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Laboratory of Telecommunications Technology
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Jan:Erik Ekberg (36259J)

Routing in Mobile Networks

Contents:

1. Routing in Traditional Telecom Networks

Since automatic routing has been evolving in the telephone network since the beginning of the century, the routing concepts applied are quite simple, however fully functional. The reader should notice the difference between packet networks and the circuit switched ones — in the PSTN the signalling is separated from the actual connection, and the routing is done only when the connection attempt is made. This lessens the speed requirements of the routing process, in big countries with old analog switching equipment a call may well take half a minute to connect.

When a call is originated from a terminal the user specifies the target (dials the telephone number) using his signalling channel — acknowledge that the signalling / communication channel separation extends all the way to the terminal. The telephone network is traditionally built in a hierachical fashion (there are international exchanges at the root of the tree, and local exchanges at the leaves), so the user's call attempt is first processed at the local branch exchange. If the telephone number indicates that the call should be terminated at the same exchange, the call is routed the that terminating point, otherwise the call is routed to an exchange one level higher in the hierarchy (along with the communication channel).

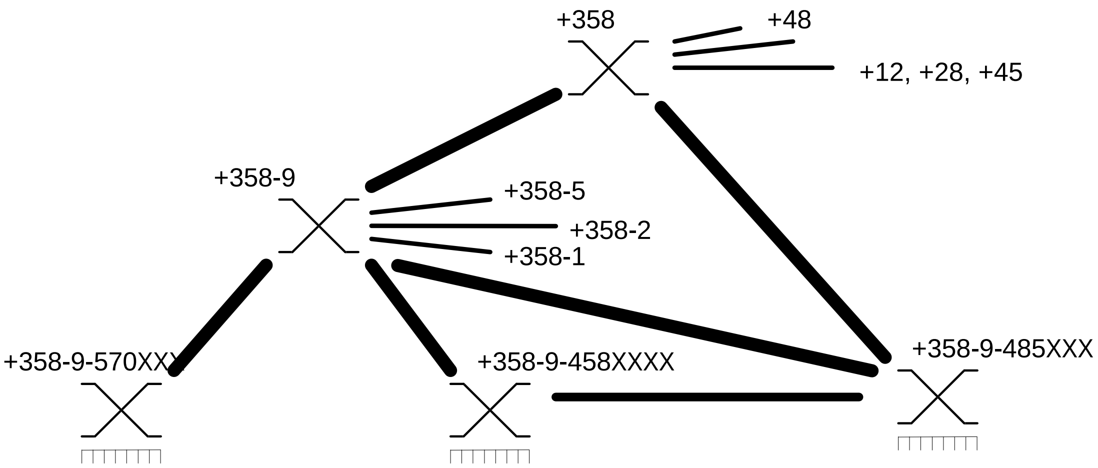

Fig 1. Example of a traditional network hierarchy

Relating to the picture above, calls from a subscriber in the +358-9-458 exchange will be routed through the +358-9 exchange in case he calls a number in the +358-9-570 series, but directly to the +358-9-485 exchange, if he wants to reach a subscriber in that particular exchange. The routing tables are fixed, and manually updated, the system as a whole is static, the traffic between point A and B is always routed in a particular way. This has, of course, somewhat changed e.g. with alternative trunk routes over the Atlantic (some kind of cost optimization is implemented when choosing between cable and satellite), or considering AT&T routing its traffic over alternative routes in the U.S.A. depending on the local time in different parts in its network, but as a whole, dynamic routing is rare and seldom used.

2. Mobile Networks, General Concepts

2.1. Introduction

Mobile networks have evolved from radiotelephony, gradually over many decades. Even simple networks, e.g. the CB-radio, usually have a dedicated 'signalling' channel where contacts are made, and then the communication is carried out over an agreed-upon channel. The first actual public mobile network in Finland was the ARP (AutoRadioPuhelin), an analog system with connection to the PSTN. Here, the channel tuning was network-controlled, and the switching operator controlled (nowadays automatic). The analog NMT 450/900 in the nordic countries was the first network to reflect the conceptual hierarchy presented in this paper - it has its equal in the AMTS system in the U.S.A. and equivalent systems in other parts of the world. In the end of the 80’s the PLMNs (Public Land-based Mobile Networks) went digital with the pan-European GSM-standard, and is in the 90’s followed by other similar solutions. Ongoing work in the UMTS (Universal Mobile Telecommunication System) envisions to take mobile networks one step further by integrating satellite-based communication and improved data communication facilities in the 21st century.

Although many of the principles and solutions described in this paper are valid for the larger part of the mentioned network solutions, all examples reflect the way things are done in the GSM system.

2.2. The Overlay Network

To fully understand the approaches taken and the signalling used in mobile networks it is important to understand that we in essence are talking about overlay networks - the case where a PLMN uses the transmission capabilities of the PSTN for its connections between different network elements. This is well documented e.g. in the GSM - standardization process, where one of the criterions for the network was that it should be compatible with the ISDN network when it comes to transmission capabilities, but also regarding supplementary services visible to the user.

The GSM network additionally uses a data network for inter-element communication. This ISO/OSI-based network is accessed through a protocol layer, called MAP (Mobile Application Part) {signal+parameter specification}, which takes its transaction capabilities from the TCAP (Transaction Capabilities Application Part) layer {session control}, continuing with the Signalling Connection Control Part (SCCP) {connection control, replication}, which sits firmly on the Message Transfer Part (MTP) of the OSI stack.

