OPEN SERVICE PROVISIONING IN GSM - WHAT DO WE GAIN WITH CAMEL?

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Abstract - **The GSM Phase 2+ item CAMEL, which allows network operators to provide access to all the subscribed services including operator specific services even when the user is roaming internationally, is evaluated in depth.**

I. INTRODUCTION

One of the most important features of the entirety of GSM networks is the possibility to roam between networks - and thus between countries - by using one and the same subscription which means being reachable under the same number and receiving only one bill from the home-operator. This functionality can only be achieved with a strict standardization of network interfaces. This in turn means that non-standardized (i.e. proprietary, operator-specific) services introduced in a certain Home Public Land Mobile Network (HPLMN) will not be reachable when a subsriber of that network is roaming in a Visited Public Land Mobile Network (VPLMN).

The ETSI *Technical Specifications for a European digital cellular telecommunications system* comprise a set of well-defined services. These are subdivided into basic services and supplementary services. Today's telecommunication market shifts from providing basic telecommunication services towards integration of value added services. Differentiation from competitors, access to existing service provisioning equipment are two reasons for network operators to seek for solutions to cross this boundary of the standard services-set. This has been identified by ETSI and measures have been taken to allow for 'service roaming'. A feature that in its early times was called 'Support of PLMN specific services when roaming' and now answers to the name Customized Applications for Mobile network Enhanced Logic (CAMEL) is the key to an Intelligent Network (IN)-like environment, [01.78, 02.78, 03.78]. Implementing a subset of the ETSI Core-INAP [374-1] protocol stack the CAMEL mechanism can be regarded as the introduction of IN into GSM networks.

II. GSM

The Global System for Mobile communication (GSM) is a digital cellular radio network that offers telecommunication and bearer services. It has been primarily intended to provide telephony with vehicle-mounted, portable and hand-held mobile stations (MS).

The enhanced signalling procedures enable subscribers to roam between different GSM networks of different network providers, even while the terminal is switched on. Handovers between different networks ('*internetwork handover*') are however not possible. Beside terminal mobility GSM provides personal mobility within the borders of the GSM service area by means of a subscriber identity module (SIM), which is inserted in the terminal. The signalling supports automatic detection of the MS's location as well as authentication and registration of equipment and subscriber. The air interface operates at 900 MHz and uses narrow band TDMA, [Geu93, Mou92].

Starting as a Pan-European mobile network the GSM standard has been adopted by many countries outside Europe. ETSI standardizes the GSM system in the GSM specifications. The standardization is performed in different phases. Phase 1 specifications have been published in 1991. The standardization phase has been frozen, change requests may only be done in order to remove errors or to solve ambiguity. Most specifications of phase 2 are stable by now, while phase 2+ drafts are currently under discussion in the standardization committees. For phase 2+ standardization results are not expected before 1997.

The GSM system architecture is depicted in figure 1. It is basically divided into the Network and Switching Sub-System (NSS) and the Base Station Sub-System (BSS), [Adr95].

