Multimedia Service Architectures - An Overview

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Abstract

Service architectures define the structure and operation of communication systems, which provide services for the user of a network. Today's services are characterized by a combined use of different media like audio, video and data to support multimedia. This paper presents a comparison of service architectures representing different approaches. For the discussion of the architectures we propose a model of the future communication market and the resulting requirements on services and architectures. Protocol based service architectures like B-ISDN and RACE/MAGIC, and open distributed service architectures like TINA are the main points of our description. Furthermore we explain an agent based resource architecture and discuss on the internet as a service architecture itself. The comparison focuses on the suitability of the different architectures for the upcoming multimedia services market.

1 Introduction

The provision of new information and communication services is the driving force behind new technologies. With the user's demand for multimedia services, which combine several different media for communication, strong requirements are set for the services and the enabling architectures. Since the transport networks are prepared to support multimedia services by broadband technologies like ATM, it is very interesting to have a closer look on the existing and upcoming service architectures now.

When using the term *service* in this paper, we consider multimedia telecommunication and information services, which provide the communication facilities of the network directly to the consumer. In this context a telecommunication and information *service* is defined as a means within a communication network to facilitate the exchange of information over the network [1]. This fulfills a certain purpose for the service user. A service is provided to the user via an access interface.

Applications are the parts of telecommunication and information systems, which bring the *services* to the users in an application specific context. In this way application programs make use of the above defined services in order to fulfill users' purposes also in areas, which go beyond information exchange. Multimedia information kiosk systems for example provide access to local information as well as to information from distant servers. They also may allow the users to contact a company's employee via a call center facility by video telephony

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for personal assistance during information retrieval. Teleeducation systems facilitating computer based "tele"-simulations and teacher–student teleconferences are another example of multimedia applications.

The structure and the operation of systems which provide telecommunication and information services are described by the *service architecture*. A service architecture is a set of modeling concepts and principles for the design of control systems, which realize the services. The service architecture includes the structure of its components and the interaction between them. It is the aim of a service architecture to facilitate the flexible installation and operation of telecommunication services during the whole life cycle [2].

Business model

Current deregulation efforts aim to reorganize the market for communication and information services according to the principles of a free market economy. Especially complex multimedia services will be deployed by cooperation of different providers. The *future telecommunications market* will present many providers, being eager to take part in the competition in all aspects. Services as well as service resources and communication connections will be part of the future multi-provider market. Concerning services the market will shift from a "universal services – one provider" to a "customized services – multi-provider" market, where services may be composed of services of other providers (3^{rd} party service provision). Providers on the resource level compete for the resources of multimedia services, i.e. connection segments and special resources, like converters or conference bridges, by offering them at different prices and with different quality properties.

Regarding the multitude of providers, the need for brokerage facilities will raise in the future market, which automatically or manually support the free selection of providers in order to meet the users' requirements in respect of e.g. service class, service content, prices, and QoS. In addition to these user oriented demands other requirements will be imposed by the future market model for services and also for the service architectures [3].

Requirements upon service architectures

The realization of *multimedia* services requires multiconnection and multi-party calls, the management of media interdependencies and the negotiation and dynamic modification of service and call parameters. In addition to that the raising customer demand for personalized services on heterogenous terminals has to be considered (*customization*). In order to facilitate universal personal service access *service mobility* aspects have to be regarded. Services have to be provided *independently* from the underlying networks. In this respect *multi-provider* service provision does not only mean a horizontal separation of service systems in service and network domains, but also a vertical separation between different providers, interworking to provide one service. *Scalability* and *performance* (quality of service) have to keep pace with the increasing complexity of services and the raising amount of users. Changing user demands and competition among providers *shorten* the *service life cycle.*

In the remainder of this paper we give an overview of different service architectures starting with the description of integrated services networks in section 2, including future developments of B-ISDN. The third section presents an advanced architecture for multimedia applications based on agent technology, which has been developed at our institute. Open distributed service architectures, especially TINA, are the focus of the next section. Finally we discuss the internet service architecture before concluding the paper with a short comparison of the different architectures.

