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INSIGNIA - A NEW APPROACH TOWARDS BROADBAND INTELLIGENT NETWORKS

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ABSTRACT

This contribution presents results from the European research project INSIGNIA (IN and B-ISDN Signalling Integration on ATM Platforms) which undertakes the specification, design, implementation and demonstration of a Broadband Intelligent Network. INSIGNIA aims at the provision of an adequate level of network intelligence for broadband multimedia and collaboration services by partially reusing concepts from the ITU-T Intelligent Network (IN) architecture.
In this paper, the functional architecture of a Broadband IN and its network elements is described. Main emphasis is on the newly introduced functionality which resides in the Service Switching Point (SSP), and in particular on session management functions. Object-oriented techniques are used to obtain a powerful model (IN Switching State Model) which describes the heart of the integrated IN/B-ISDN architecture. It is shown that the new functional model provides a viable compromise between typical IN architecture and a more abstract, object-oriented view of network resources.
Three actual implementations of broadband switches enhanced with IN capabilities are developed within INSIGNIA. The Siemens B-SSP is discussed in more detail with respect to the benefits of an object-oriented software development. The main aspects are the nearly seamless transitions from analysis to high-level design to low-level design and implementation. Finally, to investigate the behaviour of the INSIGNIA network under more realistic traffic load, a model for the simulation of the Siemens B-SSP was developed to study the performance of the INSIGNIA network with respect to the demonstrated services.

KEYWORDS:

INTELLIGENT NETWORK, BROADBAND ISDN, SIGNALLING, ATM, SWITCHING STATE MODEL, SWITCHING SOFTWARE, OBJECT-ORIENTATION, REUSE, TRIAL, SIMULATION, PERFORMANCE.

1. INTRODUCTION

Broadband networks are being realised throughout the world using ATM technology [1]. Currently, ATM wide-area networks are mainly used for the provision of high-speed communication links which are maintained over a relatively long time (permanent virtual connections) and which often carry an aggregation of diverse traffic (using e.g. the Internet protocol suite). With the next step in ATM network evolution, switched (dialled) virtual connections are becoming available, leading to the first stage of Broadband ISDN (B-ISDN). This evolutionary step will enable a much better usage of the potential of the ATM technology, i.e. individual connections with exactly defined Quality of Service (QoS) properties.

As soon as ATM switched connections will be made available by network operators in a large scale, a demand for a new class of applications will arise which make optimal use of the new technology. These applications will incorporate multimedia in an advanced form, including for example high-resolution real-time video over large distances, establishment of multiparty and multiconnection calls. Therefore, to optimally realise such applications, the network has to provide a higher level of intelligence than what is offered by B-ISDN signalling (Capability Set 1), which is just the establishment of point-to-point single-media connections between two parties with fixed attributes for the call lifetime. So the logical next step after the introduction of switched connections is the provision of network intelligence in order to adequately support multimedia services and collaborative work.

This paper presents the results of a European research project which addresses the intelligence required from broadband networks for advanced multimedia services. The project INSIGNIA (*IN* and B-ISDN *Sign*alling *I*ntegration on *A*TM Platforms) [3] takes a Broadband ISDN network (i.e. an ATM network with switched virtual connections) as its starting point. It investigates the intelligence functions required to support typical broadband multimedia services from the network side. It implements a prototype of a Broadband Intelligent Network by reusing as much as possible from the concepts of the classical "Intelligent Network" (IN) architecture [15].

INSIGNIA is a joint effort of 14 European organisations, comprising research institutions, network operators and telecommunication equipment manufacturers. The project realises a trial network infrastructure spread over three countries of Europe and practically demonstrates three different kinds of services.

2. SERVICES DEMONSTRATED BY INSIGNIA

In general, three kinds of services can be supported or provided by a B-ISDN: Basic network services, generic IN services and application services. Since basic network services and generic IN services are already provided by narrowband ISDN, the use of B-ISDN for application services, especially multimedia applications, was primarily investigated. In particular, the following multimedia applications supported by application services are selected to be demonstrated:

- Video-on-Demand service with an IN-based realisation of a brokerage and gateway function;
- High-end videoconference system with IN-based conference and connection management.