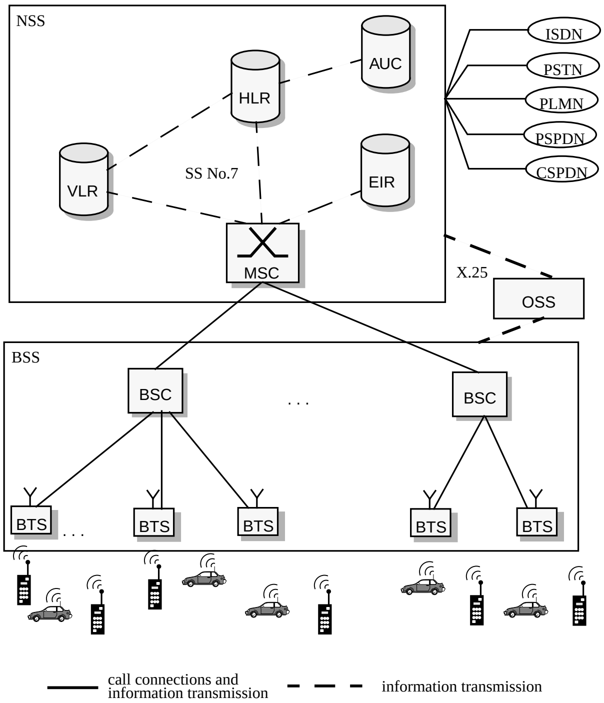

Figure 1: The GSM network

III. THE INTELLIGENT NETWORK (IN) CONCEPT

The IN concept has been developed in order to introduce new services, quickly and on top of an existing infrastructure, [Har96, Nie95]. It should enable rapid and cost effective introduction of new value added services that provide more functionality than basic telecommunication services. Thus IN fulfils the requirements for customer specific services.

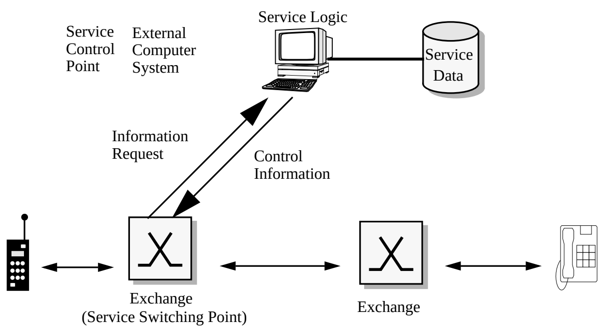

Figure 2: Separation of call and service control in an Intelligent Network (IN)

The basic principle of the IN concept is the separation of call control from service control. The signalling is performed out of band using the Signalling System No. 7 (SS7), [Küh94]. IN provides centralized access to shared data and dedicated servers as depicted in figure 2. It is a service oriented architecture for all types of services (for example real-time services and management services) on top of call control services.

The Freephone service is an example for an IN service that is available in PSTNs. Further examples for existing IN services in today's telecommunication networks are:

- Hotline
- Televoting
- Premium Rate

IV. CAMEL

The GSM system has been designed without consideration of the IN standard. Whereas the Mobile Application Part (MAP) protocol has been designed specifically for the GSM system, IN Application Protocol (INAP) has been intended to provide a platform for arbitrary applications in different networks. The IN concept focuses on the rapid introduction of new services whereas the influence of existing technologies is of minor importance.

Some network operators realized an IN-interface by adding a proprietary Service Data Function (SDF) interface to their Home Location Registers (HLRs) and using a modified INAP protocol between the HLR and an external node.

For the next GSM standardization phase a standardization issue called CAMEL is under discussion. It is more and more seen as a way to introduce IN in GSM. The network model for the introduction of CAMEL is depicted in figure 3 below.

