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Autor: Wehrli, Martin / Sawwaf, Ramzi / Diviani, Diego

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ATM NETWORK INFRASTRUCTURE

THE ATM NETWORK BUILDING BLOCKS

The requirements and expectations concerning the new, ATM-based networks are very demanding, not only on part of the user but also the suppliers.

The network elements tested in the ATM pilot network of Telecom PTT have demonstrated, however, that they satisfy the expectations and that they are fully capable of providing broadband services in the required quality and availability within the framework of the SwissWAN offered by Telecom PTT.

The ATM core network consists of powerful cross-connects, networked via high-speed connection lines of the synchronous digital hierarchy. This provides the access network with a

MARTIN WEHRLI, RAMZI SAWWAF
UND DIEGO DIVIANI, BERN

reliable and efficient Semipermanent Virtual Path Service (SVPS). By integrating a Connectionless Server (CLS), the widely used Connectionless Broadband Data Service (CDBS) can be implemented also in the otherwise strictly connection-oriented ATM network. The networking of DQDB Metropolitan Area Networks (MAN) via the ATM network and the availability of the SMDS/CDBS service across the existing infrastructure is made possible by a MAN ATM interworking unit.

The access network fulfills the important task to collect the potential data traffic which today is still largely generated on the basis of established and widely used protocols, to adapt it to ATM, and to concentrate it. This function is provided by flexible, modularly designed network elements, the service multiplexers, that offer to the customers a variety of services and interfaces for accessing the ATM network. In ad-

dition to SVPS also services such as circuit emulation, SMDS and LAN interconnection are part of the function repertoire of the service multiplexer. This means that Telecom PTT can offer already today a broad spectrum of attractive services via SwissWAN.

Topology

The topology of the new networks can be greatly simplified by using powerful ATM network nodes and optical transmission systems. It was already the case with the ATM pilot network, future public Wide Area Networks (WAN) will increasingly be set up with only two hierarchical levels, a core network and an access network (Fig. 1).

The core network consists of very large, high-performance Cross-Connects (CC) that function as nodes on the data highways and are fully interlinked to ensure high availability of the necessarily powerful transmission resources.

The ATM cross-connect handles fixed ATM connections and can be administered via an Operation and Maintenance (OAM) interface.

Since the ATM technology allows static multiplexing of data streams, better utilization of the costly transmission resources can be achieved, especially in the core area where the traffic volume is correspondingly high.

The decentralized and distributed data traffic which today, of course, is still based on established and widely used protocols, is adapted to ATM and concentrated by the access network.

Only few of the currently available terminals (CPE) are already able to generate 'native' ATM data streams. For this reason it is very important to

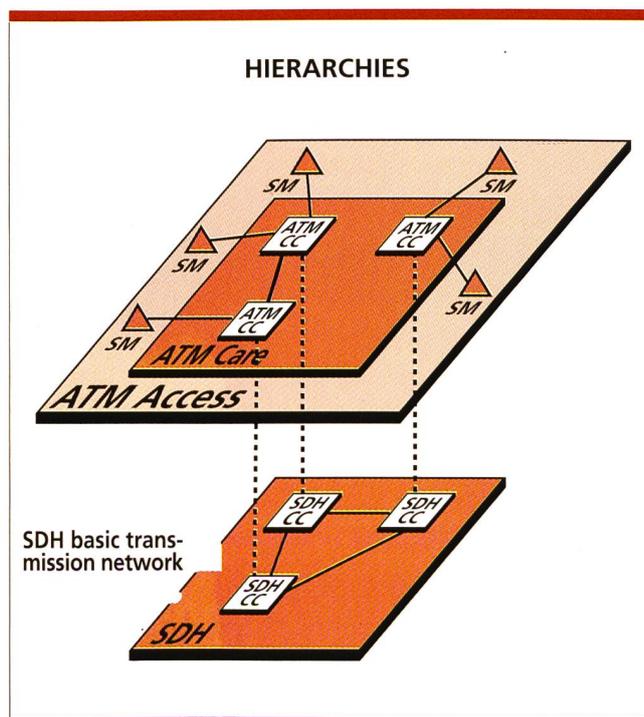


Fig. 1. Public wide area networks comprise two hierarchical levels: core and access network.