2 Protocol based service architectures

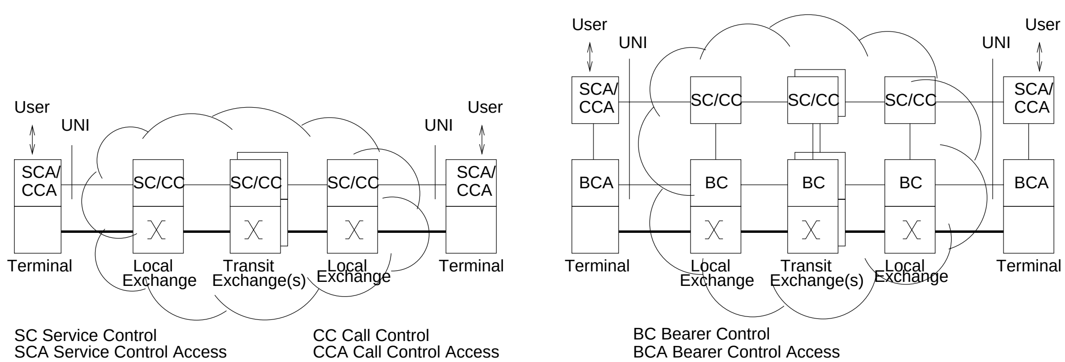
A lot of today's telecommunication systems are specialized in only one service. That means to have one network for each different telecommunication and information service. Since each service is provided by only one service provider, there is no functional separation between network and service. Service architectures like these are monolithic architectures, because open interfaces between different parts of the system are completely missing. The analog telephone system (POTS/PSTN), distribution networks for radio or television (e.g. cable TV - CATV) or data networks like X.25 packet networks are examples for service specific architectures. Of course service specific architectures are not suited for multimedia.

2.1 Integrated Services Digital Network (ISDN)

Digitalization of transport and switching technology has led to integrated services networks, which enable different services to be used through one user-network interface. The *Integrated Services Digital Network* (ISDN) provides various telecommunication services e.g. telephony, telefax, and data transfer over one universal, standardized user interface. Also multimedia services are forseen in ISDN (e.g. video telephony), but the transmission rate of 64kBit/s is not sufficient for complex multimedia services.

The service architecture of ISDN is embedded within the signaling protocols on the switching nodes. Service control is not centralized at one network node, but it can be regarded as distributed over the network.[1] Every single network node is part of the service control.

Customers can make use of the integrated and standardized services through access protocols (the ITU-T Q.931 protocol [4]) at the network interface (User Network Interface, UNI). There is no functional separation between service and call/connection control. The introduction of new services demands new protocols to be implemented in each switching node. As well as the service specific systems these protocol based service architectures are monolithic, since we have a very close integration of service control and network technology. Fig. 1a) shows a model of the ISDN architecture.



a) ISDN/B-ISDN Capability Set 1 - Architecture b) B-ISDN Capability Set 2 - Architecture

Figure 1: Integrated Services Digital Network (ISDN)

[1]Please note that this kind of distribution is quite different from the *computational* distribution, which will be described in section 4 of this paper.

2.2 Broadband ISDN

To cope with the increasing demand for bandwidth of multimedia services, the narrowband ISDN (N-ISDN), which is described above, has been further developed to *Broadband ISDN*. B-ISDN is also standardized by the ITU-T. Different evolution steps are marked as capability sets (CS). The UNI signaling protocol of CS 1 for example is described in the ITU-T recommendation Q.2931 [5].

From the separation of functions point of view, the CS 1 architecture is identical to the architecture of N-ISDN shown in fig. 1a). The transport system is based on ATM to support broadband, multimedia communication. Service and call/connection control are thightly related with each other and with the transport network. In B-ISDN CS 2 a separation between call and connection control has been realized. Fig. 1b) illustrates the functional separation of call and bearer control, a separation of the service control is still missing.