However, the following generic IN service was demonstrated by a Video Telephony application to show that the new concepts introduced for application services will also support the realisation of generic IN services:

- Broadband Virtual Private Network (B-VPN) service.

A more detailed description of these services can be found in [12]. The advantages to provide application services by the network compared with non-IN application services using only features provided by the user terminals or by servers outside the network is discussed in [14] and [4].

3. FUNCTIONAL ARCHITECTURE FOR A BROADBAND INTELLIGENT NETWORK

3.1 Network Elements for a Broadband Intelligent Network

Taking into account the requirements of multimedia services, the INSIGNIA architecture of a Broadband IN refines the classical IN [5]. The main enhancements are:

- In addition to the terms *call* and *bearer connection* which are part of the B-ISDN architecture, the concept of a *session* is introduced. A session is an association of calls and connections for the realisation of a single IN service. This network view of an IN service is located at the switching network elements; in classical IN terms it becomes part of the *Service Switching Point (SSP)*. The functionality of the SSP is generic and service-independent.

- Services are realised by Service Logic Programs running on special server computers called *Service Control Points (SCPs)* as in classical IN. The Service Logic Programs communicate with the SSP on a more abstract level than in classical IN. Instead of talking about states in call processing (Detection Points), the Service Logic is formulated in terms of operations on objects representing abstract call/connection configurations.

- For multimedia services, the used end systems are computers rather than telephone sets. Therefore, a multimedia service can be implemented in a distributed manner where service-specific software resides on the end systems. In order to free the SCPs from resource-intensive dialogues with the user, special network elements are introduced which carry out multimedia communication with the user and other service-specific tasks. To be compliant with IN terminology, these network elements are called *Broadband Intelligent Peripherals (B-IPs)*, although they are significantly different from the IPs in narrowband networks. Narrowband IPs are mainly announcement generators and digit receivers whereas the Broadband IP is based on a general-purpose computer.

2.2 Functional Architecture of a Broadband SSP

The ITU-T Recommendations Q.1214 [6] and Q.1224 [7] identify two functional entities for the provision of IN switching functionality. The *Call Control Function (CCF)* is responsible for the handling of (B-ISDN) calls in general, i.e. for IN-calls and non-IN-calls. The *Service Switching Function (SSF)* provides the set of functions required for interaction between the CCF and the Service Logic running on a Service Control Point (SCP). For this purpose, the CCF accepts certain instructions from the SSF and is able to report certain events to the SSF. There is an abstract model explaining the behaviour of the CCF in terms of a finite state machine, which is called the *Basic Call State Model (BCSM)*. In particular, the BCSM identifies a number of *Detection Points (DPs)* to define the possible event reports towards the SSF.

Figure 1 shows a functional model of a Broadband SSP used for INSIGNIA. It is based on the models defined in ITU-T Recommendations for IN Capability Set 1 (CS-1) [6] and the Recommendations for IN Capability Set 2 (CS-2) [7].

The main enhancement of the SSF is the capability to handle sessions. The main component of the SSF, the IN Switching Manager, maintains an object-oriented view of a whole session and offers this abstraction level to the SCP. The BCSM model is only valid for the Basic Call Manager and its interaction with the IN Switching Manager, but the external communication of the SSP to the SCP is based on the object-oriented session model.

