ATM passive optical network access facilities

BONAPARTE:

ATM Passive Optical Network Access Facilities

The BONAPARTE project has demonstrated that ATM PON systems are a viable way to provide access to broadband communications. This has been achieved by realising and ATM PON Access Network (AN) suitable for deployment in real communication environments, by developing user friendly multimedia applications and by carrying out telemedicine and teleteaching trials involving real users. A key result of BONAPARTE is the enhancement of the ATM PON prototype system, so that the new system is suitable for deployment in a realistic environment. The result is a "composite" one, i.e., the addition of a number of new features on top of those offered by the existing system. Important new features are the OAM F4 flow functionality, the automatic failure recovery, the VB5.1 interface between the access node and the service node, the new User Network Interface cards, and the management system which spans from the network element layer to the network layer.

The main goal of the project is to enhance the access system prototype inherited from the RACE II project and make it suitable to the realistic scenarios.

RAJKO POROBIC, BERN AND MARIO LUONI, LAUSANNE

Overview

The RACE system is an ATM PON, i.e. it is based on a Passive Optical Network (PON) infrastructure and the transfer mode is ATM. The PON topology is tree-and-branch. At the head-end of the PON, the so called Optical Line Termination (OLT) is located, as shown in figure 1. At each branch there is an Optical Network Unit (ONU), used for fibre to the curb (FTTC) configurations, or an Optical Network Termination (ONT), used in fibre to the home (FTTH) configurations. A proprietary management protocol through the M interface provides for management operations on the network element.
The main characteristics of the Access Network prototype are:
– 622 Mbit/s upstream and downstream;
– upstream transport is realised by means of a TDMA technique and a medium access control protocol that allows dynamic assignment of bandwidth;
– the maximum splitting factor of the optical distribution network is 32;
– a maximum of 81 TB-interfaces can be offered;

– 4 interfaces at the VB-side are present;
– the 1300 nm wavelength window is used, while the 1550 nm window is left available for other services (e.g. CATV);
– maximum fiber length between OLT and ONU is 10 km;
– the system is transparent for user-to-network signalling;
– routing of ATM cells, usage parameter control and cell header translation are based on the virtual path identifier;
Figure 2 shows, on top of the platform inherited from RACE, the set of enhancements developed in the project.
– A TMN based on ITU-T-recommendation M.3010. The ATM network management OS in the Italian Host and the Access Network element management OS are enhanced versions of legacy systems while the Access Network management OS is a completely new design.
– OAM F4 flow functionality according to ITU-T-recommendation I.610. This enhancement encompasses hardware and software functions in the network element and an OAM application in the ANEM-OS.
– Automatic fault recovery procedures as well as a set of hardware and software enhancements to increase the availability and robustness of the system. Some of these hardware and software enhancements are the redesign of the Bit Slot Synchroniser (BSS) device, the redesign of the optical board in the ONU and the new multi-tone coarse ranging procedure.
– The VB5.1 interface, which includes the RTMC protocol, VB5.1 management support functions in the network element and VB5.1 management application in the ANEM-OS.
– In order to increase the flexibility of the system a set of new User Network Interfaces is added to the system. Following UNIs are supported:
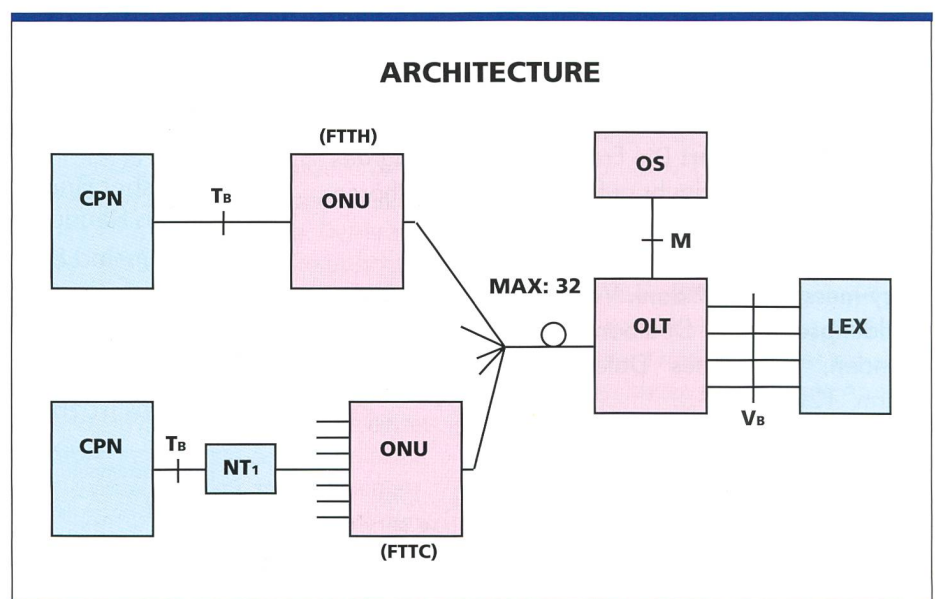