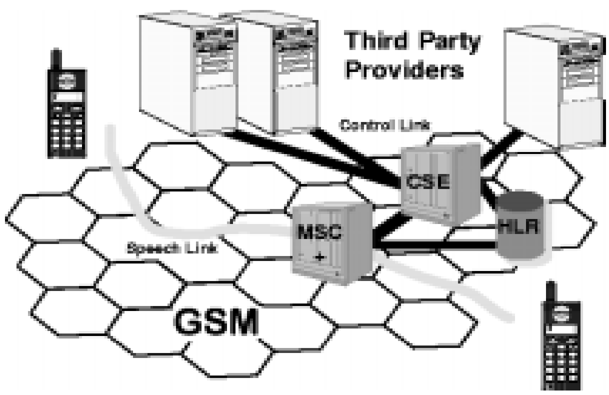

Figure 3: The principle of introducing CAMEL into GSM

The CAMEL feature allows the separation of service logic from the Mobile Switching Centre (MSC). Therefore a Service Switching Function (SSF) will be added to the MSC, and a so-called CAMEL Service Environment (CSE) will be introduced within the GSM network. This CSE contains a Service Control Function (SCF) similar to a traditional IN solution. With the help of CSEs Operator Specific Services (OSSs) can be offered to customers. The service logic of these OSS could be held totally within the CSE, or within the domain of a Third Party Provider (TPP), or partially in the CSE and partially in the TPP. This could be achieved through the IN reference points O, P, Q [Q.1211] or with the help of a Service Management Function (SMF). If the interface is realized with an IN reference point P or Q, which means that the TPP has only SDF functionality, there will be no distribution of service logic possible. In that case the whole service logic will reside within the CSE. Assuming that the CSE is under control of the PLMN operator, the network operator is able to scale the control of a TPP, [Har97].

[03.78] gives the possibility that the CSE and the HPLMN are controlled by different operators. This means that a TPPs can also have their own CSEs, implying security threats. Another problem is that up to now for each CAMEL subscriber there can only be one CSE addressed, which signifies that the mobile user can merely use services of one specific TPP.

Mobile Originating Calls

If an active originating CAMEL Subscription Information (CSI) is found in the VLR during the call set up of a MS, the Visited Service Switching Function (VSSF) sends an `InitialDetectionPoint` message to the gsmSCF and the VMSC suspends the call processing. The `InitialDetectionPoint` shall always contain the service key, called and calling party number, calling party's category, location number, bearer capability, event type Basic Call State Model (BCSM), location information and the International Mobile Station Identity (IMSI), [03.78]. After the service logic processing CAMEL specific handling is initiated from the gsmSCF, see figure 4.

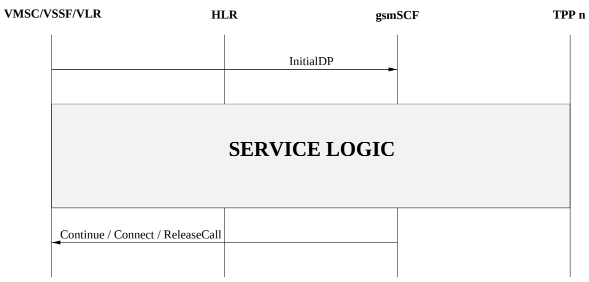

Figure 4: Signalling procedures for originating calls

Mobile Terminating Calls

In the case of mobile terminating call, the Gateway MSC (GMSC) in the interrogating PLMN identifies the HLR of the called party with the help of the MSISDN. Then the GMSC sends a `RoutingInformation-Request` to the HLR. The HLR checks the CSI of the called party and sends the information stored in the subscriber record back to the GMSC. Now, the GMSC acts according to CSI. If the terminating CSI is active the trigger criteria of a Detection Point (DP) is fulfilled and the call processing is suspended. An `InitialDP` message, which shall always contain the service key, called party number, event type BCSM and the IMSI is sent to the CSE and the service logic execution is started. Thereafter CAMEL specific handling is initiated, see figure 5.

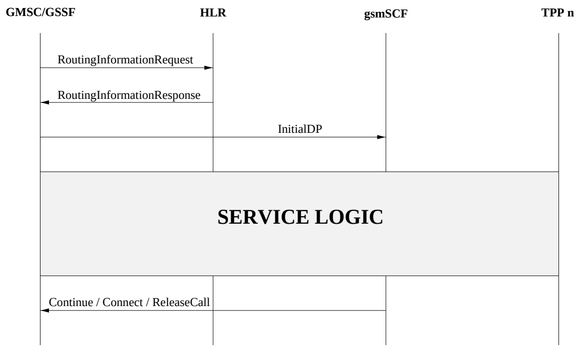

Figure 5: Signalling procedures for terminating calls

V. SECURITY ASPECTS

One of the advantages of CAMEL is that in the long-run network operators are enabled to provide services from third parties. The technical realization of this second step in broadening the GSM network for real open service provisioning is not difficult. It can be achieved by simply relaying the CAMEL Application Part (CAP) protocol through the CSE to a third party node. More difficult than the technical realization is the solution of security threats that emerge with the simple relay technique. The network operators will be very cautious when opening there signalling networks even to trusted third parties.One solution to this requirement is to run the actual service execution in the network operator's domain and only allow for off-line access for third parties. This can be done by defining a service script language to download service patterns from third party nodes. In IN terms this would mean the (partly) evacuation of the Service Management and Service Creation functions from the network operator domain. Figure 6 illustrates this approach.