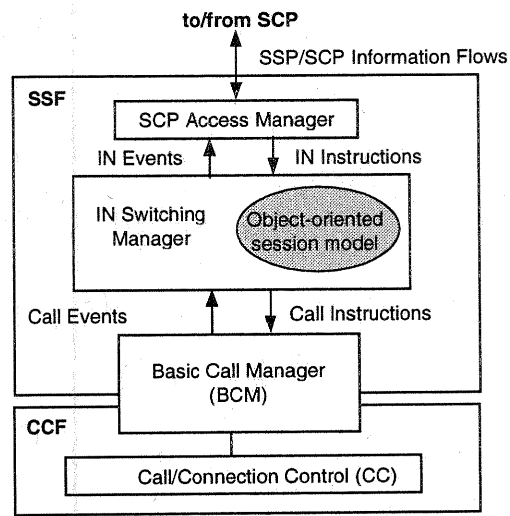

Figure 1: SSP Functional Model

INSIGNIA takes an approach to system specification which is based on the traditional functional decomposition used in the IN and B-ISDN standards, but tries to provide a smooth transition into a modern object-oriented specification. As an example, the so-called *IN Switching State Model (IN-SSM)* known from classical IN has been generalised to an object-oriented session model. Figure 2 shows the class diagram of the model according to the notation of the OMT method [9].

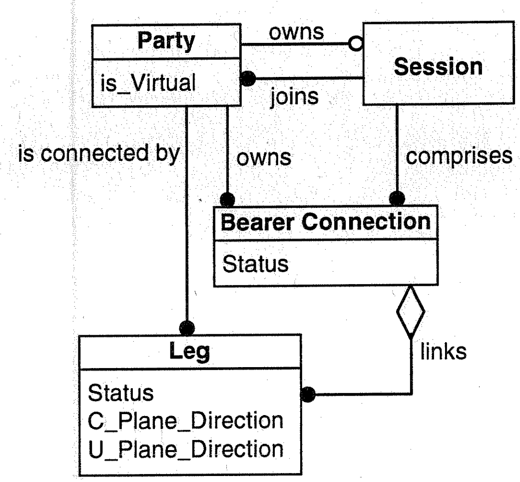

Figure 2: Object-Oriented Session Model of the IN-SSM

In the IN-SSM, a **session** is the representation of a complex call configuration, as it is seen by the IN functional entities.

Several **parties** can join a session. A party can either be an end user or a network component (e.g. the SCP), called a *virtual* party and distinguished by the attribute "is_Virtual". This allows modelling of SCP-initiated actions, for example connection establishment, connection transfer or connection release. One of the parties joining a session is the session *owner*, so at least one party joins a session. During a session, new parties can be added to or joined parties can be removed from a session.

Between the parties of a session, **bearer connections** can be established. A bearer connection is composed of several **legs**. A leg represents the communication path to a party which is connected to other parties by a bearer connection. If a bearer connection contains exactly two legs, it is a point-to-point connection. For point-to-multipoint connections each bearer connection has an association with more than two legs. A leg has two direction attributes: On the control plane (C_Plane_Direction), it can be incoming or outgoing (for the SSP), on the user plane (U_Plane_Direction), it can admit bi-directional traffic or form a unidirectional traffic source or sink.

For more information about the IN-SSM see [2] and [14].

4. OBJECT-ORIENTED IMPLEMENTATION OF A B-SSP

Within the INSIGNIA project, three different B-SSPs were developed on different platforms. As example, the following sections describe the Siemens B-SSP in more detail. Siemens used its prototype ATM Switch [11] as basis for the Siemens B-SSP. Especially the extension of the existing embedded, object oriented software (written in Object-CHILL) will be investigated

4.1 High Level Design

The development of the CCF and SSF functional blocks caused significantly different kinds of software adaptation. The CCF mainly comprises the usual B-ISDN signalling, which was already implemented in most of the platforms. Only the introduction of the feature of an SCP-initiated call was new for the CCF of each platform. Other small adaptations of the CCF were necessary to provide the CCF/SSF interface.

The design of the SSF, which had to be implemented nearly from the scratch, was eased by the seamless use of object oriented models from analysis to design. So the IN-SSM classes could directly be used for the object-oriented design of the software.

The software structure of the Siemens B-SSP, which is shown in figure 8, gives an impression of the required software modifications. This figure concentrates on the main new part, the SSF, and its interfaces to the other software components. The hatched parts of these interfacing components indicate that only small modifications were necessary to integrate the SSF into the existing software.