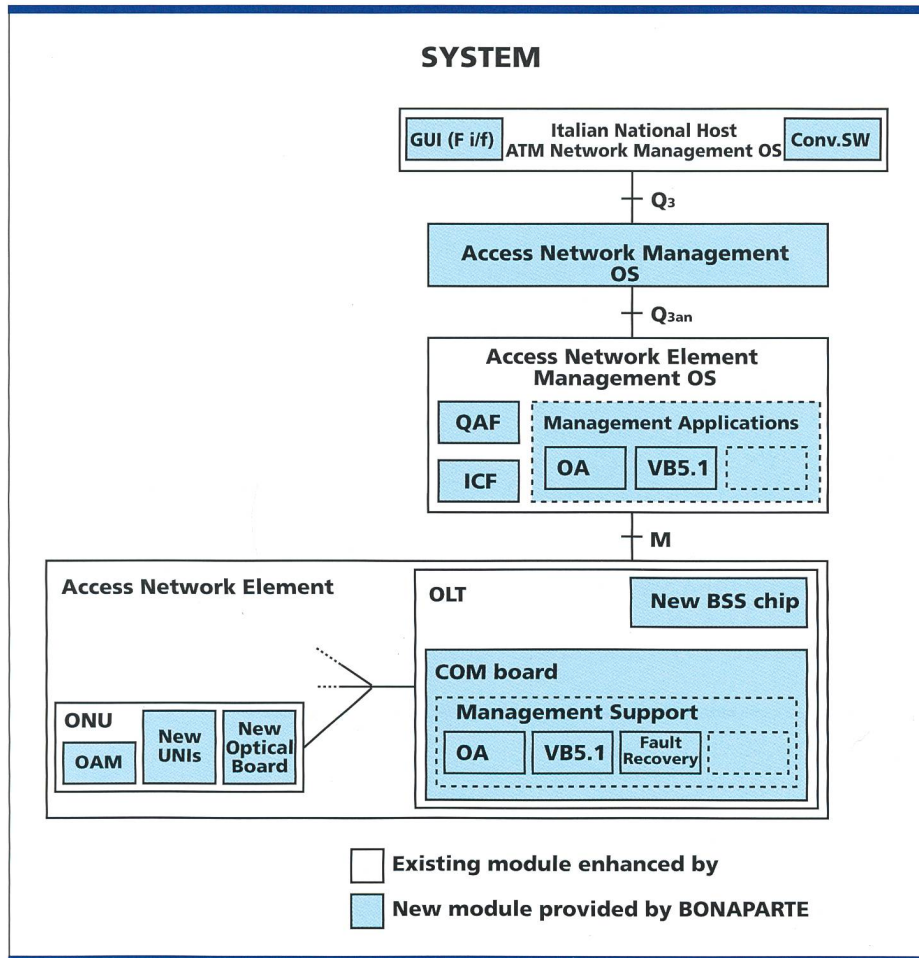Fig. 1. Architecture of the existing access network.

SYSTEM

Fig. 2. Enhancements of the existing system.

the Italian National Host. An Xcoop interface is defined in order to make the Network Management System (NMS) ready for interactions with another NMS from another operator domain. From the operator interface (F), requests for VP connections and for the status of the network can be initiated. The resulting requests are similar to Xuser messages from Service Management (SM), making this interface a simulated Xuser interface. The operator interface is adapted to BONAPARTE requirements at SM and NM level. The SM and NM operations are supported at all BONAPARTE management levels. The project has implemented a software module (convergence function) in the ATM-OS which allows for proper interworking between the Access Network Manager OS, the backbone Network Manager OS, the Xcoop handler modules and the Xuser interface. The ATM OS is based on the baseworX platform.