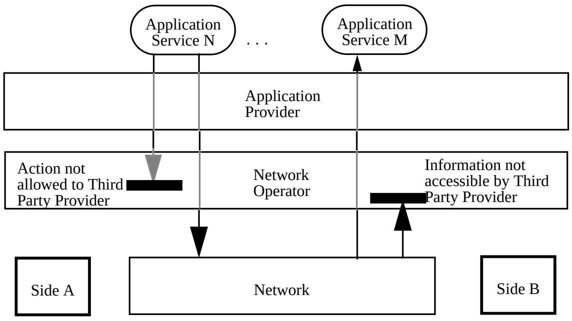

Figure 6: A security model to attach third party providers to a CAMEL Service Environment (CSE)

VI. PERFORMANCE EVALUATION

The goals of a performance evaluation are a performance *prediction* of non-existing systems, a *comparison* with existing systems and a *detection* of weak points and bottlenecks in future and existing systems, [Bol89].

The performance evaluation is based on the service provisioning scenarios presented in the previous chapter. These scenarios shall be used to introduce *new services*. Every newly introduced service may influence network performance and can possibly affect network safety. Consequently, new services except management services need to have:

1. **high speed** (real-time performance and quick service response times)
2. **high reliability** (high availability and accuracy)
3. **high security** (network security and user data integrity)

The best way to express the speed of a service is to measure the call-setup time called **post-selection delay** (ISDN term for the post-dialling delay, [E.600]). This is the time from the moment the user has dialed a number until the network reacts. It is the only delay which is measurable and noticeable for end-users.

The deployment of new services within the NSS of a GSM network will result in higher processor loads and longer post-selection delays. In the case of the CAMEL feature the elongation of the post-selection delay is the so called **service logic time**, see figure 7.

Reliable services guarantee a certain QoS. For the examination of the service reliability it is necessary to define acceptance thresholds, which should not be crossed for expected arrival rates. This will result in a guaranteed **throughput** of a service node. Moreover the **unavailability** of a system which is the probability that a system is in a failed state at a random point in time should be determined. For instance the unavailability of an MTP signalling route set should not exceed $1.9 \cdot 10^{-5}$, equaling a downtime of less than 10 minutes per year [Rüß95]. According to [Q.716] the unavailability of an SCCP relay point should not exceed 10^{-4}, equivalent to an actual downtime of about 53 minutes per year. Finally, if the service is available, its characteristics should be accurately fulfilled.

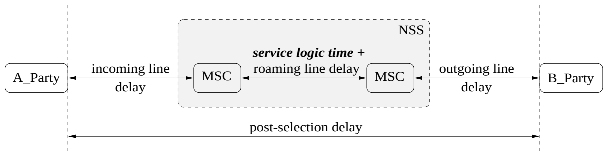

Figure 7: Additional delay of new service nodes

Last but not least new services should not affect the **network security** and the user data integrity. Therefore the network operator has to control or at least to monitor the actions taken by TPPs. This can only be achieved by a well structured interface between the network and the TPPs. However, security and reliability aspects are out of the scope of this report.

Analysis Outline

Deployment of the enhanced service provisioning methods require additional information to be transported by the signalling network. The introduction of a new service provisioning method increases the signalling network load, and may lead to a performance degradation of the signalling network, therefore affecting not only the QoS of new service provisioning methods, but also the services already offered by GSM.