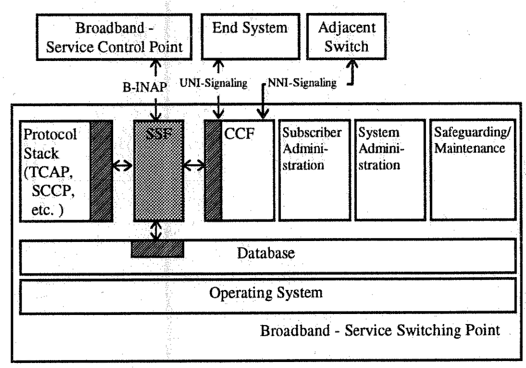

Figure 8: Software Structure of the Siemens B-SSP

Figure 9 shows the object model for the design of the SSF.

As can be easily seen, the classes of the IN-SSM are present within the design. Furthermore, some classes had to be added to provide the functionality of functional blocks of the SSF: An “SCP Access Manager”-object provides the functionality of the “SCP Access Manager” functional block for a session, and the “DP-Manager”-object performs the task of the “Basic Call Manager” functional block for a specific call.

The interfaces to other software components, as shown in figure 8, are refined to associations between objects within the different software components. The relationship between SCP and SSF is not shown anymore, because it is realised implicitly by the communication over the protocol stack. However, the INAP-Messages, which are exchanged between SCP and SSP, appear as methods of the Session class.

Another example for the refinement is the specialisation of the Bearer Connection class into a class for user-initiated calls and SCP-initiated calls. This reflects the fact that both kinds of calls are realised differently within the CCF, but, from the viewpoint of a session, there are no conceptual differences. Finally, the description of the IN-SSM classes are extended by methods and additional attributes for the design.