2.3 RACE project MAGIC

Several research projects have been dealing with the problem of further developing B-ISDN for future multimedia services. The project MAGIC (Multiservice Applications Governing Integrated Control) has been part of the European RACE (Research and Development in Advanced Communication Technologies in Europe) program and proposes an architecture for multimedia services including service control [6]. We will take it as an example of the possible evolution of protocol based distributed service architectures and to explain the principle of functional protocol layering.

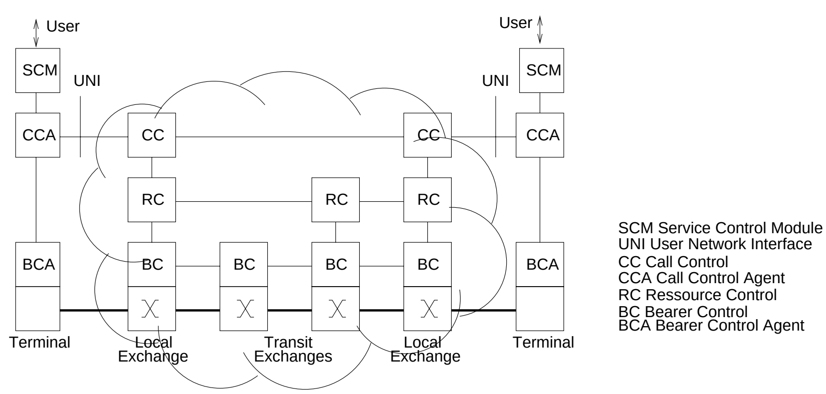


Figure 2: Functional architecture of RACE project MAGIC

Strict *functional layering*, as it is realized in MAGIC, separates the protocol based control of telecommunication networks into four main layers: bearer control, resource control, call control and service control. The lowest layer is the *bearer control* (connection control), which is responsible for the establishment of single connections. The connections may be point-to-point or – depending on the network – multipoint. The selection and control of special resources, e.g. conference bridges, is the task of the *resource control*. The *call control* deals with the handling of complex integrated multimedia call scenarios between the users of a service. To specify multimedia calls in a service independent manner MAGIC proposes an elaborated object-oriented call model. The functionality and the dynamic aspects of a certain service are controled in the *service control* layer. The service control of MAGIC is merely located in the users' terminals. Distributed applications can be built on top of the service control.

3 Agent based service architecture

As mentioned in the business model of section 1 a *future telecommunications market* will result in several new competitors and their service- respectively resource-offers on the service-, resource- and connectivity-layer. Especially competition at the lower layers will have the advantageous effect that the service-user can better adjust the service to his personal quality and price preferences by combining resource-offers from different providers. However the new freedom of choice will considerably increase the complexity of establishing a service.

A service architecture that takes into account the further liberalization of the telecommunications market will have as a main objective to best support the service user in the choice of appropriate providers. In particular the support should be at an abstract level enabling the selection among different service alternatives and thus relieving the user of comparing prices and quality of each single service resource.

Assisting in complex decisions represents a classical application area of agent technology [7]. Despite the huge variety of so-called agent-based decision systems some common functions can be identified: collecting and maintaining decision relevant informations, analysing them in the context of a concrete decision subject and autonomously providing solution alternatives to recommend to the human user for final decision.

The agent-based service architecture benefits from these "agency-like" functions to fulfill the above mentioned requirements. In detail it

- continuously gathers the offers for connection segments and special resources from different providers,
- accepts call requests at an abstract description level and acts on behalf of the user, when subsequently mapping the call request to a resource configuration and appropriate resources, and
- autonomously develops alternatives to the initial call request to fulfill user requirements on cost and quality as good as possible.