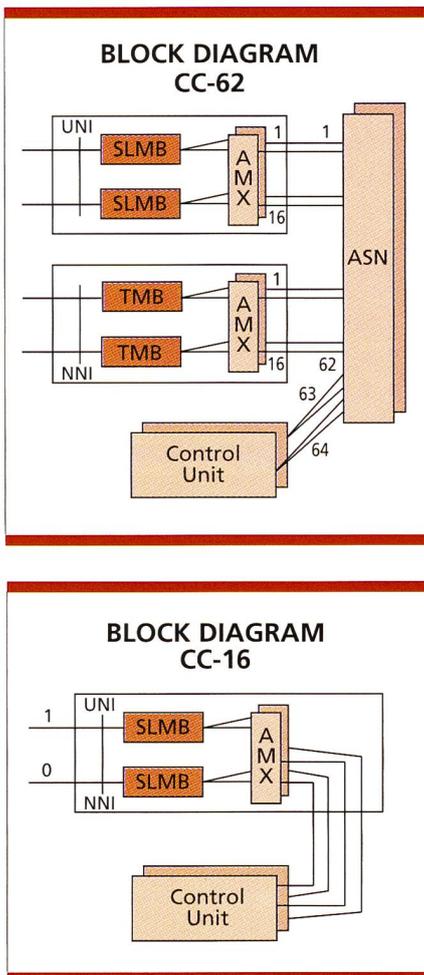


Fig. 2 Block diagram of an ATM cross-connect ATM-CC-62/16. SLMB: Subscriber Line Module Broadband; TMB: Trunk Module Broadband; UNI: User Network Interface; ASN: ATM Switching Network; AMX: ATM-Multiplexer (ATM-Max); NNI: Network Node Interface.

have adequate equipment available that can translate the currently used data communication protocols to ATM and vice versa. In this way the benefits of ATM can quickly be made available to a wide range of users. By interfacing the existing DQDB Metropolitan Area Networks (MAN) into the core network via corresponding Interworking Units (IWU) and by integrating Connectionless Servers (CLS), the connectionless services such as SMDS/CBDS which have already been introduced in MANs can be offered also in the wide-area sector across existing infrastructures.

ATM core network

On the one hand the ATM core network is the backbone network for the access network, but on the other hand it is based on the existing trans-

port network of the synchronous and plesiochronous digital hierarchy (SDH/PDH).

Network elements in the core area

The ATM VP Cross-Connect (ATM-CC)

The ATM Virtual Path (VP) cross-connects used in the core network route the ATM traffic from the high-speed transmission lines to the output port of the corresponding destination. This means that the individual ATM cells of a connection are dynamically routed via the internal switching matrix to the corresponding output port as a function of the address supplied in the cell header (VPI/VCI).

By multiplexing the incoming data streams and eliminating blank cells, high traffic concentration is achieved. Each incoming data stream is continuously monitored for compliance with the traffic profile that is admissible for the corresponding connection (usage/network parameter control (UPC/NPC), and if necessary compliance is enforced.

In the ATM CC network of Telecom PTT two types of Siemens VP cross-connects are used which differ principally in the maximum port configuration. The CC-16 can be configured with up to 16 ports, the CC-62 with up to 62 ports. Each port can be individually fitted with interfaces for SDH (STM-1) or PDH (E3) transmission lines. The entire CC, including setup and clearing of semipermanent virtual connections, is controlled via Operation And Maintenance (OAM) procedures from a central Network Management Center (NMC).

A simplified block diagram of a CC-62 and CC-16 is given in Figure 2.

Description of the function blocks: SLMB/TMB: Subscriber Line Module Broadband/Trunk Module Broadband. Adaptation/extraction of the internal ATM cell stream to the frame structure of the transmission system.

Monitoring of the incoming connections (UPC/NPC).

Generating the cell routing information by the matrix.

Exchange of the incoming VPI/VCI values by the VPI/CCI that is valid for the next link.

AMX/ASN: ATM multiplexer (ATM-MUX)/ATM switching network.

Redundant switching matrix in which both halves are active, that is, the ATM cells are routed in parallel by both halves.

GPE: Group processor.

All modules are controlled by a central unit; the control information with ATM connections is routed via the switching matrix of the CC (AMX/ASN).

UNI: User Network Interface.

NNI: Network Node Interface.

Due to the largely redundant design of the CC extremely high availability of this central network element is assured.