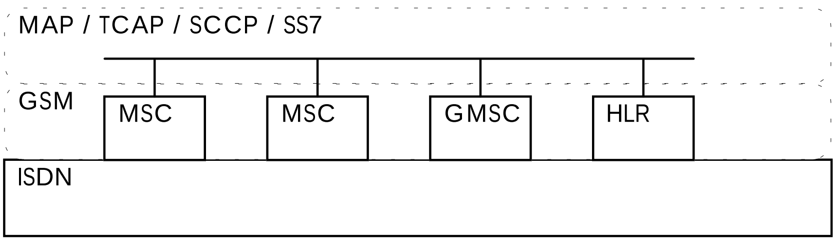

Fig 2. The overlay network concept

What sets this data connection apart from e.g. a TCP/IP connection is its strong support for *operations,* a familiar concept in telecom networks. An operation begins when the originator sends a *request* message, which the terminator sees as an *indication* message. The terminator responds with a positive or negative *response*, which is received as a comparable *confirmation* at the originating side. Operations can also be linked with subsequent operations, e.g. *acknowledgements*. An operation can last very long (there may be many unrelated intermediate messages),one typical way is to encapsulate a whole communication session within one single operation (to indicate the termination if the session when everything has been said and done)

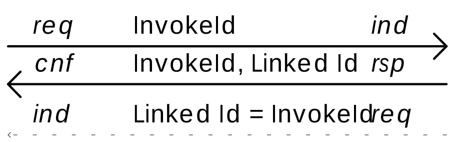

Fig 3. Operations in ISO/OSI

2.3. Elements

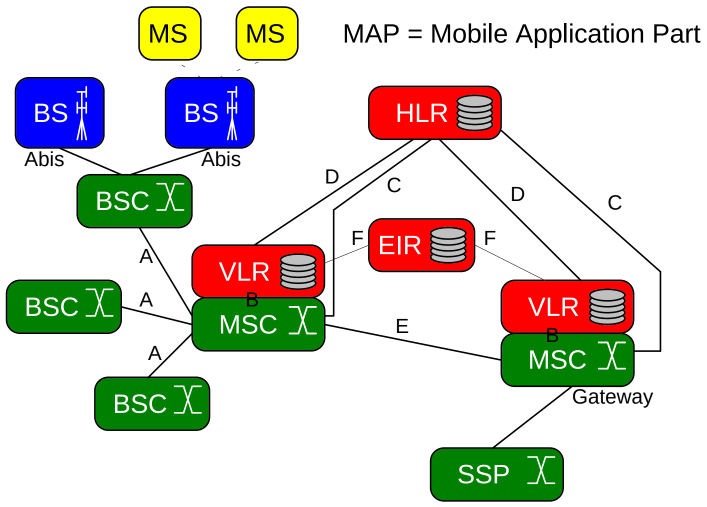

Fig 4: The structure of a Mobile Network, and its interfaces

The mobile network consists of a number of different elements, mainly to support mobility management. As this information is well known, the elements are only presented as a short glossary:

MSC: *Mobile Switching Center*. The exchange in a mobile networks, takes care of routing the calls, and connecting to external networks.

VLR: *Visited Location Register*. Even if this element usually is presented as a database, it actually takes care of functionalities such as supplementary service logic, authentication, number handling (handover numbers etc.), determining when to page a subscriber etc. Of course it also contains information of where (which location area) a certain subscriber moves at the moment, which is its main functionality.

MAP-D: The conceptual interface between the MSC and the VLR. It is not a strictly defined interface, and is largely exchange-specific. In GSM networks a MSC and a VLR are always 'glued' together, and produced by the same network supplier.

HLR: *Home Location Register*. This database, containg information of the client (which MSC/VLR serves it at the moment) also takes care of some barring functionalities, and using an authentication element it distributes authentication challenges to identify users.

EIR: *Equipment Identity Register*. This register identifies the equipment (the phones) a certain subscriber (a SIM-card) uses. It can be used to e.g. block calls from stolen mobile stations.

2.4. Numbering

A user in a mobile network (GSM) is identified by means of several identification numbers, each being used in slightly different environments. Here is a list of them.

MSISDN: The number used to make a call to a MS. (CC+NDC+SN),, CC = Country Code, NDC = National Destination Code, SN = Subscriber Number.

MSRN: Mobile Station Roaming Number (CC+NDC+SN), used for call routing in the case of a Mobile Terminated Call. It is presented by the VLR on request by the HLR, and enables the GMSC to set up a call to that VLR. Once the connection has been established (the channel reserved), the same MSRN may be reused as it is no longer needed for the first call.

Handover number: Equivalent in form to the MSRN. It is presented by the VLR on request by another MSC/VLR, and enables a MSC to set up a call to another that MSC to 'hand over the call'

IMSI: International Mobile Subscriber Identity. This number is stored on the SIM card (identifies the user), and is used within the network itself (on the radio interface, and as a search key in the databases).

TMSI: Temporary MS Identification. This one is used instead of the IMSI on the radio interface to protect the identity of the caller against eavesdropping on the radio channel.

3. Handling mobility

3.1. The Radio Interface

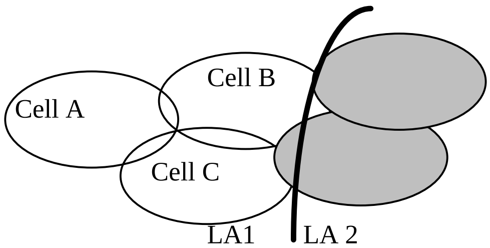

Fig 5: The Cell Structure. Mobile Station move between cells and Location Areas

The MSs communicate with the network through radio transmittes, called Brase Transceiver Systems (BTS), which logically belongs to a Base Station Controller (BSC), that is the closest signalling handling element to the MSC. Typically the MS are low-power terminals, meaning that the cells are quite small to provide acceptable service (300 m to a few kilometers in the GSM system). In the GSM system the transmission power control (60 ms tolerance) is controlled by the BSS (Base Station SubSystem) in order to prevent effective frequency reuse - frequencies are typically reused every ninth cell.

