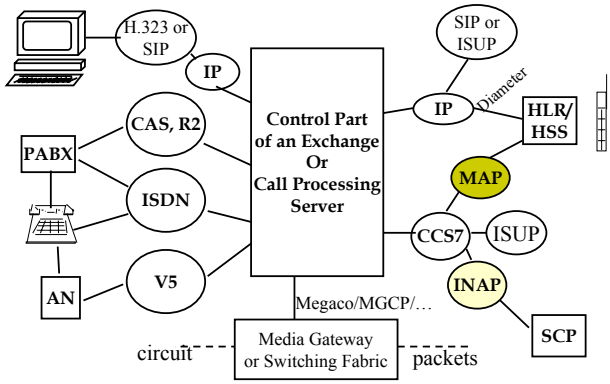
MAP - Mobile Application Part

Mobility Management in GSM
GSM (2+ …) services
Short Message Service
Support of GPRS

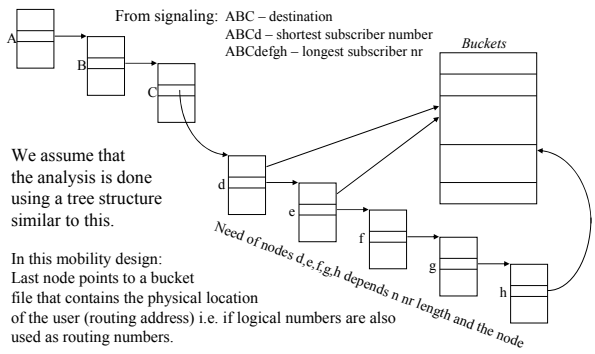
Summary of course scope



Mobility Management in General

Comparison of solutions for CS and PS networks

Analysis tree links signaling to routing



We assume that the analysis is done using a tree structure similar to this.

In this mobility design:
Last node points to a bucket file that contains the physical location of the user (routing address) i.e. if logical numbers are also used as routing numbers.

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 (topological proximity = proximity in number space).
- Example: 10^9 subscribers, number length = 13 digits

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

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

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

NB: the branch factor is rounded up to the next integer

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 calculus cont ...

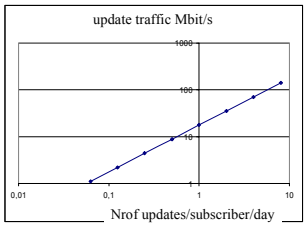
Memory requirement is 64 bytes * 305 * 10^6 = 19 Gb

- 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.

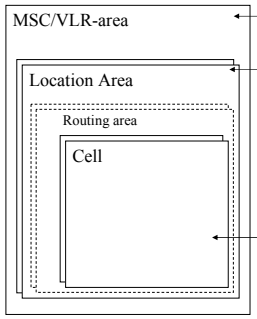
Problem needs to be partitioned!



Other problems in the design

- When the number of subscribers grows, memory allocated to the Number Analysis needs to be upgraded by all operators.
- For any single operator, most of the entries in the database are practically useless while a small portion is in active use – many national calls vs. few international calls
- Update traffic (e.g. 100 Mbit/s) per operator takes quite a bit of network capacity (expensive in PCM environment although in the times of Broadband 1Gbit/s is no big deal).

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.
- updates 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

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
  - MSRNs are topology bound numbers → any exchange (ISDN, GSM or PSTN) can easily use MSRNs to route calls.
  - MSRNs are managed and allocated by VLRs and not visible to users.

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

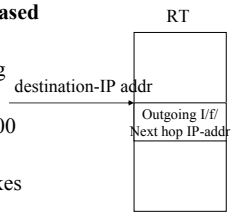
Traffic = 200 000 * 100 * 8/(5*60) = 0,53Mbit/s.

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

NB: Existence of HLR and Request to HLR to map MSISDN to MSRN means that this mapping for a subscriber needs to be maintained in two places only: the VLR and the HLR.

Mobility from IP network point of view (1)

- **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).



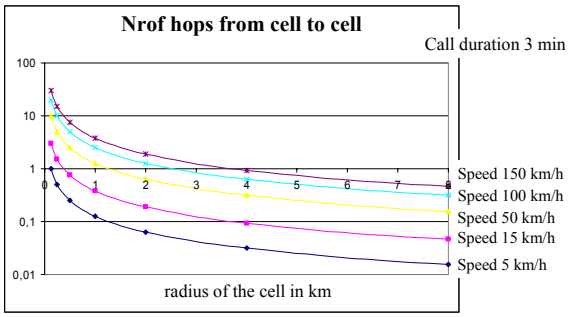
- n x 100M users →provider addressing results feasible RT size
- search is based on address prefix not a full 32 bit address

When an MS moves, its (topology bound) IP address changes. If this is not hidden from the wide area Internet routing, the RT would need to store host addresses of all MSs! These MS address entries would need to be maintained in all core routers → not feasible!