The Subnetwork Management System (the Access Network Manager OS, ANM-OS) presents the network view of an ATM subnetwork to the ATM Network Manager (ATM-OS) in the National Host. The ANM-OS is independent of the AN type, so different types of ATM based ANs can be managed at ATM level via the ANM-OS. The subnetwork can be constituted of an ATM PON or a set of ATM PONs or a mixture of different types of ATM NE. The ANM-OS presents the network level view at the Q_{3nn}-interface. At this level aggregate ATM NEs are managed as one ATM subnetwork. The Q_{3nn} is based on the ETSI specification NA4-3316 and ITU-T-recommendation I.751. The OS is implemented on an HP open view system. The NE has a standardised Q_3-interface (Q_{3an}) presenting the NE view, which is concerned with the management of the ATM PON. A Q Adapter Function (QAF) is defined, which adapts the proprietary M interface to this Q3an-interface. On the M interface a broader element view is presented to the Access Network Element Management System (ANEM-OS), which supports more functions than the Q_{3an}-interface. The ANEM-OS has an operator interface (F), which allows the operator to access all the functionality presented at the M interface.

– SDH STM-I, symmetrical 155 Mbit/s (already available from BAF)
– VDSL, asymmetrical 51 Mbit/s downstream, 1,6 Mbit/s upstream
– ATM forum, symmetrical 25 Mbit/s
– E1, symmetrical 2 Mbit/s

A key component for the support of the above mentioned enhancements is the new COM board of the OLT, which contains the central controller of the ATM PON system.

Management

The objective of the project is the deployment of the BONAPARTE ATM PON system (Network Element, NE) as an Access Network (AN) in a real-life communications environment, in which the system can be managed by an ATM Network Manager as part of the overall ATM network. To accomplish this the project defined a management architecture compliant with ITU-T-recommendation M.3010.

The requirements for the extended management are mainly determined by two pre-conditions: firstly it must be based

on the OS inherited from the BAF project, and secondly the AN is within the same management domain (i.e. the Italian National Host, INH) as the service node to which it is connected.

The first means that an adaptation function (QAF) is required to adapt the proprietary management interface of the NE to a standardised NE Q_3-interface, and the latter means that a standardised Q_3-interface is needed at network management (NM) level. These two standardised Q_3-interfaces are designated as Q_{3an} and Q_{3nn} respectively.

TMN Architecture

The architecture of the BONAPARTE management system is shown in figure 3 (the parts developed by the project are indicated in bold).

The ATM-OS manages also another Subnetwork Management System over a Q3-interface, presenting the network view of the backbone ATM switch, which is connected to the AN. The ATM-OS integrates the BONAPARTE TMN in the overall ATM network management of

Management Applications

Several management application functions have been developed. Table 1

shows the level of functionality provided by each management interface.

Network Manager (ATM-OS)

The ATM-OS is responsible for the management of a whole access and transport ATM network, i.e. setting up and releasing connections, collecting and displaying alarms, reading and setting the values of attributes in the MIB of the access and backbone network OSs.

In figure 4 a functional overview of the ATM-OS is depicted, showing the following functions:

– stack handler: basic functions and structures to interface with the stack (writing and reading primitives) of the baseworX platform;
– CMIP handler: structures and one module to distinguish and handle CMIP messages;
– Q_{3nnA}-module: functions to manage the access network through the Q_3-interface (Q3nn) towards ANM-OS;
– Q_{3nnB}-module: functions to manage the backbone network through the Q_3 interface towards BNM-OS;
– convergence module: functions to coordinate the modules and handle requests coming from the F interface;
– tables: data on access points, subnetwork, connections, subscribers data;
– RPC-module: functions for bidirectional communication with Xcoop-modules and with the graphical interface (Xuser Simulator).

  The functionality present at the Q_{3nn}-interface is outline below:
– Configuration management
  Provides set-up and release of end-to-end VP connections with complex scheduling, as well as retrieval and modification of managed object parameters, e.g. the administrative state.
– Fault management
  Receives communications alarm notifications coming from the managed objects and forward them to the graphical interface for storage and linking to the appropriate managed object.
– Xuser simulator interface
  Provides windows which allow for easy access to the functions performed by the ATM-OS. A specific window shows, in a graphical way and in real-time, the state of the network: subnetworks with their status, access points with their status, associations of the interfaces on the border between access and backbone network and, upon request, end-to-end connections.
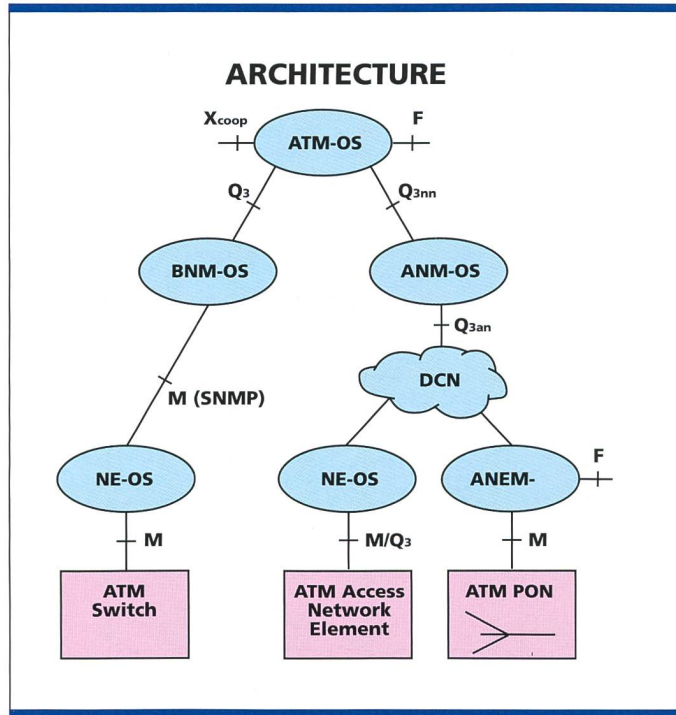