Connectionless Server (CLS)

In local and metropolitan networks, connectionless services such as Switched Multimegabit Data Services (SMDS) or Connectionless Broadband Data Services (CBDS) are already widely offered today. To ensure that these services can also be offered in the connection-oriented ATM network, a CLS must first supply them with the properties which are given by the structure of shared media networks: connectionless communication and distribution of messages to many destinations (multicast/broadcast). The CLS used in the pilot project provides the supplementary functions required for the connectionless service.

Design of the CLS

The CLS type Alcatel A1000 AX/ICLS used in this project basically conforms to the cross-connects; the modules that perform the connectionless server function (BMCLU) are connected to the switching network like the subscriber or trunk modules.

In the selected version up to eight BMCLUs with a unidirectional processing capacity of 44 Mbit/s each can be connected.

Functional description

The ATM network user is connected by means of a Virtual Path (VP) to the CLS either directly or via an intermediate node (Fig. 4). The virtual connection is terminated at an interface in the CLS.

Network access is provided either directly at the Connectionless Access Interface (CLAI) or by means of a digital service unit (DSU). The SMDS/CBDS traffic between the DSU/CLAI and CLS is handled via a VP connection.

This means that each subscriber packs all generated data, including destina-

tion and origination address (E164-based) into the CLNAP-PDU (Connectionless Network Access Protocol-Protocol Data Unit) and transmits these to the CLS. In the opposite direction the subscriber receives via the same link all data addressed to him by other subscribers (Fig. 4).

The individual VP connections between the service interface and the CLS are set up independently of each other and as required based on the parameters of the corresponding application. The CLS processes the received data, checks their conformity, and transmits them via the VP that corresponds to the destination address. When transmitting data the CLS performs traffic shaping, that is, the data are transmitted at a fixed, predefined bit rate independently of the received data signalling rate which means that the messages must be buffered.

By using a CLS, a large number of connections and considerable bandwidth can be saved if there is a large number of subscribers and virtual full networking is required. Whereas with CLS only one (CLS) connection per subscriber is required in the network, n subscribers without CLS require $n \times (n-1) / 2$ connections.

Due to the lower transmission costs the service with CLS can be offered at a much more attractive price.

Features of the CLS

The SMDS/CBDS service supports group addressing, that is, a message can have a destination address that relates to a group of subscribers. In such cases the CLS transmits a copy of the message to all group members under its control. In this way the transmission capacity to the CLS is used much more efficiently because the message is transmitted only once.

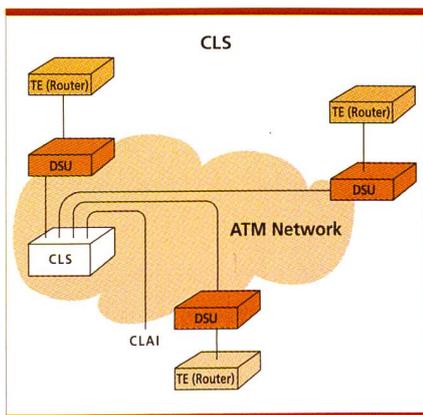


Fig. 4. Connectionless Server (CLS).

DEVELOPMENT IN THE CORE NETWORK AREA

The development in the core network area is characterized not only by the transition to faster trunks (622 Mbit/s, 2.5 Gbit/s,...) and more powerful CCs, but also strongly by the introduction of the signalization and VC switching (connection setup via subscriber signalization) which greatly enhances the flexibility and attractiveness of the ATM services.

The parallel improvements in today's ATM network and service management systems in the direction of intersystem Operations Systems (OS) will render the currently offered SVP service considerably more efficient.

To what extent and how fast the ATM core network will expand to the infrastructure of the N-ISDN depends largely on the availability of stable standards and corresponding network elements. Before complete interworking with N-ISDN becomes reality, partial interworking on the faster trunk level (2Mbit/s) will be established because in this case the problems with packeting delay and different subscriber facilities of the N-ISDN are still manageable. The penetration of equipment with ATM capability into the transit switching sector appears to be feasible and would at the same time improve the necessary coverage for the range of ATM services.

The CLS also has an address screening function. This means that it can validate the message flow from or to an access port based on the supplied address. Messages that are transmitted to or received from invalid addresses are rejected. This feature is very important and can, for example, be used for implementing a Virtual Private Network (VPN).