Frequency hopping is specified in the GSM standard, phase 2. This means, that the MS will change sending frequencies between bursts (the time-divisioned slots in the uplink) according to a certain pattern. This improves signal quality as radio-channel noise typically is fairly frequency-dependant, and lessens interference between senders. Additionally the bursts may be left out, if the signal source (the user) is quiet, this also lessens congestion and interference on the radio channels.

There are several radio channels in operation to support the MS. Uplink speech / data is transmitted in a Traffic Channel (TCH) that in GSM can be either full-rate (13 kbit/s) or half-rate (7 kbit/s). When the TCH is open, it also includes the uplink control channels SACCH (Slow Associated Control Channel), which is a slow channel for transportingg measurement information upstream, and the FACCH (Fast Associated Control Channel), which uses the TCH to transmit handover operations and other important and urgent signalling (the voice transmission is disturbed in this case). For location updates, and supplementary service (SS) management the SDCCH (Stand-Alone Dedicated Control Channel) is used , which has the transmission capability of 1/8 of the TCH.

There are even more downlink channels, to keep the MSs in line within a BTS area. The FCCH (Frequency Correction Channel) keeps the MS in line with its intended frequency, and the SCH (Synchronization Channel) keeps it synchronised with the BS. To choose between BSs the MS continuously monitors the BCCH (Broadcast Control Channel), for BS advertisements. Additionally it continually listens to the PCH (Paging Channel) for incoming calls and the AGCH (Access Grant Channel) for call setup.

Additionally the attach procedure, when the MS is turned on is transmitted on the uplink RACH (Random Access Channel), and then there is downlink a CBCH (Cell Broadcast Channel) for small messages intended for the MSs within a cell (e.g. SMS-messages).

3.2. Location updates

Every time a MS is turned on, it registers with the network, and performs a *location update*, i.e. it informs the network of its position. The BS that receives this message forwards it to the MSC and the VLR. The VLR checks whether the user is a already registered within its databases, if not the data of the user is fetched from the HLR (the address of the HLR is determined by means of the IMSI of the user). The HLR returns a message including authentication triplets and user supplementary service information to the notifying VLR, and sends a 'disconnect' message to any VLR that earlier was registered as being the closest one to the user. In any case the user is registered as 'present' in the location area it sent the attach message from.

Equivalently, the MS sends a detach message whenever it is turned off, or when the battery is running out. If the network receives this message, the 'detached' state will be stored in the VLR to prevent unnecessary paging (see later). Some mobile phones also send detach messages when the field becomes to weak for communication.

Additionally, the network operator may ask the MS to periodically perform a location update. The update is initiated by the MS, according to this operator specific interval (6minutes - 24 h). A typical value is once every 90 minutes.

3.2.1. Moving between cells

As long as a mobile station (MS) moves within a single GSM cell, controlled by a base station (BS), there is necessarily not much communication between the MS and the BS. The MS constantly monitors the field strength of the down-channel of the BS, as well as neighbouring BSs, if there are any to be heard. As the field strengths of the BSs vary not only due to their respective distance to the MS, but additionally based on geography, weather conditions and other disturbing factors, the GSM specification recommends that the MS uses a floating average algorithm to smooth the in practice quite radical swings in field strengths (other methods of signal correction have been proposed within the scientific community as well). Only when the MS approaches the border of the cell (the field of a neighbouring BS becomes dominant) it informs the BS of this fact, i.e. tells the new BS of the location update.

3.2.2. Moving between Base Station Controllers

To minimize load on the network, a number of cells constitute a location area, which can correspond to a small united geographical area (a village). The cells within this entity are considered as a unity seen from the network, and location switching within this area is not updated to the VLR - it is transparently handled by the BSC. A location area is consequently the smallest entity used for a paging request.

3.2.3. Moving between Location Areas

If a MS moves from one location area to another there are many possible alternatives regarding how far the position is updated. If both location areas are managed by the same MSC, the only consequence will be, that the new location area will be stored in the VLR. If they are managed by different MSC/VLR - pairs, the new VLR will recognize that the MS is not to be found in its databases. It will reqest this information from the HLR, which will return information regarding the supplementary services, authentication parameters and temporary Ids of the user. The HLR will update the new VLR as the current position of the MS, and send a message to the 'old' VLR telling it to remove the user from its databases.

3.3. Roaming

When a MS moves outside the reach of its own network it might still be able receive and originate calls if some local network operator has a roaming agreement with the user's own operator. In practice this means that the MSC/VLRs of the foreign network serves the roaming MS precisely as if it would be moving around in its own home network.

In the GSM network the roaming is a working concept, as network operators use roaming agreements as a marketing advantage against competing operators. There is, however, a small problem with roaming, which falls back on the international SS7 network, which in the GSM network is very crowded. A MS attach (location update) at a foreign site might take minutes - meaning that the MS will have to wait quite long to be authenticated and accepted by the network.