Fig. 3. Management reference architecture.

Access Network Manager (ANM-OS)

The ANM-OS is able to manage several ATM network elements which constitute an access network, like one or more ATM PONs, as deployed in BONAPARTE, or e.g. ATM PONs in combination with other types of elements. The ANM-OS is independent from the type of Access Network element and allows the Network Manager for opaque subnetwork management, i.e. the subnetwork is managed with no visibility into the subnetwork. Only the end points at the edges of the subnetwork are seen by the Network Management System. This subnetwork view is exposed to the Network Manager, the ATM-OS, at the Q_{3nn}-interface.

The ANM-OS creates and maintains the coherence of the MIBs related to the network elements that constitute the access network, like the MIB at the Q_{3an}-interface (between the ANM-OS and the ANEM-OS), and provides a generic network view at the Q_{3nn}-interface by instantiating ATM network managed objects.

The ANM-OS is also responsible for maintaining the required relationships between the network objects and the network element objects.

The management information at the Q_{3nn}-reference point is based on the information model defined in ETSI NA4-3316 specification (GOM). As this specification is too generic and the ATM requirements are not covered by this general information model, the network managed object classes (MOCs) defined in BONAPARTE are derived from GOM by using GOM attributes and by inheriting from MOCs defined in GOM and by using parts from I.751.

The MIB at the Q_{3nn}-interface contains objects related to:
– the access network: the VP access subnetwork as a whole;
– the ATM network access points: the ATM layer physical access points to the ATM Access Network and the allocated bandwidth and VPI range attached to that particular access point;
– the VP connections through the access network: the subnetwork connections in the ATM access network; the parameters of the connections in the Access Network are the network access points they connect, the VPIs allocated for them and their scheduling.

By means of this network view, the following management services are offered:
– Knowledge of the Access Network topology, in terms of the managed access systems, UNIs connecting the users to the access network, and NNIs connecting the Access Network to the transport network.
– Management of this topology by changing the administrative state of the network elements. The UNI and NNI are provisioned by the ANEM-OS and are reported to the ANM-OS by

means of creation and deletion notifications. Operational state changes (disabled, enabled) of UNI and NNI are reported to the ATM OS.
– Management of ATM Virtual Path (VP) connections:
  – Validation of VP connection requests coming from the ATM-OS.
  – All VP connection requests are issued from the ATM-OS.
  – Set-up, modification and release of VP connections through the access network.
– Scheduling of the VP connections. The connections in the network have a schedule which indicates the moments when the connection should be active. At activation/deactivation ANM-OS sends management requests over the Q3an-interface to the ANEM-OS.
– The ANM-OS reports communications alarms related to the end-to-end VP connections to the ATM-OS. Apart from this alarm reporting, no further actions are taken.

Access Network Element Manager (ANEM-OS)

The Access Network Element Manager OS (ANEM-OS) is based on the management system (BAF-OS) inherited from RACE 2 project BAF, which developed the ATM PON system. It manages the ATM PON system over the proprietary M interface and is managed over the Q_{3an}-interface. The system incorporates the Q-adapter function (QAF) and information conversion functions (ICF), which convert management information flows between the M interface and the Q_{3an}-interface. The central control function of the PON system has been moved from the BAF-OS to the system controller (SC). Physically, the SC is a new board of the OLT. All the functionality in the ATM PON system can be accessed from the ANEM-OS operator interface. Several forms have been designed and implemented for management data provisioning and presentation of fault and Performance Management data. Apart from the forms, maps can be invoked, which present outlines of the overall PON and of the different sub-systems.