The integration of a CLS has little influence on the performance of the service handled via this unit. This has been demonstrated by various measurements in relevant applications.

Of course, the SMDS/CBDS service can also be offered internationally by connecting the CLS located in different countries via the Euro ATM pilot network. During the TeleNetCom 95 a corresponding application via SMDS/CBDS between a subscriber in Switzerland (Zurich) and Germany (Stuttgart) was demonstrated (Fig. 5). The connection was routed via a VP to the CLS in Zurich and from there via an additional VP ATM connection to the CLS in Stuttgart and from there to the other subscriber.

Performance parameters of the CLS

The Alcatel CLS A1000 AX/ICLS currently being used has a processing capacity of 308 Mbit/s or max. 159 000 packets/s. It is connected via 2x155 Mbit/s interfaces to the cross-connect in Zurich.

- traffic shaping for each outgoing ATM connection
- message/streaming mode principle
- Access Class Enforcement ACE

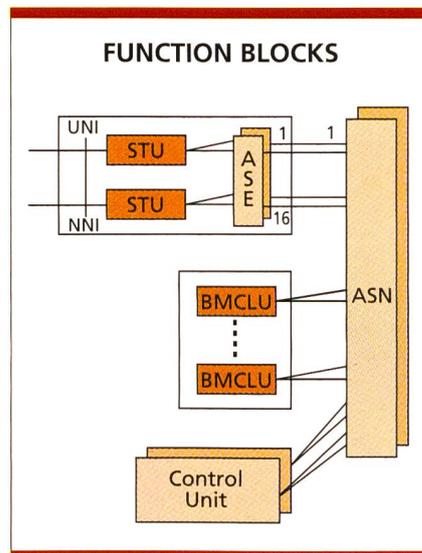


Fig. 3. Function blocks of the CLS.

- max. 256 users per server
- international transit server function
- transit delay by CLS <10 ms without, or <20 ms with encapsulation
- source and destination address screening function
- 256 group addresses with 128 subscribers each per server

MAN-ATM interworking unit

To satisfy the customer requirements for high-speed wide area network communication, Bellcore standardized the Switched Multimegabit Data Service (SMDS) and ETSI the compatible Connectionless Broadband Data Service (CBDS). These services are already widely supported by public as well as private networks based on

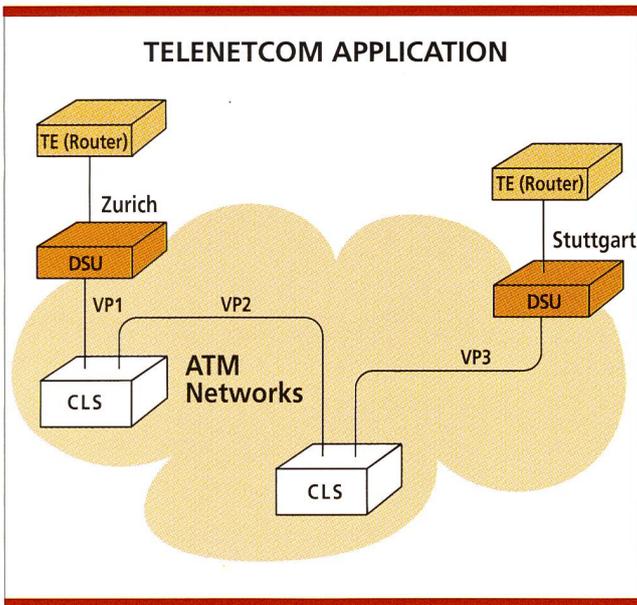


Fig. 5. Application via SMDS/CBDS during the TeleNetCom in Zurich.

technologies such as MAN-DQDB and ATM in metropolitan as well as wide area networks.

MAN and ATM network relationships

A reference scenario with respect to the MAN interconnection via ATM as well as the interworking of MAN SMDS user with ATM-CBDS user is illustrated in Figure 6.

This scenario shows that basically two communication types are possible:

- between subscribers on the same network (MANs interconnection via ATM-WAN)
- between subscribers on different networks (MAN-ATM interworking)

To provide these interworking interconnection functionalities, an additional network element, the MAN-ATM Interworking Unit (IWU) must be used. Each IWU is connected either to the CLS through semipermanent virtual connections, or directly to other IWUs.