SS7 is the protocol under the MAP signalling protocol used e.g. for communication between the VLR and the HLR. Within one operators domain, all such connections are done over a local SS7 network, using an addressing method composed of two parts: a *Point Code* (PC) identifying a node in the local SS7 network, and a *SubSystem Number* (SSN) identifying a certain entity at that node (e.g. as the MSC and VLR usually are built as one network node (with one network interface), they will have the same PC but different SSNs). On the other hand, in the international SS7 network the global addressing is more complicated, and is formed more or less as an ISDN B-number, including parameters such as numbering plan, encoding, address nature and digits. The latter is used when a roaming MS initiates the need for communication between a 'foreign' VLR and the HLR.

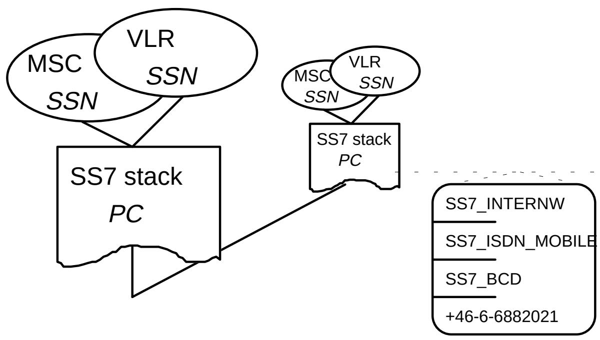

Fig 6: The SS7 network

3.4. Call Establishment

There are two forms of call establishments, mobile originating and mobile terminating, naturally a single call may be a combination of the two as well.

The mobile originating call is easy to handle. The MS first asks the BS for communication channel allocation. If one is available the MS authenticates with the VLR (which at this point might need to fetch additional information from the HLR). When the authentication is performed, the MS sends the call setup parameters (the B-number) to the MSC/VLR, the VLR inserts the A-number (as the MS identifies itself by means of a IMSI/TMSI), and the MSC connects the call to the indicated B-number.

Mobile terminating calls are somewhat more complicated to perform. We go through the case where the call is originated from a network external to the PLMN. These calls are always routed through a MSC with a direct connection to the HLR, called the *Gateway MSC* (GMSC). The GMSC asks the HLR for the current location of the MS (the HLR has the knowledge regarding which VLR is handling the MS for the moment). Additionally the HLR, asks the VLR for a *Roaming Number* (MSRN), i.e. a number to 'dial' in order to initialize a communication channel to the MSC/VLR. The call is sent forth using this number, i.e. the MSC/VLR sees it as a normal incoming call. When the call comes, the MSC asks the VLR for the current route to the MS. The VLR *pages* the MS in the location area in which it is registered - in other words it asks for the MS over all BSs within this location area. If the MS responds, a communication channel is reserved, the authentication procedure is performed, and the call is connected over the appropriate BS.

3.5. Handovers

The procedure, when an ongoing call is transferred (handed over) from one cell to another of from one frequency to another is called a handover. There are several variations of this scheme, depending on the position of the neighbouring cells in relation to the network structure.

3.5.1. Handover within a cell

If the signal quality degrades during a call, the BTS, upon receiving information about this, has the possibility to change the frequency or timeslot of a given call. The BTS knowns (or is able to monitor) the signal quality on the currently free channels, so it knows how to allocate a better channel.

3.5.2. Handover within a BSC domain

A BSC may order a handover between its BTSs for the same reasons as above, or because the MS moves between cells, or if a certain BTS becomes too crowded. It is a function totally internal to the BSC, and only a notification is given to the MSC regarding the new position of the MTS.

3.5.3. Handover between BSCs connected to the same MSC

As a MS moves close to the border of a BSC domain, and the chosen 'best alternative' for handover belongs to another BSC domain, the BSC sends a handover request (HANDOVER REQUIRED) to its MSC. The MSC chooses the the new cell based on the list of possible BTSs received from the MS, or rejects the request altogether. The MSC also determines when the handover takes place.

3.5.4. Handover between MSCs

When a call needs to be transferred between cells belonging to different MSC domains. In this case the 'originating' MSC asks the terminating MSC to route the call within its domain. The call is routed through the fixed network to the terminating MSC. The responsibility of the call and the MS, however, remains with the 'originating' MSC until the call ends and the location of the MS is updated (the MS never performs location updates during an ongoing call).This enables the network to easily recogize busy MSs, as all connection attempts during a specific call are terminated to the MSC/VLR that currently is 'in charge'.

The handovers between MSCs are shown here in the form of Message Sequence Charts (MSCs !), and should be more or less self explanatory. The first chart shows four cases. The first one shows a normal successful MSC to MSC handover. The communication with the BSCs has been simplified, and only some kind of 'pseudosignalling' is used to show at which point the BS is part of the signalling. The target cell Id is received from the mobile station, and is propagated to the receiving MSC in order for it to know which BS to direct the call to. As a separate communication connection is opened, the receiving MSC must return a handover number, i.e. a number to 'dial' in order for the originating MSC to establish a voice connection to the terminating MSC. All signals are MAP - signals except those prefixed with ISUP (the ISDN inter-exchange protocol), which control the voice connection. The second part shows that the MAP-signalling received from the mobile station (for example to control the supplementary services Call Wait and Call Hold) is directed to the originating MSC, and not to the MSC/VLR on whose area the MS currently moves around in). Then there is the case when a call is terminated in a handover situation, and a second handover when a MS moves back into the area of the original MSC/VLR.

The second MSC-chart shows the fairly complicated case when a call is handed over to a third MSC, which is not the original one. It is important to notice, that the intermediate MSC is 'released from its duties' alltogether.