A new Information model at the M-interface is implemented to allow easy adaptation to the Q_{3an}-interface, and to allow management of newly added functionality. The protocol is enhanced to support the information model at the M interface. It resides on the SC inside the PON system. This information model exposes the network element view of the ATM PON as an access network. It contains the following management ensembles:
– The ATM Layer management ensemble, which covers VP layer configuration management (CM), fault management (FM) and Performance Management (PM), and is compliant with ITU-T-recommendation I.751.
– The physical layer management ensemble, which covers ATM PON layer CM and FM, and is derived from the functional model (developed according the modelling principles of ITU-T-recommendations G.805) designed for the ATM PON.
– The equipment management ensemble, which covers equipment CM and FM.
– The VB5.1 management ensemble, which covers CM and FM of the VB5.1 interface of the AN.
For the new functionality management application functions (MAFs) have been developed which act as manager over the M interface on the agent running on the system controller.
For the implementation of the Q_{3an}-interface a QAF has been developed which converts the M interface messages into Q_3 CMIP/CMISE messages and vice-versa The QAF contains the MIB which exposes the network element view at the Q_{3an}-interface. This MIB is compliant with the MIB defined in ITU-T recommendation I.751 and contains the ATM layer management ensemble (VP connection CM and FM). The QAF is developed on the OSIMIS platform (inherited from the RACE II project ICM). An ICF has been developed, which aligns the management information and views of the M and Q_{3an}-interface.
Like the ANEM MAFs, the ICF MAFs act as manager over the M interface on the agent running on the system controller. The different views of a VP connection traversing the ATM PON is given in figure 5.

Network Element Enhancements (COM Board)

An important enhancement of the ATM PON is related to shift of the central system control function from the legacy management system (BAF-OS) to a newly developed system controller inside the OLT. The central controller allows to keep the system running when the ANEM-OS is disconnected or crashes, and it enables fast recovery from certain hardware failures in the access network. This enhances the availability of the access network. The system controller is implemented on a new board in the OLT, the so-called COM (control, OAM and management) board.
It communicates with the other hardware controllers (sub-controllers) via the internal management interface Mi and with the ANEM-OS over the M interface. The sub-controllers do not communicate between them. Communication be-
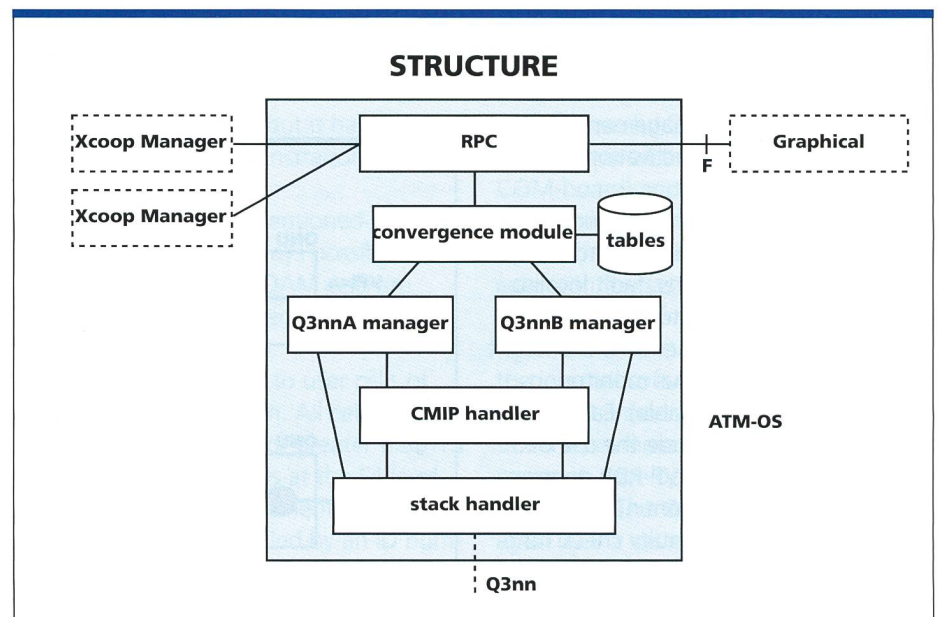

Fig. 4. ATM-OS structure.

tween the SC and the ONU sub-controller goes via so-called slow OAM messages over the PON connection. These messages are transported in the payload of dedicated ATM cells on the PON. The messages exchanged over the M and Mi interfaces are transferred over an Ethernet network.