Mobility from IP network point of view (2)

- TCP sessions are identified by
  - Source-IP-add, Source-port, dest-IP add and dest port
- Internet follows provider addressing for scalability reasons – i.e. IP addresses allocation follows network topology closely → route aggregation in the network core.
  - Exception that violates topology aligned addressing is multi-homing: e.g. one corporate network connected to at least two ISP networks results that the IP-address aggregate of this corporation becomes visible in the non-default routing core of the Internet
  - A movement of a mobile node from one network to another means that a new IP address is allocated to the Mobile node. The result is that the TCP session will fail. Possible solutions to this are: Mobile-IP, tunneling, a new transport protocol instead of TCP etc.
  - GPRS and 3G WCDMA use tunneling, "US" CDMA uses Mobile IP, an example of a new transport protocol is SCTP, etc.
  - Tunneling = carry IP-packets(with non-changing IP addr) inside IP-packets with source IP-address that changes with movements from cell to cell
- The problem with a large number of entries in a core routing table is not the size itself, rather the problem is maintaining all these route entries up to date at all times.

Nrof probable handovers from cell to cell during a telephone call



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

Power saving is important for mobiles

- Sending and complex processing consume most power.
- The more the mobile can sleep the better.
- Small cells lead to frequent location updates → power consumption increases

Conclusion from the slide with nrof hops from cell to cell as a function of cell size:

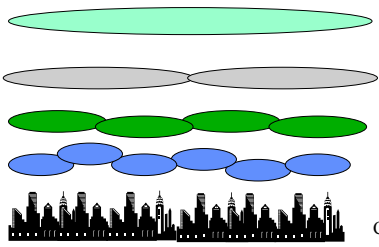
Systems that do not allow building cells with the radius in kilometers can not succeed for voice services. This is also confirmed by the history of wireless telephony (CT2, DECT…)

Why are handovers important?

- Telephone calls:
  - Users are annoyed if an ongoing call breaks down in the middle
  - Users accept that sometimes you must redial because often the B-party is busy or the network may be busy or one may misdial.
  - → for voice calls handovers in cellular networks are a must!
- Data services using TCP/IP:
  - When the service is client-server like e-mail, the application can always try again. Getting mails read or sent may take a little longer but one can build applications that can try to hide the difficulties from the users. In web browsing, breaks in connectivity of many seconds cause irritation.
  - It is difficult to point out data applications that very many people would like to use while they are moving fast, because while moving one needs eyes for avoiding hitting things.
  - Once you arrive, it would still be nice to use be able to use some data services like read your e-mail where ever you are.
  - → It would seem enough to reduce the cell attachment time to <1s and build applications that can live with un-ideal network connectivity while providing connectivity from any point of attachment.

Why worry about this: Handovers are a very expensive feature to implement: e.g. cmp WLAN and 3G network costs.

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 nodes of 64 octets, each for analysing 4 bits.

Usage of hexa code points:

$m^N = 10^9 \Rightarrow N \lg m = 9 \Rightarrow m = 13.34 \ldots 1{,}9$, when N goes from 8 to 32

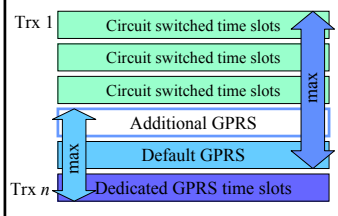
Nrof nodes in the tree is

$$1 + m + m^2 + \ldots m^{N-1} = \frac{m^N - 1}{m - 1} = 114 \text{ to } 4290 \text{ million}$$

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

NB: the branch factor is rounded up to the next integer

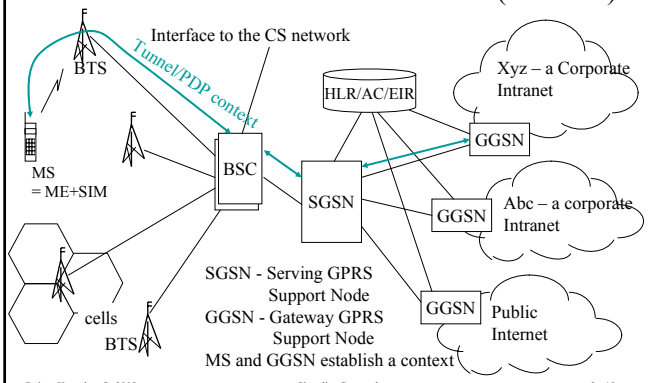
GPRS shares TRX timeslots with CS services in GSM



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

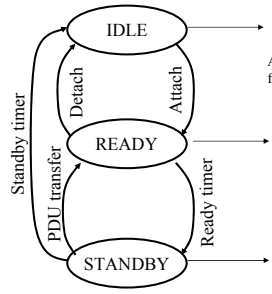
By setting the parameters between PS/CS services appropriately an elastic boundary is created between GPRS and CS services – QoS, Revenues and network usage need to be optimised.