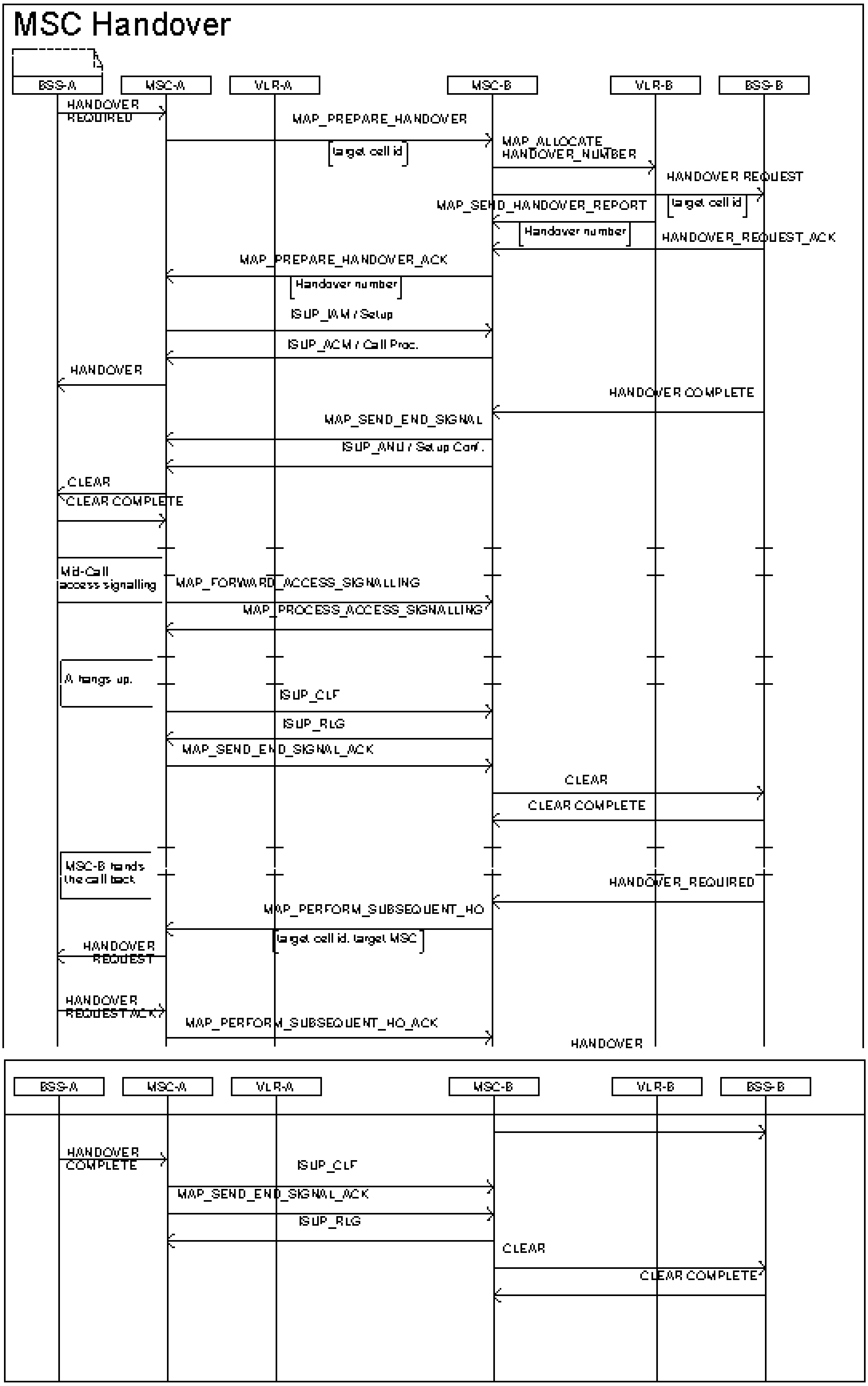

Fig 7: Different handover cases

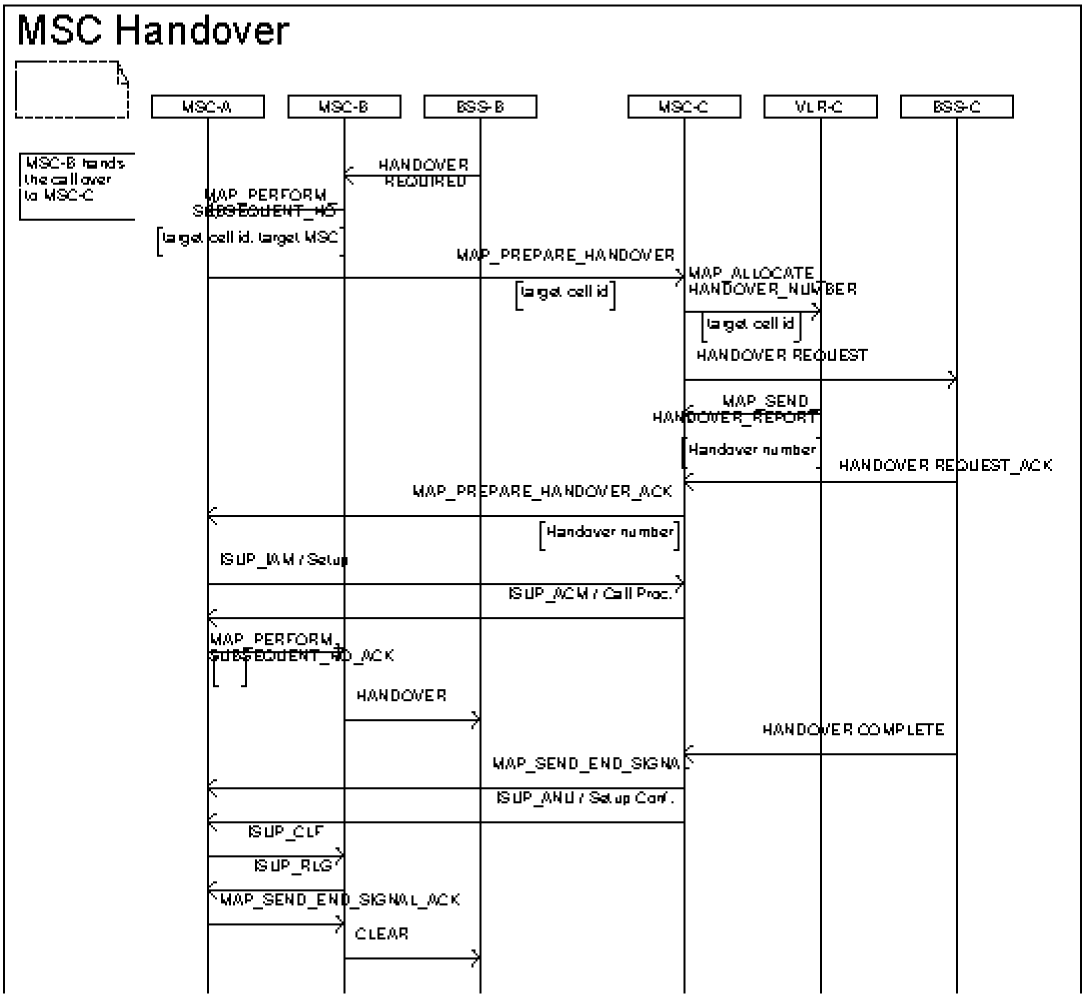

Fig 8: Handover to a third MSC

3.5.5. Soft Handovers

In the new digital CDMA - standard, foremost developed by U.S. companies, the concept of soft handovers are used. In a soft handover the handover procedure followes the outlines sketched in the previous paragraphs, but the MS does not switch over between BSs or frequencies abruptly, but rather 'listens in' to two simultaneous down-channels simultaneously, constantly choosing the better signal or possibly even superpositioning the two for improved redundancy. This method requires more advanced MSs as well as base station systems.

4. Supplementary Services

At first the reader might wonder what Supplementary Services (SSs) in a mobile network have to do with routing. The truth is, that even in the cases that they do not do actual address conversions, they affect routing decisions more or less as a rule, and make element logic nightmarish to implement. In this paper a few clarifying examples are given — but this is by no means a complete coverage on the subject.

A SS-profile for each user is stored in the HLR, and distributed to the VLRs e.g. during a location update. The list profile contains bitfields for recognizing the SSs that are active, and logically also contain information regarding numbers to forward to etc. In the GSM specification, a MS has the ability to update these values directly by signalling (the messages are transparently routed through the BSs and the MSC/VLRs to the HLR). Some operators restrict this signalling to prevent mischief and misunderstandings. Also, in some networks the SSs are used to achieve alltogether different services —

call forwarding in busy- and MS-detached cases is for example often used to route calls to an answering machine service.

4.1. Simple Services

Call forwarding and barring are two groups of SSs that interact with the network in quite similar ways. In GSM calls can be forwarded unconditionally, when the user is busy, when he doesn't answer or when he is detached from the network. The user is able to barr all incoming calls, all incoming calls from the home PLMN or all outgoing calls for example.

Call forwarding introduces the problem of loops in the network, as two subscribers may forward their calls to each other. This problem is solved by using a feature of the underlying ISDN-network. Every time the call is forwarded, a counter in the setup message is increased. If this counter exceeds a certain limit the call is discarded. This counter is typically set to something like 5-10, effectively aborting loops in the routing, but preventing long chains of forwarding at the same time.