The subscriber has an overall, “black-box” view of the network. The sum of the subscriber's experiences when using the system constitute the subscriber view. It is mostly related to quality issues such as e.g. the post-selection delay and probability that a call attempt fails. Subscriber accept certain delays within specific services, but excessive delays are seen as indicative of call failure and result in premature release or reattempts, worsening any network traffic load situation.

An analysis is a mathematical presentation of reality. The complete model for the entire signalling network includes extended queueing networks e.g. with full duplex flow controlled links, priority processors, segmenting and reassembling of messages. The exact analysis of such a large and complex system is far beyond the current knowledge, [Baf93]. Therefore in this thesis an approximation based on combined *decomposition* and *aggregation* technique is used, [Meh96].

The principle of decomposition is to break up a complex system into its subsystems in order to achieve a reduction in the complexity of the whole system. This assumption is valid if the interactions between the subsystems are largely dominated by the local interactions inside each subsystem. Assumptions have to reflect real behavior. Aggregation means to group similar actions and messages for similar reasons.

In this paper the network is decomposed into link sets, Signalling Points (SPs) and Signalling Transfer points (STPs). The global performance results, e.g. post-selection delays or message transfer times are obtained by composition of the submodels result. The advantages of this strategy are short calculation times, because the algorithms used are easy to program and rapid. Furthermore, through decomposition it is achieved that the results give a realistic idea of the relations between the parameters, because the impact of each parameter is comprehensible.

The services *Cellular Virtual Private Network* (CVPN), *Prepaid SIM/Calling Card* (PPSCC) and *Traffic/Tourist Information* (TTI) are used to evaluate the performance of the new service provisioning model described above.

Figures showing the “CAMEL service use in [%]” on the abscissa assuming the following service mix: 60% CVPN, 20% PPSCC and 20% TTI. This distribution takes into account that for service such as Hotline, Private Numbering Plan and Suppress of Announcements the same service logic (conditional number translation) is used which is unnecessarily implemented in the CVPN service.

VII. CONCLUSIONS

Based on the message sequence charts of the examined services and on the message lengths which have been evaluated the amount of signalling data that is transferred between the physical locations of the SSF and SCF can easily be calculated with the following equation:

$$\sum signallingdata = \sum CAPmessagelengths + n \cdot l_{header}$$

The results for each analyzed service are shown in table 1. Obviously for the PPSCC service the highest amount of signalling information has to be transferred over the SS7 signalling data links. Therefore it can be stated that the service times will be most critical for the PPSCC service, [Har97].

Service	SSF->CSE	CSE->SSF
CVPN	140 bytes (1)[a]	140 bytes (1)[a]
PPSCC	440 bytes (4)[a]	540 bytes (4)[a]
TTI	340 bytes (3)[a]	410 bytes (3)[a]

Table 1: Amount of signalling data

a. number of MSUs

Processing Times

The processing times vary depending on the processor type and on the number of parameters transmitted within the messages. The values shown in table 2 have been estimated for an Ericsson processor latest standard. The processing times are assumed to be known and constant.

Service	MSC/SSF/VLR processing time	CSE processing time
CVPN	4.9 ms	4.3 ms
PPSCC	7.7 ms	8.0 ms
TTI	7.7 ms	8.2 ms

Table 2: Processing times in SSP and SCP

Processor Load

In order to get a clear opinion about the feasibility of enhanced service provisioning methods a GSM network similar to german GSM network operator Mannesmann Mobilfunk, which is the largest private GSM network in the world, has been investigated. Furthermore, it has been assumed that the nodes and the links work under normal load (70%) and high load (84%), which is normally not the case. Finally, it should be mentioned that the number of calls is kept constant in this analysis.

Figure 8 shows the increase in the MSC processor load and CSE processor load as well as the increase of the link load when using CAMEL services. Whereas the MSC and the SS7 links are already working under normal load, the CSE processor is merely charged through idle load (5%). Obviously, it is the CSE anyhow which will first reach capacities problems when using only one CSE in the evaluated network configuration.