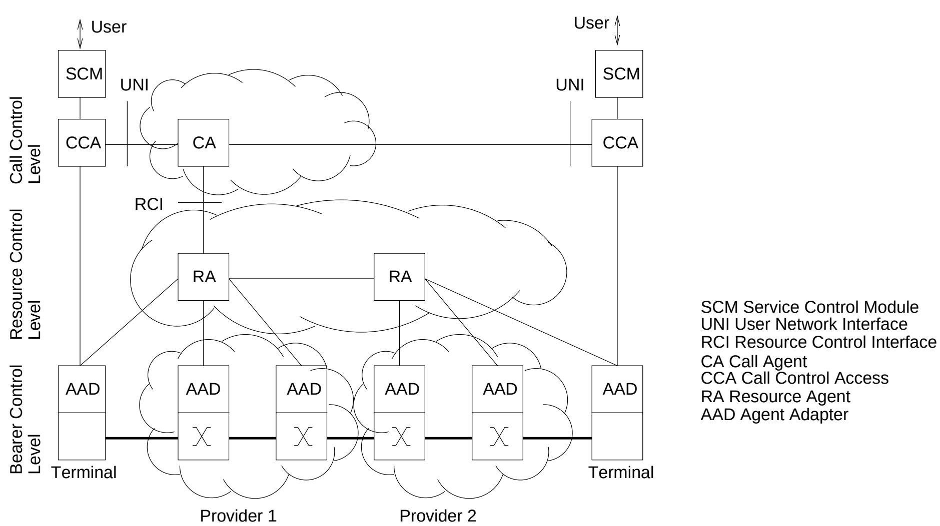


Figure 3: Agent based architecture

Figure 3 gives an overview of the architecture. It is roughly based on the layered architecture of the RACE / MAGIC project described in section 2.3. Each layer is considerably enhanced to perform the agency functions.

At the call control layer a single call agent acts on behalf of the call initiator to coordinate the other participants and to develop call alternatives. The user specifies his intended call via the user interface on the basis of an abstract call model or by choice of a predefined service. The call model contains media-quality limits giving to the call agent the possibility to develop call alternatives by iteratively degrading quality requirements in order to fulfill certain cost preferences.

In determining the resources for a call alternative the call agent is supported by the resource control layer. The latter offers a new brokerage facility providing the call agent with the necessary information about price and quality of a complete resource configuration. Given a standardized interface between call control and resource control the brokerage facility can be offered by a separate provider. The (iterative) verification of several call alternatives poses severe time constraints on the brokerage facility. Additionally the returned price information must be sufficiently precise while taking into account worldwide offers. These requirements are taken into consideration by the architecture and the function of the resource control:

- Time contraints ⇒ off-line information gathering: the provider permanently announces the newest offers to the resource control via a network management interface. As a consequence offers don't have to be requested but are already well-known at the time an inquiry from the call agent comes in.
- Manageability of worldwide resource offers ⇒ distributed control: it is not possible to manage the multitude of offers for one central resource control agent. The distributed realization of the resource control has the advantage, that each agent is responsible only for the offers of a geographically bounded area.
- Precision ⇒ agent cooperation: to determine the cost of a resource configuration as exactly as possible, requires that the agent knows the offers of remote areas additionally to his local resources. For that purpose agents cooperate by exchanging an aggregated view of the offers of their responsability area.

The cooperating resource control agents are structured hierarchically to achieve scalability of the agent-based service architecture. After having found appropriate resources for the intended multimedia service the resource control agents request the providers to reserve the resources via agent adapters. These give restricted access to the management functionality of the switching facility.

The agent-based service architecture evolves from the layered RACE / MAGIC architecture. The resource control layer is considerably enhanced to provide the brokerage facility which is essential on a liberalized telecommunication market. Given a standardized interface between resource control agents and providers would facilitate of the vertical separation at connectivity layer.

4 Open distributed service architectures: towards TINA

The service architectures described above are based on protocols between different protocol instances. Their functional separation has been described according to the layering principles mentioned in section 2.3. Nevertheless the provision of service control through different and independent providers is still a problem, because the separation of call and service control on different platforms is still not solved. In addition to that vertical separation between different providers on the same layer is missing in protocol based architectures. The agent based architecture only focuses on vertical separation on the resource and connection layers. The following section illustrates service architectures, which separate the service control from other network controls in order to facilitate different providers to control one service (or even parts of it) independently. To show the evolution, we begin with a very common and widely applicated service architecture, which is based on a centralized service control.