The call forwarding cases are checked at various places in the network, depending on the service. Unconditional forwarding and barring of all incoming calls are for example checked in the GMSC on external calls, as there is no point in establishing unnecessary signalling connections if the call is doomed to be rerouted or barred. In case of a mobile originating call the same features are checked at the originating end, as the location of the terminating MS anyway must be determined. Rerouting on no-answer cases or detached cases can only be checked for at the terminating end, at the same time the paging is performed. However, the VLR might know that the user has detached from the network (if the MS sent a detach message before disappearing), and in that special case the call might be rerouted with no paging. And the same detach information is also propagated to the HLR, so the GMSC might be able to do the same decisions as well on PSTN - originating calls.

4.2. Complex Services

The most complex service defined by the GSM specification is the *Closed User Group* (CUG). The purpose of the service is to offer a company or equivalent a closed or semi-closed numbering scheme within a mobile network. All mobile subscribers belonging to this 'subnetwork' can have separate restrictions on calls (incoming or outgoing), and there might be automatic call reroutings in case the MS is not reached (e.g. the call might be routed to a PABX operator).

“The Closed User Group (CUG) supplementary service enables subscribers, connected to a PLMN and possibly also other networks, to form closed user groups (CUGs) to and from which access is restricted. A specific user may be a member of one or more CUGs. Members of a specific CUG can communicate among each other but not, in general, with users outside the group.The ability to set up emergency calls remains unaffected” (ETSI 2.85)

In essence the VLR will have a CUG index (unique for one CUG) for all users subscribing to this kind of service. Each user within the CUG may have the right to originate external calls or not, additionally they may have the right to receive calls from CUG-external sources or not. When a user originates the call the index will be compared against the index of the called MS (using the information received from the HLR). Now this seems simple, but when two networks have a roaming agreement the CUGs probably do not match, and in that case, if the user has no rights to originate external calls, the call will be rejected alltogether. On the condition that it is not an emergency call ...