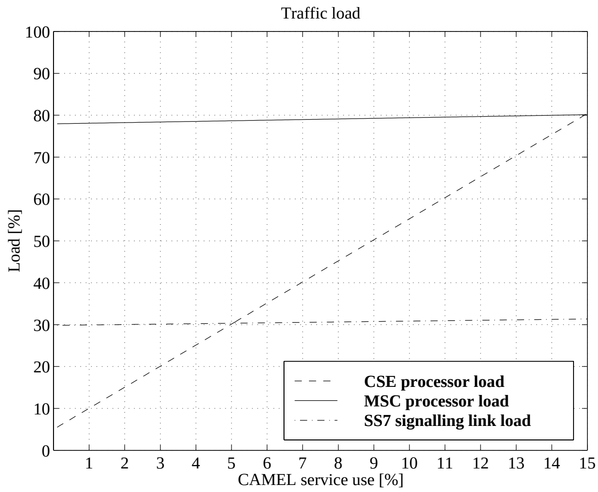

Figure 8: Processor and link load (high load)

The SS7 activity covered here take place between two MSCs, between an MSC and the CSE, or between an MSC and an HLR. Figure 9 shows the relative increase

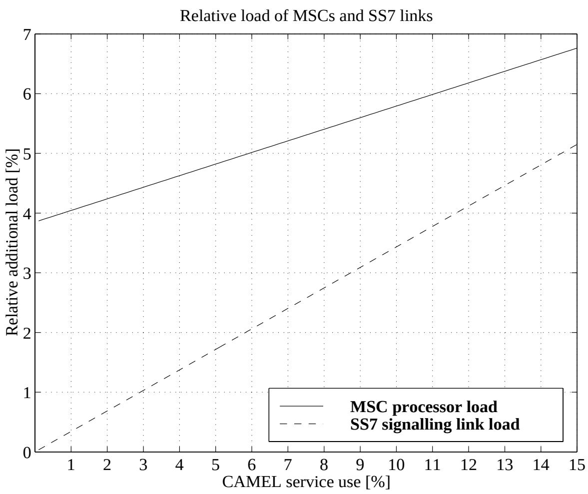

Figure 9: Rrelative load of MSCs and SS7 links

in the MSC load and link load. The additional MSC load starts at round about 4%, because with the introduction of CAMEL every call respectively subscriber has to be checked if she/he/it needs CAMEL support.

The analysis showed that the impact of the evaluated methods on the signalling links is nearly negligible. The increase of signalling link load is less than 4%, given that up to 10% of all calls use a CAMEL based service.

Taking a division of service logic and data between the CSE and a TPP into consideration it can be stated that the detachment of SCF and SDF functions would cause additional signalling overhead, but this represents no risk for the signalling network. However the services with multiple transactions, for example several user interactions and rerouting procedures, produce a noticeable increase on the signalling links.

Service Logic Times

The service logic time is the additional delay in the chain of actions in the SSF, the SCF and in STPs plus the propagation time of the channel. The mean service logic time of the CAMEL feature is illustrated in figure 10 in dependence of the MSC processor load and on the use of CAMEL based services. This graphs shows explicitly that the mean service logic time can be controlled through the MSC processor load.

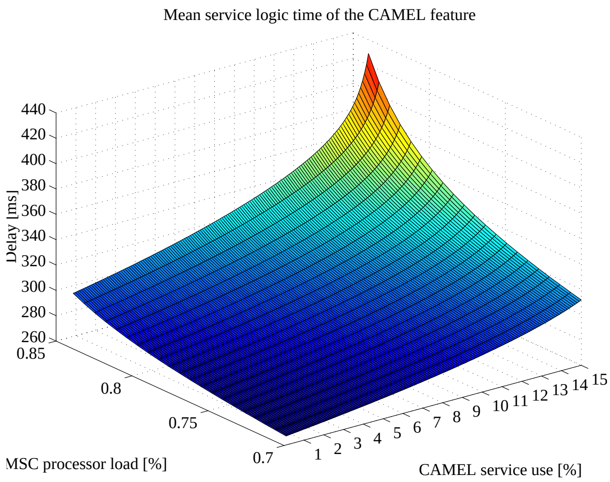

Figure 10: Service logic time dependent on service use and processor load:

VIII. BIBLIOGRAPHY

[01.78] ETSI TC-SMG. *Digital cellular telecommunication system; Requirements for the CAMEL feature.* GSM Recommendation 01.78, Version 0.2.0, June 1995.