Functions of the IWU

The interface between the IWU and the ATM network, a MAN-ATM Interface (MAI) based on the ATM-NNI or UNI for private MANs, allows the transparent transfer of the end user connectionless data messages SMDS/CBDS.

This MAI interface can operate in two modes: the first in which the MAN and the ATM network belong to the same Public Network Operator and the second, in which they belong to different Public Network Operator.

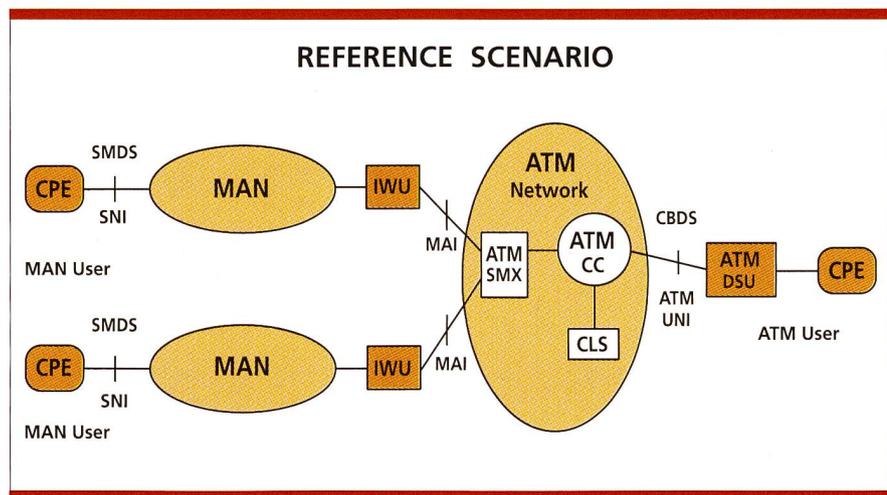


Fig. 6. Networking reference scenario.

According to the reference scenario in Figure 6 the ATM based network provide the transport of the connectionless (CL) data units SMDS/CBDS between the IWU and the CLS with a permanent or a semipermanent pre-established connection (VP/VC).

In particular, the IWU performs routing functions with the destination address analyse of the connectionless information SMDS/CBDS and the send on a specific ATM connection (VPI/VCI). In the interconnection of MANs via ATM as well as in the interworking of MAN and ATM, the IWU provide the transfer of the complete CL message towards the two environment MAN/ATM. This solution is named frame mode IWU.

ATM cells are fully reassembled into messages before the protocol conver-

sion and the segmentation into slots MAN-DQDB or vice versa. Protocol stacks MAN-DQDB/SMDS and ATM/CBDS are fully implemented. The relationship between the protocols of the two environment MAN and ATM is shown in Figure 7.

Evolution of the IWU

It is reasonable to expect that a universal IWU for isochronous as well as asynchronous services based on a 'Cell-to-Slot' solution will soon be available. This allows direct mapping of the user data from ATM cells into DQDB slots and vice versa. Segmentation and reassembly functions become superfluous. Fast interworking would be possible because only a

single cell have to be stored. It would be advantageous if the IWU were integrated directly as an interface in an ATM-CC or service multiplexer.

Supplying the network services for the ATM core sector

The core network offers the following network services to the access network:

Semipermanent Virtual Path Bearer Service (SVPS)

This service allows unrestricted transport of ATM cells between two termination points of a Virtual Path (VP) or Virtual Channel (VC). The format of the cells corresponds to the ITU-T re-

commendation I.361. The information can be transmitted with a constant or variable cell rate, balanced or unbalanced, bi-directional or unidirectional. The maximum transfer rate per connection is within the range of 64 kbit/s to 135 Mbit/s that can be selected in fine increments but remains fixed for a defined period of time. According to I.361 256 virtual paths can be defined for each interface.

The maximum admissible data rate (UPC/NPC) is monitored for each VP. It is possible to test for each VP either the Peak Cell Rate (PCR), or Sustainable Cell Rate (SCR). If there is a high content of traffic conventions based on SCR, a throughput gain is achievable on the corresponding transmission line though controlled 'statistical multiplexing'.

Connectionless Broadband Data Service (CBDS)

The SMDS/CBDS service handled by the Connectionless Server (CLS) can be offered on each interface of the core network. Access is provided via the Connectionless Access Interface (CLAI) through the Connectionless Network Access Protocol (CLNAP).