In GPRS, SGSN takes care of mobility and GGSN is the interface node to other networks (GSM 2+)



GPRS mobility management states/ MS in MS and in SGSN

this is a bit simplified



Network does not follow MS location

Attach means that the mobile device and the base station form a bi-directional radio link between each other

User is active. Network follows the user with the accuracy of one cell, user has a topology bound IP address

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. This address does not change with movement.
  - at PDP context (=tunnel) establishment
  - GGSN = edge or access router from Internet and Intranet point of view
  - Several address allocation methods including DHCP
- BSC-SGSN-GGSN (+HLR) network manages mobility using topology bound internal IP-addresses.
  - The role of SGSN is to maintain the PDP-context/tunnel between MS and GGSN while MS is moving and hide the movement from the network core behind the GGSN. Without hiding the movement from the core, the core would not scale to *n* x 100M users.
- 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)

MM – Mobility Management

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
  - Packet Push service to a GPRS terminal is an issue.

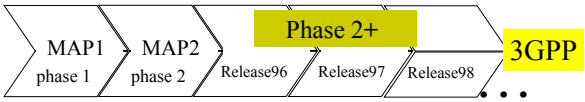
MAP

For GSM Generation 2.5

The purpose of MAP in GSM

- Call signaling between GSM exchanges is still based on ISUP
- MAP brings in all the added signaling functionality to the core network as compared to a fixed ISDN network so that the mobile network can work
  - Mobility management on the network level is based on MAP
  - MAP is used to implement all kinds of other services that are not present in wireline networks but are provided by GSM (e.g. short message service). This is not particularly modular and has lead to a specs of > 1000 pages…

Milestones in MAP development

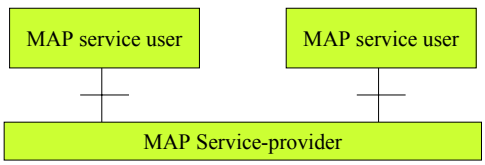


- In phase 2+ … versioning is per operation package.
- This supports the idea of deploying small sets of features at a time in the network.
- If a remote system does not understand the newest tricks, *fall-back negotiation* restores operation on the level of the previous version.
- Release98 3GPP TS 09.02 V7.11.0 in www.3gpp.org (03-2002), ETSI →3GPP
- Later releases have small improvements
  - 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: 29002-680 etc…

MAP is used by many network elements

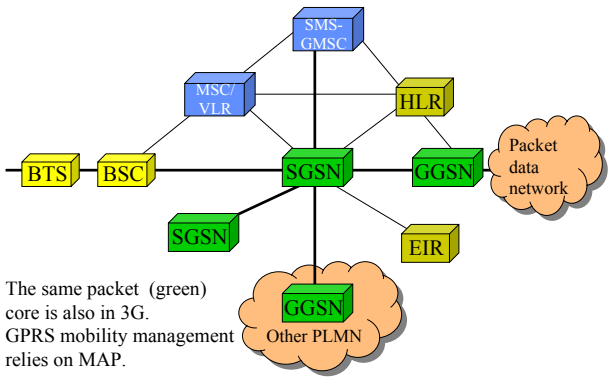
EIR	Equipment Identity Register - usually integrated with HLR
GCR	Group Call Register (does not appear in rel 7)
GGSN	Gateway GPRS Support Node - for interfacing to IP or other PD networks
GMLC	Gateway Mobile Location Center - for interfacing to Location Services
GMSC	Gateway MSC - for routing calls 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 (not in rel 7!)
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
VBS/VGCS Relay MSC	Voice broadcast/group call service relay MSC
VLR	Visitor Location Register -in practice integrated with MSC
VMSC	Visited MSC

MAP works between MAP Service Users and MAP Service Providers



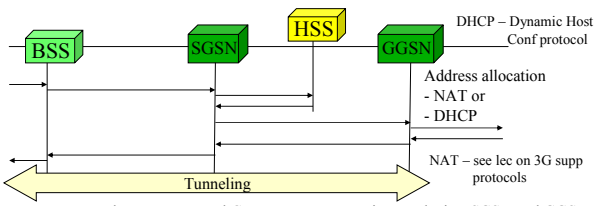
- MAP SUs and MAP SPs are network functions such as HLR, MSC etc.
- The roles are dynamic, i.e a node can be a user for one operation and a service provider for another.

GSM/GPRS Core Network



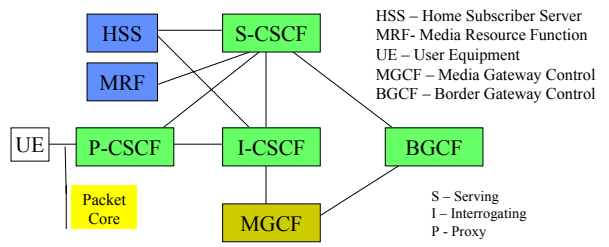
The same packet (green) core is also in 3G.
GPRS mobility management relies on MAP.