[02.78] ETSI TC-SMG. *Digital cellular telecommunication system; CAMEL; Service definition (Stage 1).* GSM Recommendation 02.78, Version 5.0.0, July 1996.

[03.78] ETSI TC-SMG. *Digital cellular telecommunication system (Phase 2+); CAMEL.* GSM Recommendation 03.78; Version 0.9.0, July 1996.

[374-1] ETSI. *Intelligent Network; Core INAP; Part* ETS 300 374-1, September 1994, February 1996.

[Adr95] Adrian Marc. *Operator specific services in a GSM network using new enhancements of the Mobile Application Part protocol.* Master's thesis, Dep. of Communication Networks, RWTH Aachen, Germany, December 1995.

[Baf93] Bafutto M., Kühn P.J. *Capacity and Performance Analysis for Signaling Networks Supporting UPT.* Messung, Modellierung und Bewertung von Rechen- und Kommunikationssystemen. Springer-Verlag, 1993.

[Bol89] Bolch Gunter. *Leistungsbewertung von Rechensystemen mittels analytischer Warteschlangenmodelle.* B.G. Teubner (in German), 1989.

[E.600] ITU-T. *Telephone Network and ISDN; Terms and Definitions of Traffic Engineering.* Recommendation E.600, March 1993.

[Geu93] Geulen Eckhard. *UPT impact on GSM.* Master's thesis, Dep. of Communication Networks, RWTH Aachen, Germany, June 1993.

[Har96] Hartmann Jens. *Intelligent Network Services for Mobile Users.* Project work, Dep. of Computer Systems and Telematics, Norwegian Institute of Technology, University of Trondheim, Norway, February 1996.

[Har97] Hartmann Jens. *Performance evaluation of enhanced service provisioning methods within the cellular GSM mobile radio network.* Master's thesis, Dep. of Communication Networks, RWTH Aachen, Germany, April 1997.

[Küh94] Kühn Paul J., Pack Charles D., Skoog Ronald A. *Common Channel Signaling Networks: Past, Present, Future.* IEEE Journal Vol.12, No. 3, pp. 383-394, April 1994.

[Mat93] MATLAB® High-Performance Numeric Computation and Visualization Software. *User's Guide.* The MathWorks, Inc., July 1993.

[Meh96] Mehrholz Stephan. *Intelligente Netze: Analyse und Optimierung eines OSI-Anwendungsschicht-Protokolls für die Benutzer-Netzschnittstelle.* Master's thesis (in German), Dep. of Communication Networks, RWTH Aachen, Germany, January 1996.

[Mou92] Mouly Michel, Pautet Marie-Bernadette. *The GSM System for Mobile Communications.* Published by the authors, 1992.

[Nie95] Niebert Norbert. *Vermittlungssysteme.* Lecture papers (in German), Dep. of Communication Networks, RWTH Aachen, Germany, 1995.

[Q.716] ITU-T. *Specification of SS7 - SCCP Performance*. Recommendation Q.716, March 1993.

[Q.1211] ITU-T. *Introduction of IN Capability Set 1*. Recommendation Q.1211, March 1993.

[Rüß95] Rüßmann Michael. *Corporate Networks: Analysis of New Mobile Communication Services and Interfaces to the Public Network based on Intelligent Network Technology.* Master's thesis, Dep. of Communication Networks, RWTH Aachen, Germany, June 1995.