4.1 Intelligent Networks

The Intelligent Networks (IN) principle describes an architectural concept for the flexible creation and operation of supplementary telecommunication services. One central Service Control Point (SCP) provides supplementary services by the interaction with several Service Switching Points (SSP), which are strictly separated from the SCP by a standardized interface (see fig. 4). Implementing the Intelligent Network principle, the basic call process (BCP) has to be extended to form an SSP, which is able to determine supplementary service calls. In this way the IN is very dependent on the basic call (normally the telephone service) and its call model. The Intelligent Network is defined by the ITU-T in the IN series [8].

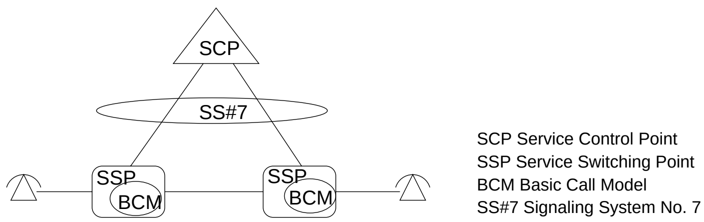


Figure 4: Intelligent Networks

The IN service architecture also defines the composition of services out of a set of Service Independent Building Blocks (SIBs). Different features of one service can be comfortably specified by this method. Service creation does not rely any more on protocols and signals, but is characterized by the composition of different features to form a specialized service. The INAP protocol, which is transported over SS#7 signaling networks [9], forms an *open* interface for different Providers to cooperate. Unfortunately, in spite of the standardization, almost every company has got its own INAP dialect, which all coexist and make interworking quite difficult. Regarding multimedia there are several research projects existing, which propose possible solutions for a broadband IN, e.g. [10].

4.2 Telecommunication Informations Networking Architecture (TINA)

Alternatives to the IN approach propose service architectures, where the service control is not centralized but distributed over different network nodes. The methods of distributed systems hide the network architecture completely from the service architecture by the introduction of middleware platforms. Most methods are based on the concepts of Open Distributed Processing (ODP).

ODP is a standard of the ITU-T [11] and provides a framework for the standardization of open, distributed systems for information exchange. It is the aim to support portability of the systems and to assure the interworking over different platforms. All distribution aspects are transparent to the programmer or user of the system. Concerning service architectures the introduction of middleware as a basic platform means separation of service control against network details.

It is the goal of the Telecommunication Informations Networking Architecture (TINA) to describe the characteristics of a world wide system of distributed processing, which integrates the control and the management of multimedia telecommunication and information systems [12]. TINA is based on the IN concept regarding separation of service and call control. It distributes the principle functions and additional TINA components over the network, supported by a middleware platform, that provides the signaling between the components (see fig. 5).

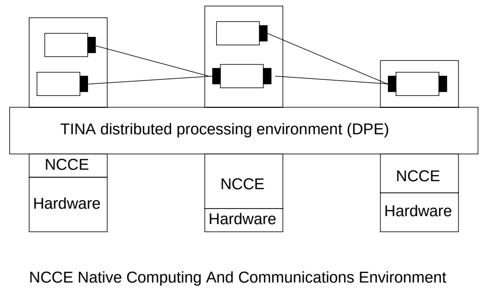


Figure 5: Using middleware for open distributed service architectures: TINA DPE

The TINA architecture is an *open* service architecture, since the interfaces of the service control are well defined to allow in principle many different providers to offer their services to the user in a multi-provider domain according to the proposed business model. The TINA business model reflects five domains: consumer, service provider, third party provider, broker, and network provider. The definition of the interfaces does not only include inter-domain interfaces, so called *Reference Points*, but also the interfaces between the TINA components within a domain.