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



PDP context = Packet Data Protocol Context = some state in user device, SGSN and GGSN
- 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



- MultiMedia subsystem works on top of the packet core.
- CSCF – Call Session Control Function processes signaling and controls the Multimedia services.
- IMS does not use MAP! Instead, IETF protocols are used.

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 MAP 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 not counting SDLs ...
  - Rel 7 spec is a little more compact, only ca 900 pages + SDLs…

Map has become "cleaner" by rel 7

Mobility services	**Nrof Serv**
Location management services	8
Access management services	1
Handover services	7
Authentication management services	3
Security management services	1
International mobile equipment identities management services	2
Subscriber management services	2
Identity management services	2
Fault recovery services	3
Subscriber Information services	5
Total for MM	***34***
Operation and maintenance services	
Subscriber tracing services	3
Other operation and maintenance services	1
Call handling services	14
Supplementary services related services	13
Short message service management services	10
Network-Requested PDP Context Activation services	3
Location Service Management Services	3
Total nrof services in MAP rel 7	***81***

Mobility services	**From**	**To**
Location management services		
MAP_UPDATE_LOCATION service	VLR	HLR
MAP_CANCEL_LOCATION service	HLR	VLR, SGSN
MAP_SEND_IDENTIFICATION service	VLR	VLR
MAP_PURGE_MS service	VLR, SGSN	HLR
MAP_UPDATE_GPRS_LOCATION s	SGSN	HLR
MAP-NOTE-MM-EVENT	VLR, SGSN	gsmSCF, PNA
MAP_PAGE service	VLR	MSC
MAP_SEARCH_FOR_MS service	VLR	MSC
Access management services		
MAP_PROCESS_ACCESS_REQUEST s	MSC	VLR
Handover services		
MAP_PREPARE_HANDOVER service	MSCa	MSCb
MAP_SEND_END_SIGNAL service	MSCb	MSCa
MAP_PROCESS_ACCESS_SIGNALLING service	MSCb	MSCa
MAP_FORWARD_ACCESS_SIGNALLING service	MSCa	MSCb
MAP_PREPARE_SUBSEQUENT_HANDOVER service	MSCb	MSCa
MAP_ALLOCATE_HANDOVER_NUMBER service	MSC	VLR
MAP_SEND_HANDOVER_REPORT service	VLR	MSCb
Authentication management services		
MAP_AUTHENTICATE service	VLR	MSC
MAP_SEND_AUTHENTICATION_INFO service	VLR,SGSN	HLR
MAP_AUTHENTICATION_FAILURE_REPORT service	VLR,SGSN	HLR
Security management services		
MAP_SET_CIPHERING_MODE service	VLR	MSC

PNA – Presence Network Agent

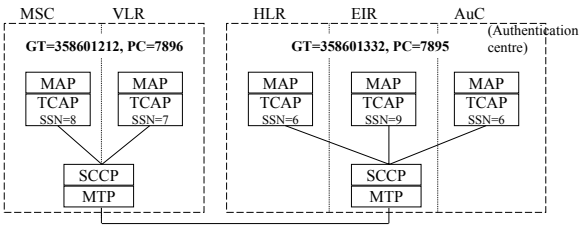
Mobility services (cont.)	**From**	**To**
International mobile equipment identities management services		
MAP_CHECK_IMEI service	VLR/MSC, SGSN	EIR
MAP_OBTAIN_IMEI service	VLR	MSC
Subscriber management services		
MAP-INSERT-SUBSCRIBER-DATA service	HLR	VLR
MAP-DELETE-SUBSCRIBER-DATA service	HLR	VLR, SGSN
Identity management services		
MAP-PROVIDE-IMSI service	VLR	MSC (MS)
MAP-FORWARD-NEW-TMSI service	VLR	MSC (MS)
Fault recovery services		
MAP_RESET service	HLR	VLR, SGSN
MAP_FORWARD_CHECK_SS_INDICATION service	HLR	VLR/MSC(MS)
MAP_RESTORE_DATA service	VLR	HLR
Subscriber Information services		
MAP-ANY-TIME-INTERROGATION service	gsmSCF, PNA	HLR, GMLC, NPLR
MAP-PROVIDE-SUBSCRIBER-INFO service	any	VLR, SGSN
MAP-ANY-TIME-SUBSCRIPTION-INTERROGATION s	gsmSCF, IM-SSF	HLR
MAP-ANY-TIME-MODIFICATION service	gsmSCF, PNA, IP-SM-GW	HLR, VLR, SGSN
MAP-NOTE-SUBSCRIBER-DATA-MODIFIED service	HLR	gsmSCF, IM-SSF
Operation and maintenance services		
Subscriber tracing services		
MAP-ACTIVATE-TRACE-MODE service	HLR	VLR, SGSN
MAP-DEACTIVATE-TRACE-MODE service	HLR	VLR, SGSN
MAP-TRACE-SUBSCRIBER-ACTIVITY service	VLR	MSC
Other operation and maintenance services		
MAP-SEND-IMSI service	VLR	MSC?