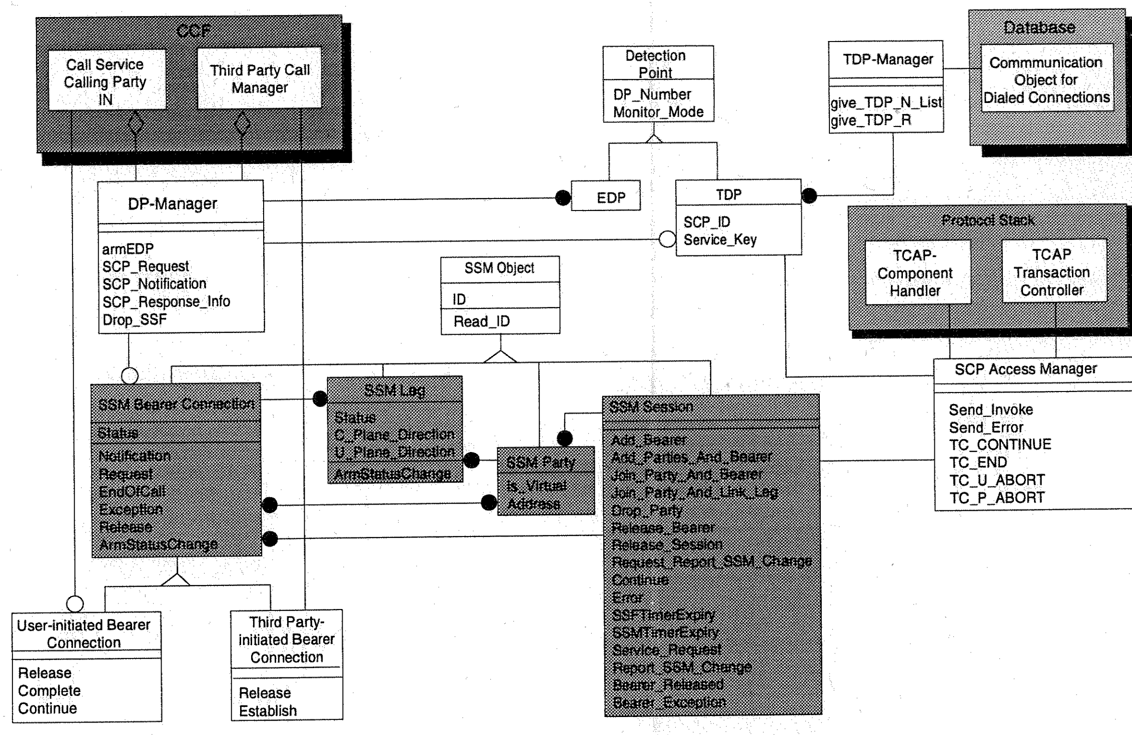

Figure 9: Design of the SSF for the Siemens B-SSP

Figure 10 gives an example of the dynamic behaviour of the objects, showing the invocation of methods during the set-up of an IN call.

4.2 Low Level Design

The object-oriented approach was not only used successfully for the high level design, but it also provided powerful means for the low level design and the coding. For the Siemens B-SSP, a significant part of the existing software could be reused. Earlier experiences with reuse at Siemens are documented in [11] and [13], where [13] discusses a very simple IN implementation which provided a starting point for the INSIGNIA development.

Some statistics about software reuse for the Siemens B-SSP can be found in [14].

5. TRIALS

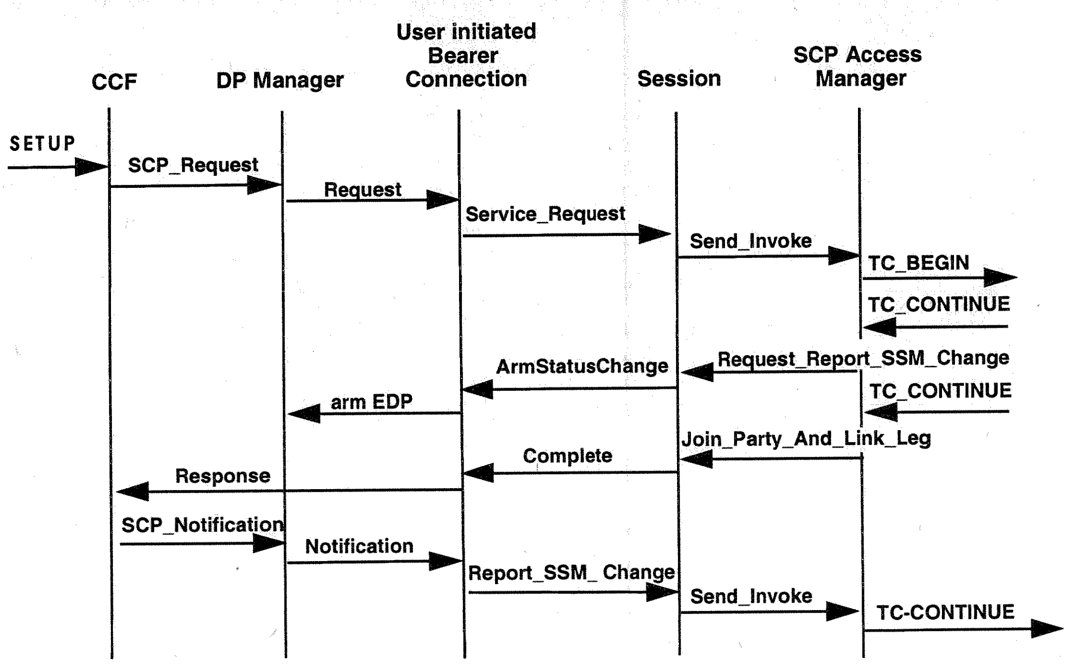

Figure 10: Communication between SSF-objects during the set-up of an IN call

The selected services were practically demonstrated by a prototype INSIGNIA network consisting mainly of four B-SSPs connected by an international ATM network. Besides local demonstrations, the following international scenarios were shown within a first trial in summer 1997:

- Video Telephony using B-VPN with terminals in Madrid and Munich;
- Video on Demand with CPE (Customer Premises Equipment) in Milano and a Video Server in Turin;
- Video Conference with terminals in Berlin, Munich and Madrid;

Within a second trial, enhancements of these services and new services will be demonstrated in the mid of 1998.