5. Intelligent Networks

During the last 5-10 years a growing need to serve subscribers with ever more advanced and personalized services have emerged. The suppementary services in ISDN and GSM form a good base, but cannot be modified according to customer needs and fancies. To accommodate for this need the ETSI has specified a set of standards defining a protocol, the Core Intelligent Network Application Part (Core INAP). This standard enables an external element, called the Service Control Point (SCP) to control the routing of a call by means of a functional library in the switch, the Service Switching Point (SSP). This technology is moving into mobile networks, and will enable the building of quite advanced services and routing, based in information such as customer location and area congestion.

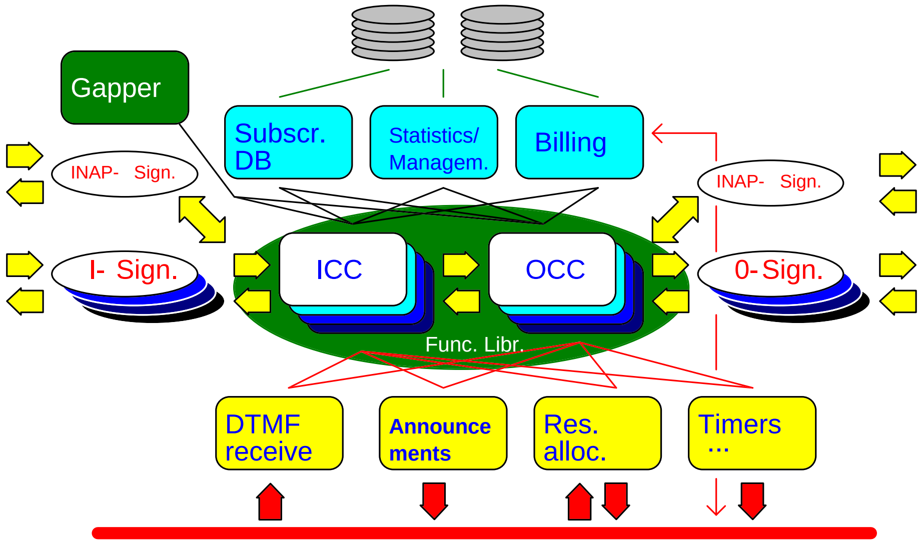

Fig 9: A MSC, upgraded with SSP capabilities.

The SCP is, by means of the INAP protocol, and a set of capabilities, the so called *Capability Set 1*, for example given the means to change the A-number of the call, block it, ask for more digits, control announcements, change the billing parameters and monitor the call. In other words, it is given full control over the further proceedings of the call if it exercises all its power.

IN-methods are today used mainly to adjust the billing of certain calls, and for simple number conversions (giving subscribers the possibility to keep their number when moving). However, as the technology is maturing, many new value-adding services might be introduced in the near future. And the location information of a mobile network could enable services such as children-watching or local advertisments over the mobile phone.

In order to understand how this technology affects routing, the following framework must be defined:

5.1. Basic Call State Model (BCSM)

To provide some generality regarding how a call is routed in an exchange, mobile or not, independent of network supplier or the configuration of the switch, ETSI has defined the following model, that defines how the call is processed in a switch during its lifetime. It is two-folded, and consists of an *incoming call state model*, which takes care of routing of the call, and defines the functionality of the exchange applied for an incoming call. The *outgoing call state model* is simpler, and equivalently defines the functionality at the terminating end of the call (from the exchange's point of view).

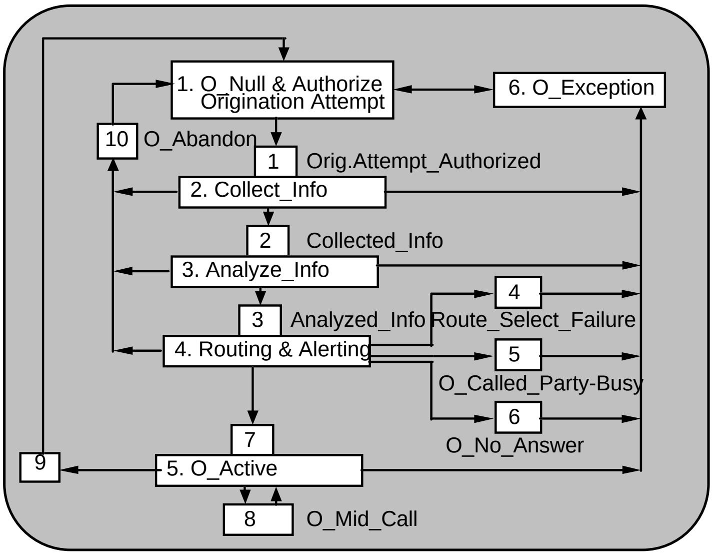

Fig 10: Basic Call State Model, originating side

The small boxes with a number in them denote *detection points*, i.e. such places in the call proceeding phase where the SCP might be given a chance to affect the call.

5.2. An IN-boosted Call

When IN services are provided in a GSM network, a service identification number, called a *trigger key*, is stored together with the subscriber data in the HLR. This data is propagated to the VLR that currently serves the subscriber e.g. when a location update is performed. This trigger key is converted into a *service key*, defining the service to be implemented, and a *detection point*, i.e. at which point in the call state model is the control to be handed over to the SCP. The conversion may depend on the time of day, and other parameters easily available to the exchange.