Call handling services	From	To
MAP_SEND_ROUTING_INFORMATION service	gMSC, gsmSCF	HLR, NPLR
MAP_PROVIDE_ROAMING_NUMBER service	HLR	VLR
MAP_RESUME_CALL_HANDLING service	vMSC	gMSC
MAP_PREPARE_GROUP_CALL service	AnMSC	RelMSC
MAP_PROCESS_GROUP CALL_SIGNALLING service	RelMSC	AnMSC
MAP_FORWARD_GROUP_CALL_SIGNALLING s	AnMSC	RelMSC
MAP_SEND_GROUP_CALL_END_SIGNAL service	RelMSC	AnMSC
MAP_SEND_GROUP_CALL_INFO service	vMSC	GC-Serv MSC
MAP_SET_REPORTING_STATE service	HLR	VLR
MAP_STATUS_REPORT service	VLR	HLR
MAP_REMOTE_USER_FREE service	HLR	VLR
MAP_IST_ALERT service	MSC	HLR
MAP_IST_COMMAND service	HLR	MSC
MAP_RELEASE_RESOURCES service	gMSC	vMSC
Supplementary services related services		
MAP_REGISTER_SS service	MSC/VLR	HLR
MAP_ERASE_SS service	MSC/VLR	HLR
MAP_ACTIVATE_SS service	MSC/VLR	HLR
MAP_DEACTIVATE_SS service	MSC/VLR	HLR
MAP_INTERROGATE_SS service	MSC/VLR	HLR
MAP_REGISTER_PASSWORD service	MSC/VLR	HLR
MAP_GET_PASSWORD service	HLR	MSC/VLR
MAP_PROCESS_UNSTRUCTURED_SS_REQUEST s	MSC/VLR,HLR	HLR, gsmSCF
MAP_UNSTRUCTURED_SS_REQUEST service	gsmSCF, HLR	HLR, VLR/MSC (MS)
MAP_UNSTRUCTURED_SS_NOTIFY service	gsmSCF, HLR	HLR, VLR/MSC (MS)
MAP_SS_INVOCATION_NOTIFY	MSC, HLR	gsmSCF
MAP_REGISTER_CC_ENTRY service	MSC/VLR	HLR
MAP_ERASE_CC_ENTRY service	MSC/VLR	HLR

Short message service management services	FROM	TO
MAP-SEND-ROUTING-INFO-FOR-SM service	gMSC	HLR
MAP-MO-FORWARD-SHORT-MESSAGE service	sMSC	SMS-iwMSC
MAP-REPORT-SM-DELIVERY-STATUS service	gMSC	HLR
MAP-READY-FOR-SM service	MSC/VLR, SGSN	HLR
MAP-ALERT-SERVICE-CENTRE service	HLR	iwMSC
MAP-INFORM-SERVICE-CENTRE service	HLR	gMSC
MAP-SEND-INFO-FOR-MT-SMS service	MSC	VLR
MAP-SEND-INFO-FOR-MO-SMS service	MSC	VLR
MAP-MT-FORWARD-SHORT-MESSAGE service	gMSC	sMSC, SGSN
MAP-MT-FORWARD-SM-FOR-VGCS service	SMSgMSC	GC-AnMSC
Network-Requested PDP Context Activation services		
MAP_SEND_ROUTING_INFO_FOR_GPRS service	GGSN	HLR
MAP_FAILURE_REPORT service	GGSN	HLR
MAP_NOTE_MS_PRESENT_FOR_GPRS service	HLR	GGSN
Location Service Management Services		
MAP-SEND-ROUTING-INFO-FOR-LCS Service	gMLC	HLR
MAP-PROVIDE-SUBSCRIBER-LOCATION Service	gMLC	vMSC, SGSN
MAP-SUBSCRIBER-LOCATION-REPORT Service	vMSC, SGSN	gMLC

Cmp to older releases, some of the services have become more generic (can be used e.g. between HLR – VLR or SGSN)
Also, VLR is more clearly integrated with MSC (instead of having specific names for services used for VLR, the same services name is used on several interfaces).
PNA – Presence Network Agent as an element has been added.
Some things in older versions have become "historical" and have been removed.
Text spec is 900 pages (SDLs are additional)…

Addressing MAP messages



GT formats:

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

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

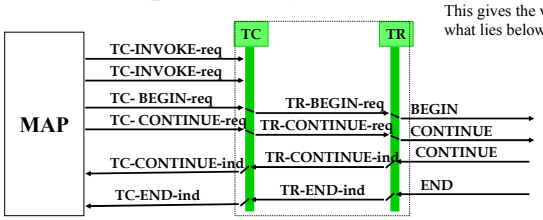
Common MAP services

• 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 (this is simplified a bit):

- 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)

SIM card does not store the MSISDN nr but has the IMSI

Home Location Register - HLR - contains subscriber and service information

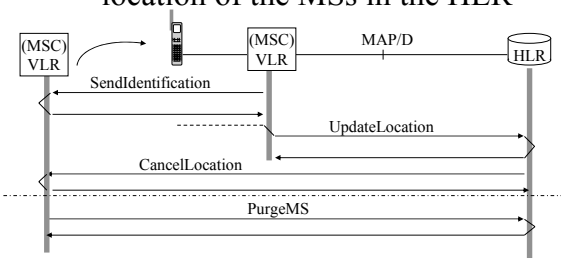
IMSI ⇨ Subscriber information (location, etc)

MSISDN ⇨ Service info (voice, fax, blocking modes, etc)

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* and/or *Number Portability* 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 (NPLR).

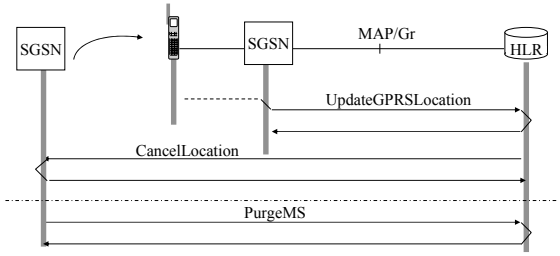
Release98 HLR database has
- location information (VLR number)
- basic telecommunications services subscription information
- service restrictions (e.g. roaming limitations)
- supplementary service parameters
- GPRS subscription data and routeing information: e.g. APN – Access Point Name pointing to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

Location management maintains the location of the MSs in the HLR



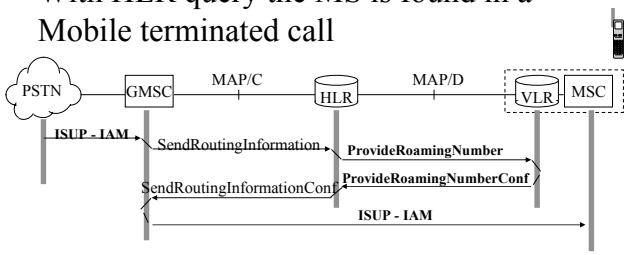
- **SendIdentification requests MS info (IMSI, authentication) from the previous VLR.**
- **UpdateLocation updates the new location with the accuracy of a VLR area**
- **With PurgeMS VLR tells to HLR that MS is unreachable e.g. because of out-of coverage condition (independent of the previous sequence).**

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



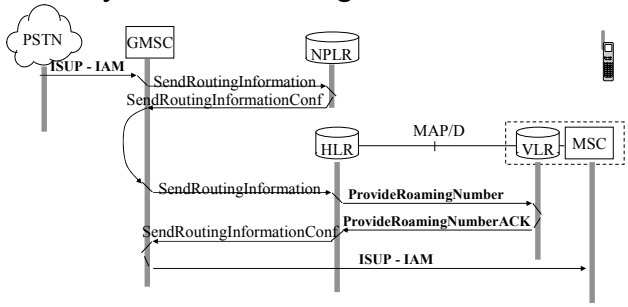
- **SendIdentification requests MS info (IMSI, authentication) from the previous SGSN.**
- **UpdateLocation updates the new location with the accuracy of a SGSN area**
- **With PurgeMS SGSN tells to HLR that MS is unreachable.**

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

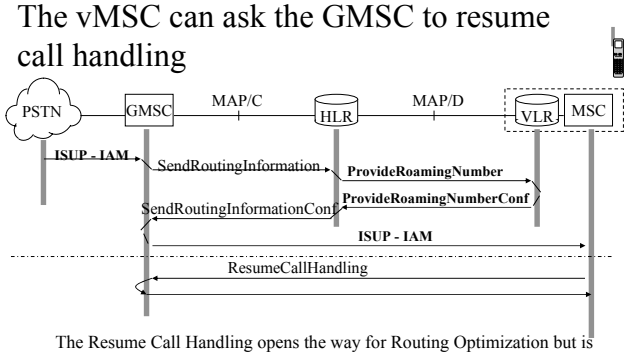


MSRN - Mobile Subscriber Roaming Number
- conforms to E.164 format (any exchange can pass along the number)
- each MSC has a limited range of topology bound MSRNs allocated by VLR
- MSRN has a validity timeout
- MSRN may be allocated *on a call by call basis or for the duration of a visit*