6. PERFORMANCE MODELLING AND SIMULATION STUDIES

Besides the demonstration of the INSIGNIA concepts, INSIGNIA networks and services are studied for performance issues [8]. To obtain performance results also for the individual network elements, the behaviour of the Siemens B-SSP was investigated in more detail. With the help of a model for the Siemens B-SSP (figure 11), simulations were performed to investigate the behaviour of the SSP under certain kinds of load. This model separates the processing into different phases. The phase TRIG distributes external messages to the appropriate phases responsible for processing these messages.

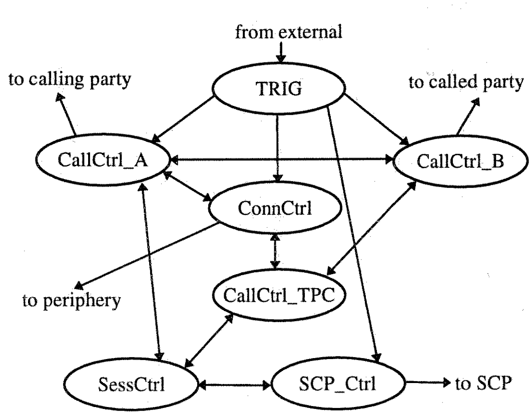

Figure 11: Performance Model of the Siemens B-SSP

The phase CallCtrl_A performs the communication with the calling party, whereas CallCtrl_B is responsible for the communication with the called party. ConnCtrl throughconnects the requested connection through the switch, and CallCtrl_TPC coordinates the two sides of a third party call. The phases SCP_Acc and SessCtrl represent the SSF within this model.

As an example, some results of these simulations for different kinds of traffic is presented. More results can be found in [10].

To show the portion of the IN extension on the occupancy of the system, the proportions between the processing time for the different phases is investigated for having only basic calls, only VPN-calls (figure 12) and only calls belonging to Video Conferences.

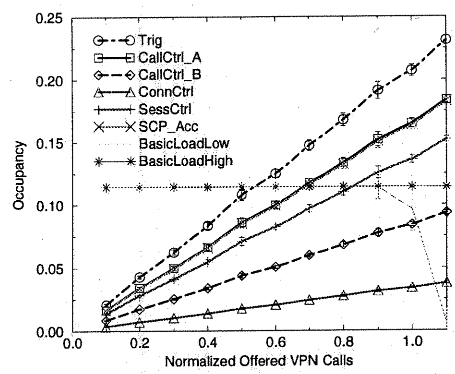

Figure 12: Proportions of phases for processing VPN calls

The processing of the calling side of a call occupies most of the processing time for basic calls. The situation is different for VPN-calls. Here, the IN-phases (SessCtl and SCP_Acc together) are superior to all other phases. Although one reason for this unfavourable behaviour is the prototypical implementation of the IN-extension (e.g. a not efficient implementation for the coding and decoding of the INAP-messages), this is an indication that the concepts introduced for supporting complex multimedia services by IN causes a very high overhead if these concepts are applied to a simple IN-service as the VPN. However, the results for the VC service show that there the IN phases become less expensive compared with the call processing phases.

Another kind of performance results are the mean response times for processing incoming messages. An important topic for investigation is the response time needed for processing the SETUP-message for an IN-call, which results in the sending of a CALL_PROC message. Figure

13 shows the differences of the response times for basic calls and VPN-calls. In particular, many user timers supervising the processing of the SETUP-message of VPN-calls will expire if the load exceeds 80% (with respect to the normalisation), whereas basic point to point (PtP) calls will not cause any timing problems.