Connection setup

After prior agreement with the NMC a connection can be set up permanently, periodically or on request (Fig. 8). The period can be defined either as a day or week. The granularity of the time has recently been defined as 15 min and the bit rage granularity as 64 kbit/s.

The traffic profile admitted and monitored for each VP can be agreed upon either based on PCR or SCR.

Interfaces in the ATM core network

The services of the core network are offered via the following interfaces:

- PDH E3 34 Mbit/s, frame structure according to G.804/G.832, electrical interface according to G.703
- PDH E3 34 Mbit/s, frame structure according to G.751/ETS 300 214 with embedded PLCP, electrical interface according to G.703
- SDH STM-1 155 Mbit/s, electrical according to G.709, frame structure according to 1.432. ATM cells directly in C4

The cell transmission capacity available as a function of the type of interface is summarized in Table 1.

Transmission system	Transmission bit rate	Bit rate available for ATM cells	Informations transfer rate (available)
STM-1	155 520 Kbit/s	149 760 Kbit/s	115 286 Kbit/s
E3 (G.804/G.832)	34 368 Kbit/s	33 920 Kbit/s	24 576 Kbit/s
E3 (G.751/PLCP)	34 368 Kbit/s	30 528 Kbit/s	22 118 Kbit/s

Table 1. Available cell transmission capacity.

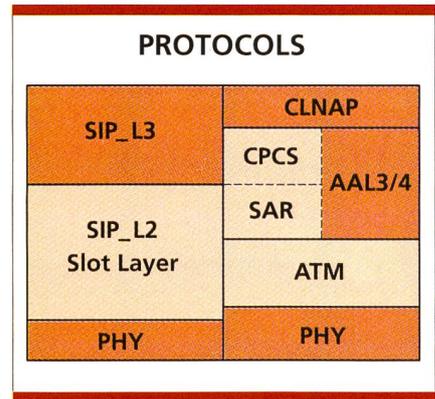


Fig. 7 Protocols and relationships between MAN/SMDS and ATM/CBDS.

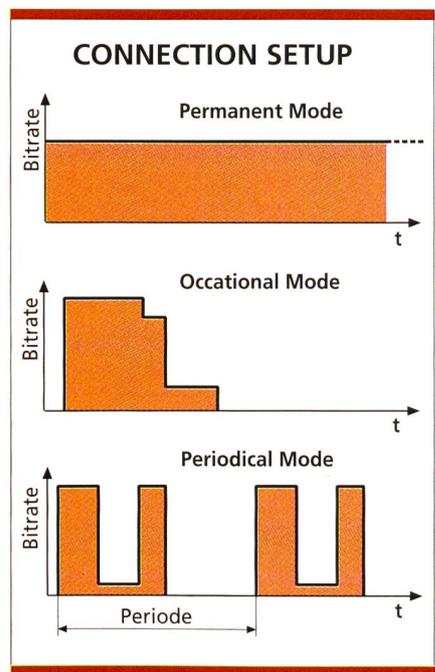


Fig. 8 Connection setup after prior convention with the NMC.



Martin Wehrli holds an HTL degree in electrical engineering, specializing in EMRT. He is responsible for the ATM Technology Unit in the Strategies and Systems Section N31, Transmission Division N3, at Telecom PTT.



Ramzi Sawwaf, born in Buenos Aires, Argentina. He received degrees in Economics and Mathematics at the University of Fribourg and the «Ingenieur» degree in Computer Science at the Swiss Institute of Technology (EPFL) in Lausanne. Since 1987 he has worked in the telecommunication area. In 1991 he joined the Research and Development department of Swiss Telecom PTT where he currently leads the Broadband Networks group. He has been involved in the specification, evaluation and testing of the Swiss ATM Pilot. He is the Swiss Telecom PTT representative in the Technical Working Group of the European ATM Pilot.



Diego Diviani, grad. from the Swiss Federal Institute of Technology (ETH), started working for the Swiss Telecom PTT R&D in 1991. He participated at the service concept definition and evaluation of the SwissMAN-DQDB. He was involved with consulting and engineering for SwissMAN customer projects (KOMBV1 the most important). Member of the ETSI STC NA5. In 1994/95, he collaborated at the SwissWAN services definition. Actually, he is responsible for the MAN/ATM interworking activities within the Swiss Telecom R&D and also for the broadband network services integration in the private and/or shared network domain.

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