GSM Number Portability can be implemented by NP Location Register

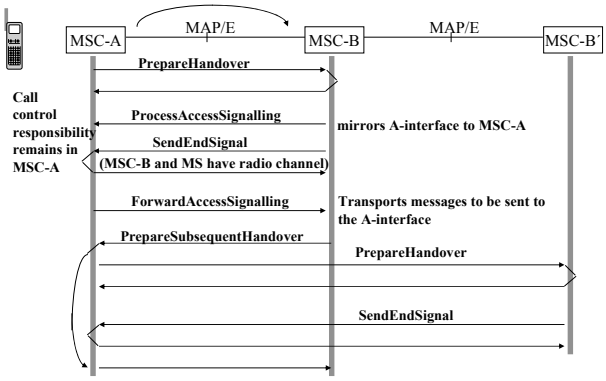


The vMSC can ask the GMSC to resume call handling

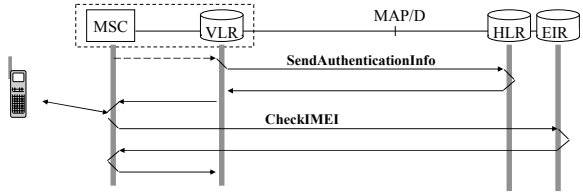


The Resume Call Handling opens the way for Routing Optimization but is not used:
- calls are normally always routed through the Home Network due to charging reasons.

Handover from MSC to MSC

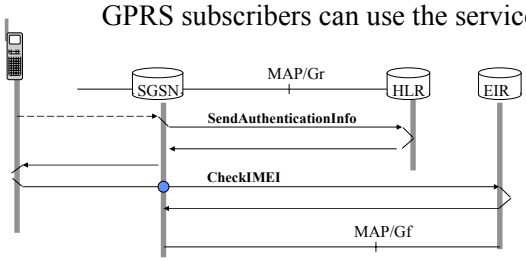


Security operations ensure that only authorized subscribers can use the service



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

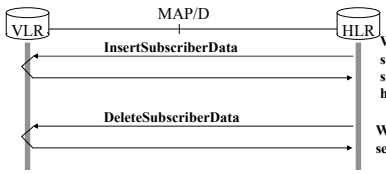


If SGSN does not have the IMEI, it asks it from the MS. After authentication a PDP context can be established for packet transfer.

MAP support for GSM specific services

- Subscriber Management
- SS procedures
- Short Message Service
- CCBS
- USSD
- Summary

Subscriber management takes care of the subscriber data in the VLR

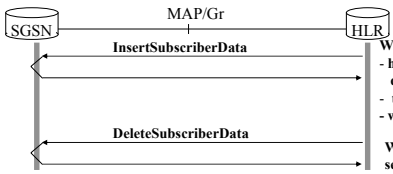


When the operator or the subscriber have changed any of subscriber data. When location has been updated.

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



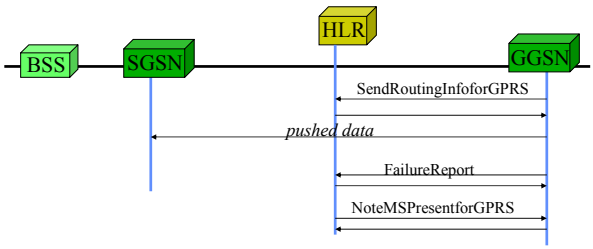
When the operator or the subscriber
- have changed any of subscriber data (e.g. barring).
- the mode has changed
- when location is updated.

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

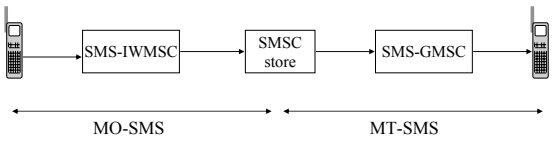
MS --> MSC/VLR --> HLR

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

Events, such as activation, registration, interrogation, deactivation etc come from SS lifecycle model.

Short Message Service

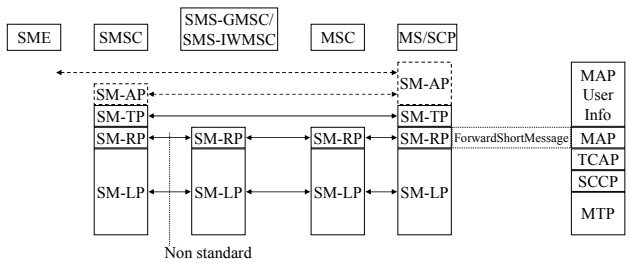


SMSC - Short Message Service Center (or SC - Service Center)
SMS-GMSC - Short message Gateway MSC, issuer of routing information query to HLR in MT-SMS
SMS-IWMSC - Short message Inter-working MSC, routing MSC in MO-SMS service
SMS-GW = SMS-IWMSC + SMS-GMSC