The COM board hardware supports two VB5 interfaces. The following functionality is included:

– Optical transmission interfaces
– SDH physical layer functions: According to ITU-T-recommendation G.707
– Transmission convergence layer functions: Header error check, cell delineation, cell rate decoupling and framing
– ATM layer functions: VP crossconnect, VP link termination, VP segment termination, and F4 flow termination (performance monitoring, continuity check, loopbacks, etc.). On each COM-board there are two additional processors which process the OAM F4 flows in conjunction with the ATMC devices, which insert/extract the ATM cells belonging to the OAM F4 flows into/from the ATM cell streams.
– Auxiliary functions: loopback facilities, flash PROMs, which hold the RAM images for the system controller and all the OLT sub-controllers, insert/extract devices, which insert/extract ATM cells belonging to both the VP connections providing the RTMC protocol channels to the switch for the VB5.1 interface and VP connections providing the OAM communication channels to the ONUs.

Operation and Maintenance

The F4-OAM functions can be classified in three groups: Fault Management functions, Performance Management functions and activation/deactivation functions.

The Fault Management (FM) functions are useful tools for detecting and forwarding alarm conditions, fault localisation and real time monitoring of VP connection continuity. These functions might also be used for VP status monitoring (i.e. available or unavailable). Fault Management functions include the use of alarm cells (VP-AIS and VP-RDI), loopback cells (VP-LB) and continuity check cells (VP-CC). The continuity check function is subject to activation/deactivation functions as described below.

The Performance Management (PM) functions are required for implementing inservice monitoring and estimation of performance parameters at the VP level. These performance parameters, as described in ITU-T-recommendation I.356, include: cell error ratio, cell loss ratio, cell misinserted ratio, severely errored cell block ratio and cell delay variation. The Performance Management functions rely on two types of OAM cells: Forward Performance Monitoring (FPM) and Backward Reporting (BR). The Performance Management functions are subject to activation/deactivation functions as described below.

The activation/deactivation (AD) functions are required for the following purposes:

– to coordinate the beginning or to end the transmission and downstream reception of Performance Management and continuity check cells,
– to establish agreement on the block size and direction of transmission to start or stop monitoring in the case of Performance Management.

The VP-CC, VP-FPM and VP-BR cells act over the user cells. The term "user cells" at the F4 level include all cells belonging to the same virtual path connection (VPC) whose VCI takes values 1, 2, 5 or greater than 15.

After describing the possible segment configurations in the first section, the subsequent sections describe in detail the characteristics of all the OAM functions which can be performed in the network element contained in the BONAPARTE AN. The following convention on the naming of the different functions has been used:

– The detection functions imply that the OAM cells used in the specific OAM function is removed from the flow at the time it is processed.
– The monitoring functions imply that the OAM cells used in the specific OAM function is forwarded at the same time that it is processed.
– The generation functions imply the insertion of OAM cells in the flow in response to a particular state, alarm or detection of other type of OAM cells.

The cells belonging to the F4 segment flows are explicitly identified with the word "segment" to avoid confusing it with F4 end-to-end cells.

Segments

The ATM-PON considered in the BONAPARTE project includes two types of network elements: OLT (Optical Line Termination) and ONU (Optical Network Unit) which constitute the Access Network (AN) with Tb interfaces on one side towards the users and Vb interfaces on the other side towards the switched transport network.

Each ATM connection traversing the PON passes two ATM cross-connect functions inside the PON, one in the Optical Line Terminator (OLT) and one in the Optical Network Unit (ONU). This means that per ATM connection there are four VP connecting points involved. According to I.610 each VP-CP shall be configurable as segment endpoint (SEP). This means that internal segments can be set-up in the PON system covering the VP link between OLT and ONU.

A number of different segment scenarios are possible. The figures 6, 7, 8, 9, 10 and 11 show these different segment configurations. The customer premises equipment (CPE) and local exchange
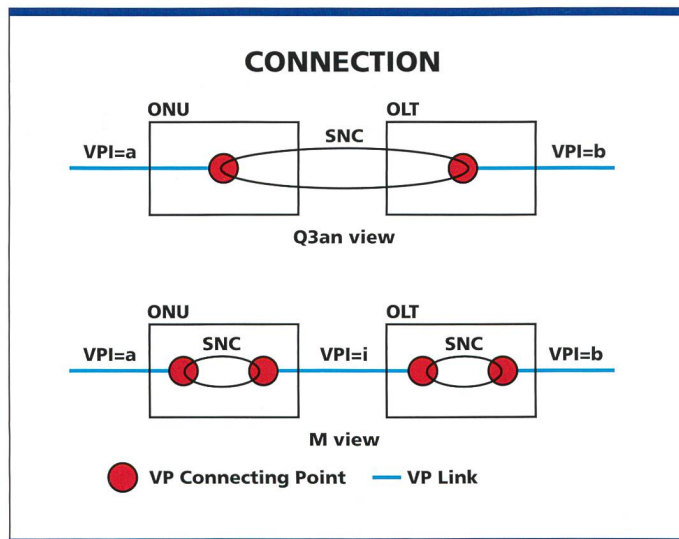

Fig. 5. Element management view of VP connection at Q3an- and M-interface.

