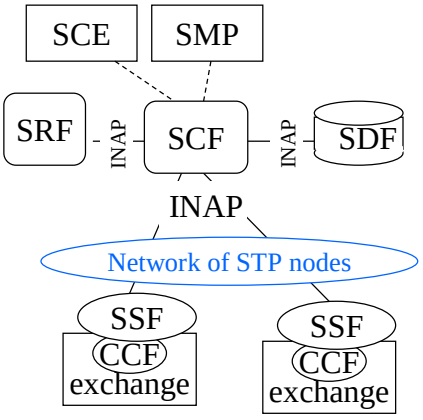


there is also the Notify USS data –service...

CAMEL adapts the IN technology to GSM

- CAMEL - Customized Application for Mobile network Enhanced Logic
- The goal is the capability of providing the home network services to visiting subscribers
- CAP - CAMEL Application Part is a subset of ETSI CoreINAP
  - phases (Capability Sets) 1 and 2 are ready

IN is a way of implementing services in nodes separate from exchanges

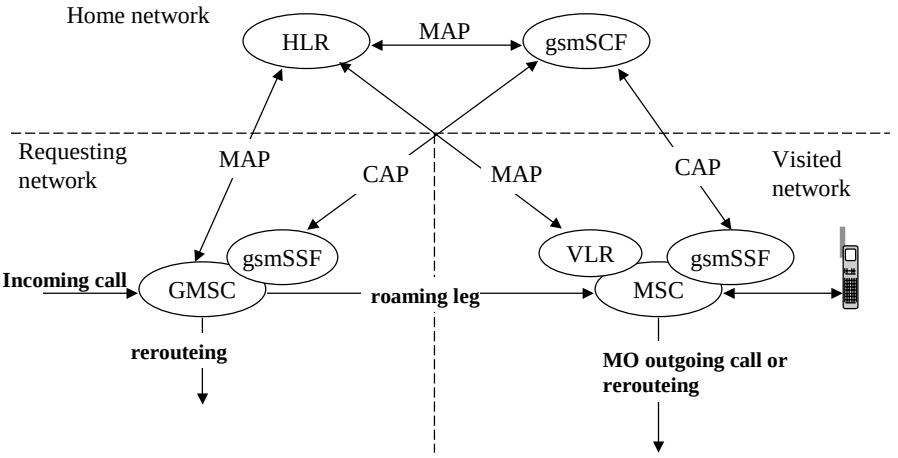


INAP = IN Application Part
= main protocol
SSF - Service Switching Function
maintains call state with CCF
SCF - Service Control Function
implements service logic
SRF - Special Resource Function
processes in-band signals
SDF - Service Data Function
is a database
SCE - Service Creation Environment
for creating new service logic
SMP - Service Management Point
implements mgt functions

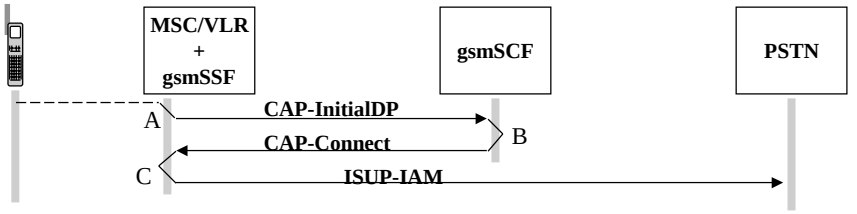
Features of the IN architecture ...

- BCSM - Basic Call State Model is a standardized state machine in SSP - couples/ de-couples IN service logic from connection resources
- BCSM states (detection points) can be programmed to trigger queries on conditions to an SCF concerning a certain call
- BCSM architectural issue is that a call is also a service and therefore the architecture is service dependent
- INAP messages are independent of voice channel connections

Phase 1 CAMEL architecture



MS originated CAMEL call

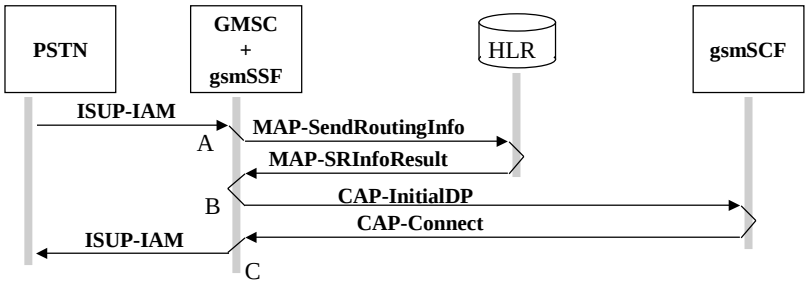


A - MSC gets the CAMEL service info from the VLR concerning the A subscriber, sees an active CAMEL service and hands the call to gsmSSF. gsmSSF queries gsmSCF:lle (service key, A-nr, B-nr, IMSI, location...

B - gsmSCF can for example do a number translation

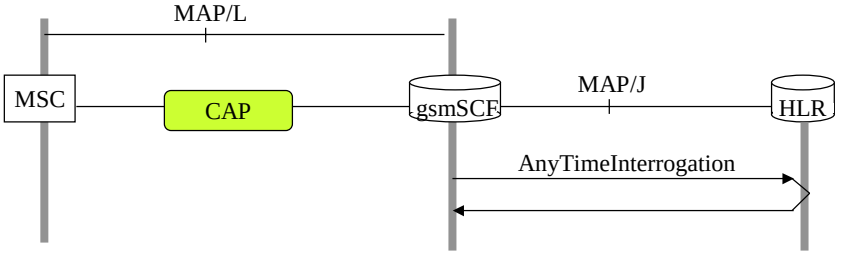
C - MSC sets up a call using the received info

Mobile terminated CAMEL call



A - GMSC queries HLR of the location of the MS. HLR sends the terminating CAMEL service data of the subscriber.
B - GMSC hands the call to gsmSSF, which queries gsmSCF gsmSCF returns C-number that is used for routeing the call
C - GMSC sets up the call to C-number. If needed, GMSC can first do a new HLR query.

An SCF can interrogate HLR at any time



This is a MAP98 (of 2002) feature.
See also slide nr 59:

IN+GSM integration based on CAMEL is a step towards 3G

- CAPv1 supports only 7 operations
- CAPv1 call model has only a few triggering points (TDP - trigger detection point)
- CAPv2 has 22 operations
- Still no triggering for Short Messages
- CAMEL compatible equipment is in use in many networks

MAP summary

- MAP has been introduced in several phases and releases.
- Provides a working solution to mobility including smooth handovers for CS services.
- Supports mobility for packet services (simplified handover) for GPRS Core.
- Is heavy on features.
- Future: MAP over IP? MAPSec (Release 4)?