When the call has proceeded to the detection point where it is supposed to trigger to the SCP the routing of the call is stopped, and an InitialDP - message is sent to the SCP. The SCP makes some kind of a decision regarding the routing of the call based on the A- and B-numbers, possibly the SSs in use for the A- or B- subscriber, possibly the location of either, or based on any other information it has internally in its databases or is able to collect using external interfaces. The call can e.g. be rerouted, barred or continued (as explained above).

6. Feature interaction

Feature Interaction is when two (or more) network services interact. Usually the term is associated with non-logical network response fron the user’s point of view, caused by the abovementioned interaction. One typical example could be the interaction between GSM supplementary services and IN-services.

Example:

A company has a PABX, and the bosses’ mobiles have their CFB-services routed to their respective secretaries. The company upgrades from their old PABX to an intelligent solution, giving the same services, but IN-based within the public MSC/SSP. As the IN-services (in the MSCs) override the GSM supplementary services the new programming is done using these. But, one day:

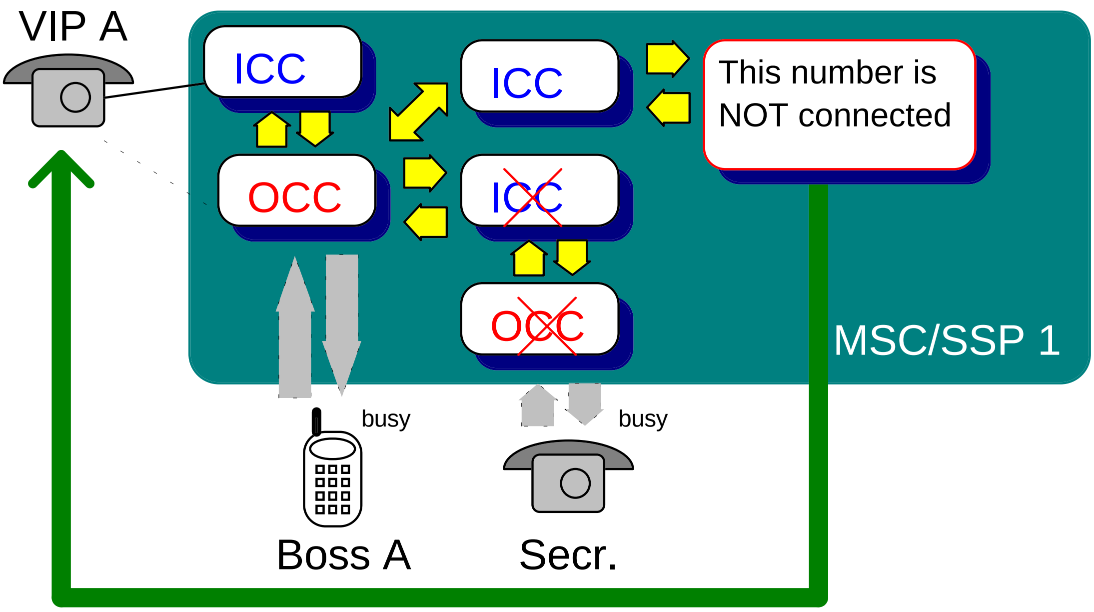

Fig 11: Feature interaction

The old call forwarding to the PABX has not been removed, and as the secretary is busy the call will be released up to the point where the IN-call forwarding of the boss fails. However, as the call at that point is released by the IN-service, and is treated as a normal mobile call the call forwarding of the GSM system is allowed to be used. But the old PABX has been removed from the network, and thus the confusing announcement to the caller.

7. Future Directions, Conclusions

As the previous text hopefully has shown, the complexity within mobile networks lies very much in mobility management and radio channel control (which as not belonging to routing has been more or less left out of this exposition). And as the routing in telephone networks in general is well structured, simple and easy to understand (even though there are many subtle routing problems emerging from the mere size of the network, regulatory issues, slowness of old equipment and the such) the interesting questions lie in concepts such as IN or SSs, where the routing is enhanced in some way (these can be thought to be yet an overlay layer of network structure).

Mobile networks are currently evolving towards better integration of other types of data (non-voice), better codecs for voice and better efficiency on the radio interface. Non of these directly affect routing. And even as the UMTS-consortium strives towards integration of satellite-based mobile communication into a land-and cell-based infrastructure, the routing in the actual network is more or less undisturbed - the base-station only takes off, so to say. Of course, satellite-based systems have more complicated handover procedures at the BS-level (both the BSs and the MSs move), and in some low-orbit systems (Iridium) where the call might be routed even between satellites there might be some additional procedures to take into account. But disregarding packet-switching (another seminar), the future of the routing in mobile networks seems to be quite static.

8. Abbreviations

ARP	AutoRadioPuhelin
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Tranceiver System
CDMA	Carrier Detect Multiple Access
ETSI	European Telecommunications Standards Institute
GMSC	Gateway MSC
HLR	Home Location Register
IMSI	Internationwl Mobile Subscriber Identity
ISDN	Integrated Services Digital Network
ISUP	Integrated Services User Part
IN	Intelligent Networks
LA	Location Area
MAP	Mobile Applications Part
MS	Mobile Station
MSC	Mobile Switching Centre
MSISDN	Mobile Station ISDN
NMT	Nordic Mobile Telephone
PABX	Public Access Branch EXchange
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
SCCP	Signalling Connection Control Part
SCP	Service Control Point
SIM	Subscriber Identity Module
SSP	Service Switching Point
SS7	Signalling System No 7.
TCAP	Transaction Capabilities Part
TDMA	Time Division Multiple Access
TMSI	Temporary IMSI
UMTS	Universal Mobile Telecommunications System

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