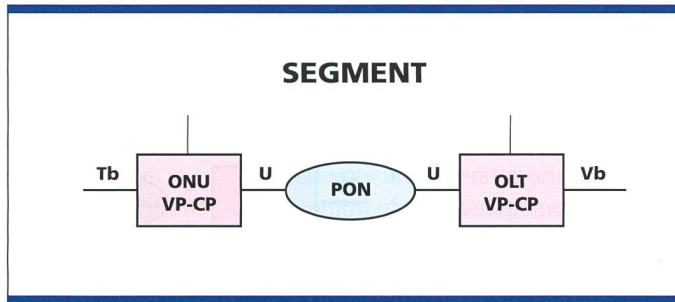*Fig. 6. No segment established or established outside the AN.*
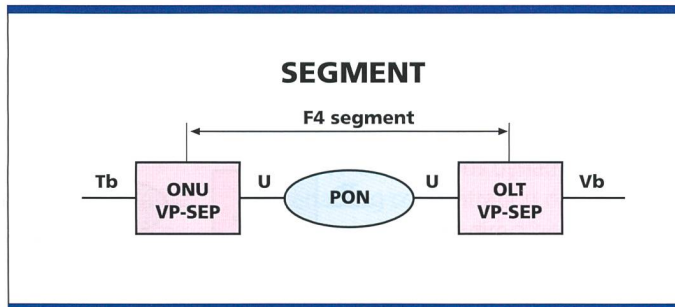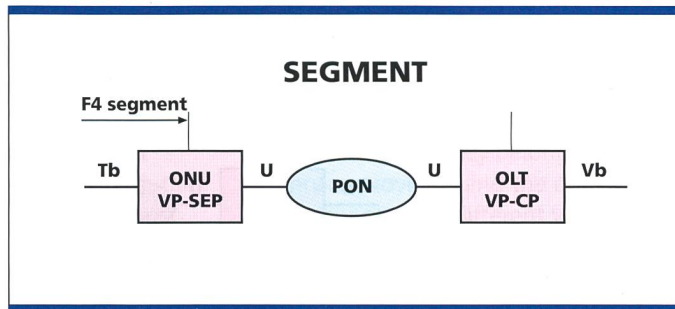

Fig. 7. ONU-OLT segment.

Fig. 8. CPE-ONU segment.

(LEX) are not shown in the diagrams.
It is clear that configurations in figure 7, figure 8 and figure 11 may coexist, allowing adjacent segments CPE-ONU-OLT-LEX. Therefore, the definition of VP-SEP behaviour can be assigned both towards the Tb or U interfaces in the ONUs or towards U and Vb interfaces in the OLT. The segment configuration depicted in figure 7 lies entirely within the domain of the access network. It is the most suitable to assess the behaviour of the user connections as they cross the AN and, therefore, is normally used to demonstrate the F4 OAM functionality. In this configuration, the OLT is responsible for initiating any activation/deactivation of the Performance Management and continuity check functions. The segment configurations in figure 8 and in figure 9 show scenarios in which the CPE is able to collect and process OAM information at the ATM layer. The CPE will initiate any activation/deactivation process in the segment configuration in figure 8 whereas the initiation of activation/deactivation processes is a shared responsibility in configuration in figure 9. By means of the

F4-OAM segment and end-to-end flows the CPE may have different insights of the in-service network performance over its own virtual path connections.
The segments configuration in figure 9 is required in order to provide adequate OAM flow termination functionality at the segment level towards the public network. The segment configuration depicted in figure 10 has been included here for completeness but it has not been used in the demonstrations of the F4-OAM functionality.
On top of the above mentioned segment configurations, it is always possible that end-to-end F4 and F5 OAM cells are transparently transported through the AN.
The F4 OAM cells refer to user cells of the same VP connection. All cells whose VCIs values are 1, 2, 5 or greater than 15 are considered user cells at the F4 level. Each of the network elements (ONUs and OLT) can be identified by an ID number which is used for the alarm and loopback cell processing.
The implementation is compliant with ITU-T-recommendation I.610. Minor devi-