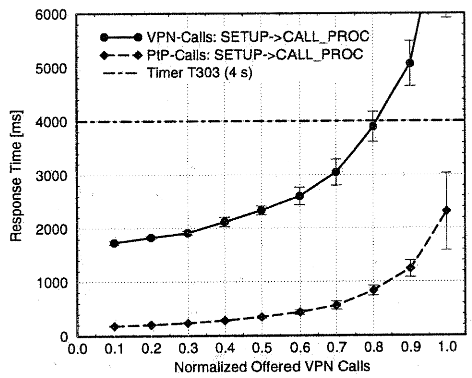

Figure 13: Mean response times for SETUP-messages

7. SUMMARY

This paper has shown an object-oriented approach towards Broadband Intelligent Networks. This approach is based on concepts of existing Narrowband Intelligent Networks, but provides additionally powerful mechanisms to add value to multimedia applications.

The INSIGNIA project gives a demonstration for the practical usability of this approach by setting up trial networks for a Broadband Intelligent Network providing Broadband IN services. In addition, the performance of an IN-based signalling network with INSIGNIA network elements is studied. INSIGNIA has already started to submit its results as input for ITU-T Study Group 11 into IN CS-3 standardisation.

REFERENCES

[1] Chen, Thomas, et al.: 'ATM Switching Systems', Artech House, Norwood, MA, 1995

[2] De Zen, Giovanna et al.: 'Proposal for an IN Switching State Model in an Integrated IN/B-ISDN Scenario', IS&N'97, *Fourth International Conference on Intelligence in Services and Networks*, Cernobbio, Italy, May 1997, pp. 179-188

[3] http://www.fokus.gmd.de/nthp/insignia

[4] Hussmann, Heinrich: 'Intelligent ATM Networks: Services and Realisation Alternatives', IS&N'97, *Fourth International Conference on Intelligence in Services and Networks*, Cernobbio, Italy, May 1997, pp 87-96

[5] ITU-T: 'Recommendations Q.1201 - Q.1205', *Study Group XI*, Helsinki, 1993

[6] ITU-T: 'Recommendation Q.1214', *Study Group XI*, Helsinki, 1993

[7] ITU-T: 'Recommendation Q.1224', *Study Group XI*, Nice, 1996

[8] Kolyvas, G.T., Polykalas, S.E. and Venieris, I.S: 'Performance Evaluation of Intelligent Signalling Servers for Broadband Multimedia Networks', *IEEE ICCS'97*, Alexandria, July 1997

[9] Rumbaugh, James et al.: 'Object-Oriented Modeling and Design', *Prentice Hall*, New Jersey, 1991

[10] Schwarz, Albrecht, Domschitz, Peter and van der Vekens, Alexander: 'Performance Modelling and Simulations Studies of a Broadband Service Switching Point', PMCCN'97, *International Conference on the Performance and Management of Complex Communication Networks*, Tsukuba, Japan, November 1997

[11] von der Straten, Gernot and Totzke, Juergen: 'An Object-Oriented Implementation of B-ISDN Signalling', SUPERCOMM/ICC 94, *IEEE International Conference on Communications*, New Orleans, 1994, pp. 885-890

[12] von der Straten, Gernot et al.: 'Realization of B-IN Services in a Multi-national ATM Network', ICIN'96, *4th International Conference on Intelligence in Networks*, Bordeaux, France, November 1996, pp. 41-46

[13] van der Vekens, Alexander: 'An Object-Oriented Implementation of B-ISDN Signalling - Part 2: Extendibility Stands the Test', 18. ICSE, *International Conference on Software Engineering*, Berlin, March 1996, pp. 125-132

[14] van der Vekens, Alexander et al.: 'Object-Oriented Realization of a Broadband Intelligent Network Architecture', ISS'97, Toronto, September 1997

[15] Wu, Tsong-Ho, et al.: 'ATM Signaling Transport Network Architectures and Analysis', *IEEE Communications Magazine*, December 1995, pp. 90-99