MO - Mobile Originated
MT - Mobile Terminated

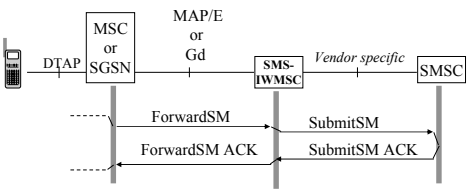
SMSC - HLR operations:
- MS short message buffer full
- MS reachability
- successful delivery of message

Short message transport protocol stack



SME - Short Message Entity (may reside e.g. in a computer)
SM-LP - Short Message Link Protocol
SM-RP - Short Message Relay Protocol
SM-TP - Short Message Transfer Protocol
SM-AP - Short Message Application Protocol

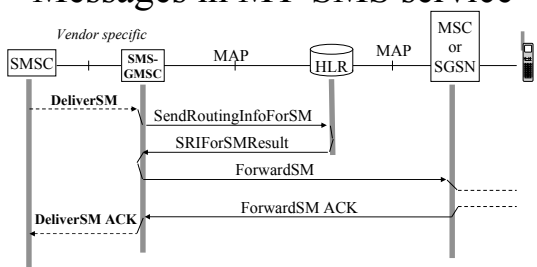
Messages in MO-SMS service



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

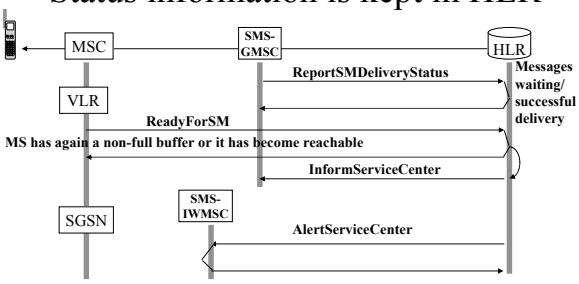
DTAP is part of BSSAP (Data Transfer Application Part...), BSSAP = A-interface or Base Station Subsystem Application Part

Messages in MT-SMS service



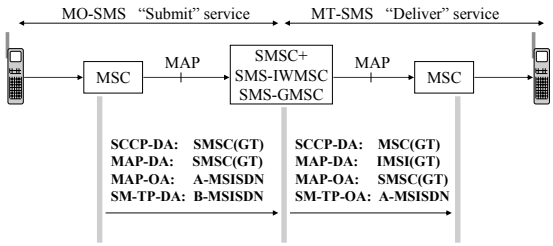
The SMS can be delivered either by a serving MSC or the SGSN thru GPRS service.
NB: When SMSs are carried over MAP, they may create a significant load on the underlaying CSS7 signaling network!

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.**
- **Interpretation: IWMSC to SMSC and GWMSC to SMSC interfaces are vendor specific. Optionally either one of the MSCs can report itself onto the Waiting list in HLR.**

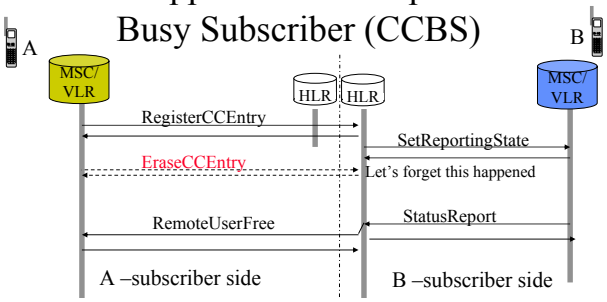
Addressing of Short messages



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!

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

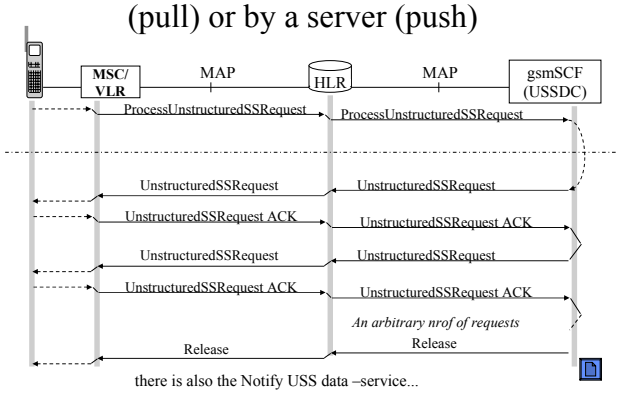
- Network destinations can be e.g.
  - MSC, VLR, HLR
  - HLR-> SCP, WWW-server
- Data is in "ascii"(cmp DTMF)
- E.g. WAP - Wireless Application Protocol can in principle use the USSD service
- a latecomer among features
- Supports push service to an MS.

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...

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(?)
  - MAP for 3G release 6 (end of 2005) has 79 services and rel 7 has 81 services