TINA defines the service architecture [13] and also network and management architecture using components running on the same middleware. For a comparison with the protocol oriented architectures, fig. 6 shows both service and network architecture components of one provider and two user domains. For a flexible service provision TINA separates the service access from the service usage. The call model is replaced by a session model. An access session is mandatory for starting a service session. The components of the access session (asUAP, PA, IA, and UA) negotiate the user's access to all provider's services according to the contract of the user with the provider and create a service session on user's demand. Each service session is controled by a Service Session Manager (SSM), which is created by a Service Factory (SF) for each service. USM and ssUAP act on behalf of the user whithin the service session. The CSM controls the communication session and requests network connections from other components of the network architecture. The components of the TINA network architecture are also supported by the TINA DPE.

5 Internet service architecture

The Internet, or to be more precise, networks based on the IP protocol, already has realized the principle of an open, distributed architecture by a common, platform independent protocol stack. Due to the fast raise of the Internet from a pure data network to a world wide spanning information and – in future – even multimedia telecommunication network the internet holds a special role among service architectures, though currently a dedicated multimedia protocol is not part of the internet.

The traditional internet provides a very flexible environment for services e.g. FTP, Email, WWW, and News. Computer programs (layers 5-7 according to OSI) in the user terminals realize the services in the internet. Service installation and modification is completely independent from the network. The flexibility of the internet is based on the fact, that network operators only provide the TCP/IP protocol stack (middleware) and are not obliged to care

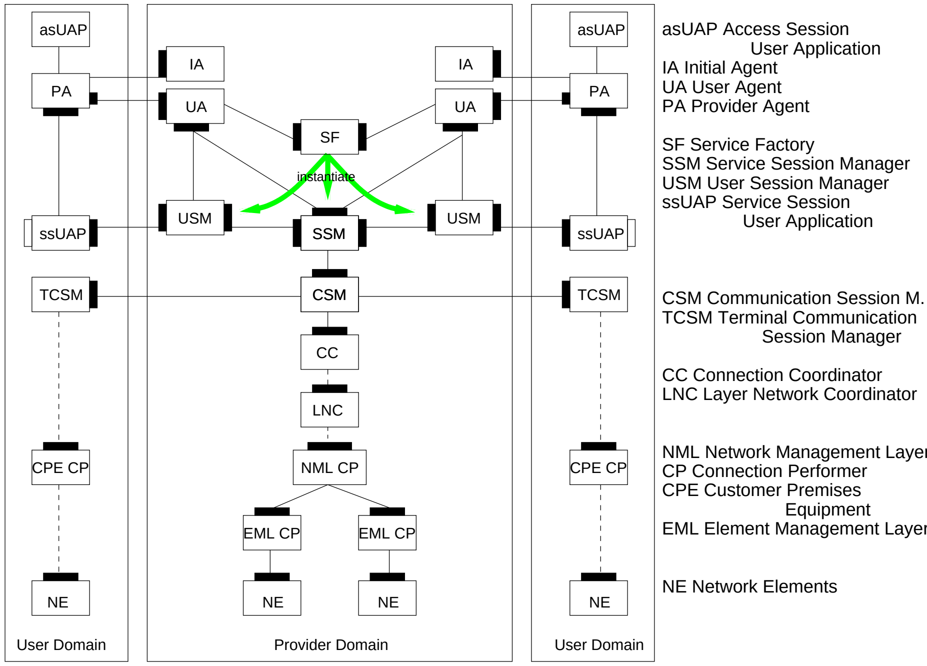


Figure 6: TINA Service und Network Architecture

about the services they are carrying. The effort of updating the programs in the user terminals, when introducing new services, is low compared to updates of ISDN signaling protocols in every switch. Software updates could be provided via the net itself, but scalability aspects for a huge amount of users are still open.

The most critical point of the internet for the provision of multimedia services is the performance of the IP network, which acts as a middleware and as transport network at the same time. Since the internet is just a best effort network, a certain quality of service can not be guaranteed. New approaches and advanced IP protocol versions (IPv6) are going to improve the QoS by resource management and bandwidth allocation, but this may have impact on the flexibility of the internet service architecture.

6 Comparison

Multiple interacting providers specialized on different functionality are the main characteristics of the liberalized telecommunication market, which is described by our business model in section 1. Service architectures should face these new challenges by supporting the interaction of providers at different functional layers (horizontal separation) as well as the competition of providers offering the same functionality (vertical separation).

The evolution of protocol based architectures demonstrates that the principle of horizontal separation has been fully recognized (ISDN, B-ISDN, RACE/MAGIC). Even the further distinction between a basic call layer and a service layer for additional call features has already been standardized (Intelligent Network).

Vertical separation fostering provider competition plays a minor role in state-of-the-art service architectures. Vertical separation can take place on the service layer and the resource layer (including special resources and network connection segments). The focus of agent based service architectures lies on the resource layer. Agency-like functions in an enhanced resource control provide a brokerage facility, which supports the service control in determining optimal network resources from competing providers.

The focus of future service architectures on the basis of open distributed systems (TINA) lies on the service layer. The structuring of complex service logic into well defined components with standardized interfaces is an important prerequisite for competition at the service layer. However a brokerage facility at the service layer enabling the user to choose between different service providers has not been specified yet. Service decomposition into components is also a necessary step towards faster service creation, although systematic service engineering methods are still missing.

References

[1] ITU-T. Recommendation I.112: Vocabulary of terms for ISDNs. ITU-T Study Group XVIII, Geneve, 1993.

[2] J. Hunt. Service Architecture. In: A. Clarke, M. Campolargo, and N. Karatzas (ed.), Bringing Telecommunication Services to the People - LNCS 998, Proceedings of IS&N'95. Springer, 1995.

[3] W. Kellerer. Dienstarchitekturen in der Telekommunikation - Evolution, Methoden und Vergleich. Technical Report TUM-LKN-TR-9801, Technische Universität München, 1998.

[4] ITU-T. Recommendation Q.931: Digital Subscriber Signalling System No.1 (DSS1) - ISDN User Network Interface Layer 3 Specification For Basic Call Control. ITU-T Study Group XI, Geneve, 1993.

[5] ITU-T. Recommendation Q.2931: Broadband Integrated Services Digital Network (B-ISDN) Digital Subscriber Signalling System No.2 (DSS 2) User Network Interface (UNI) Layer 3 Specification For Basic Call/Connection Control. ITU-T, Geneve, 1995.

[6] R. Knight. Service Description Framework and B-ISDN Service Descriptions. RACE project R2044 MAGIC, 1993.

[7] B. Quendt. A Signaling Concept for Multimedia-Applications on an open Telecommunication Market. In proceedings of the 2^{nd} international conference on the Practical Application of Intelligent Agents and Multi-Agent Technology (PAAM'97), London, 1997.

[8] ITU-T. Recommendation Q.1200: Q-Series Intelligent Network Recommendation Structure. ITU-T, Geneve, 1993.

[9] ITU-T. Recommendation Q.700: Introduction to CCITT Signalling System No. 7. ITU-T, Geneve, 1993.

[10] G. De Zen, L. Faglia, H. Hussmann, A. van der Vekens. Proposal for an IN Switching State Model in an Integrated IN/B-ISDN Scenario. In A. Mullery, M. Besson, M. Campolargo, R. Gobbi, R. Reed (eds.), Intelligence in Services and Networks: Technology for Cooperative Competition - LNCS 1238, Proceedings of IS&N'97. Springer, 1997.

[11] ITU-T. Recommendation X.903: Information Technology - Open Distributed Processing - Reference Model: Architecture. ITU-T, Geneve, 1995.

[12] M. Chapman, S. Montesi. TINA-C Overall Concepts and Principles, Version 1.0. TINA-C, 1995. URL: http://www.tinac.com

[13] L. Kristiansen. TINA-C Service Architecture, Version 5.0. TINA-C, 1997. URL: http://www.tinac.com