ations from and some additions to these recommendations have been made where appropriate. Internal segments can be set-up in the PON system covering the VP Link between OLT and ONU. External segments are possible by applying a terminal adapter in the Italian and Spanish NH. The terminal adapter provides OAM F4 flow functionality thus allowing BONAPARTE to perform all kind of F4 flow experiments on internal and external VP link connections. The F4 flow functionality can be managed from the ANEM-OS operator interface based on ITU-T-recommendation I.751. The system is transparent to the F5 Flow cells.
The BONAPARTE project succeeded well in implementing the F4 Flow functionality in the APON compliant with ITU-T-recommendations. This counts for the transmission functions in hardware and firmware inside the APON system (OLT and ONUs) and for the network element management (ANEM) system. It turned out that the F4-OAM implementation, especially the performance monitoring, demands high processor power and a very high number of gates for the hardware functions. Even then, just a limited number of VPCs can be serviced concerning performance monitoring.
Because the cost of the user interface has an high impact on the overall cost of the equipment and the cost share charged to the user, it was recognised that OAM functionality at the Tb-interfaces must be reduced in order to maintain these interfaces as cheap as possible. As a result the functionality at the Tb-interfaces is a sub-set of the functionality at the Vb-interfaces.
The hardware implementation consists of a one-chip solution together with a dedicated powerful OAM processor, and is the same at all the Vb- (on the OLT COM-board) and T-interfaces (on the newly implemented T-boards in the ONU). These OAM processors communicate with the system controller on the COM-board. Keeping the OAM software functions on the OAM processors and the internal software interfaces between the OAM processors and the system controller as common as possible allowed common development for the Vb- and T-interfaces. The OAM functions are managed by the system controller, which in turn is managed by the ANEM-OS through the M-interface information model, which is based on ITU-recommendation I.751.

User Network Interfaces

A number of candidates of possible new types of User Network Interface were analysed at the beginning of the project. Three new ONU boards have been realised providing the interfaces listed below. All UNI types have a common block which provides the internal interface to the existing ONU hardware, common hardware and software functionality up to and including the ATM layer and OAM F4 flow processing and functions for remote management via the operations system. All board types have been successfully used in the system.

E1 ATM Interface

Standardisation efforts were undertaken by a number of organisations (including the ITU, the ATM forum and ETSI) to ensure the correct functioning and interworking of equipment, designed to provide interworking functionality between ATM-based systems and systems of the PDH. The use of the existing PDH-infrastructure for the transmission of ATM cells in access networks allows for cost effective interfaces with the low bit rate (2048 kbit/s) suited for the emerging market (e.g. is in teleteaching trials). Relevant ITU-T-recommendations are G.703 [i], G.704 [ii], and G.804 [iii].
Samples of this board type are available.

ATM Forum Symmetrical 25 Mbit/s Interface

The symmetrical 25.6 Mbit/s interface specification were approved by ATM-Forum [iv] in November, 1995. Since then, it has been the standard interface for terminal equipment and many ATM25-adapter cards for PCs and workstations are available. The ATM forum 25.6 Mbit/s is a short range symmetric interface over twisted copper pairs. It covers about 100

Fig. 9. CPE-OLT segment.

Fig. 10. ONU-LEX segment.

Fig. 11. OLT-LEX segment.

meters and the user has 25,125 Mbit/s. The line symbol rate is 32 Mbaud because of overhead and line coding.
The frame structure is based on the transmission of an asynchronous stream of cells of 53 octets each, which are coded in 5 bit symbols (a 4B/SB code). ATM cells are transmitted on the line only when there is information coming from the ATM layer (user cells, OAM cells, ...) otherwise no cells are transmitted and the line goes in an idle state. Because of the asynchronous nature of the stream the standard cell delineation algorithm (used for example in the SDH-ATM interfaces) can not be ap-

plied. A two-symbol overhead is used instead to mark the start of cell. When there is no user data to transmit, arbitrary data will continue to be encoded, scrambled and transmitted to maintain synchronisation of the receiver PLL.
Samples of this ONU board are available.

VDSL Asymmetrical 51 Mbit/s Interface

The VDSL user interface is intended to follow the DAVIC 1.0 specification for short-range baseband asymmetrical PHY on copper and coax [v]. The interface is intended for distributive applications, at low cost, in the near future: the main objective is to deliver high bandwidth (51,84 Mbit/s) to the customer, using already deployed UTP-3 telephone cables, for distances up to 300 meters. As the amount of data expected to be sent by the user is low, the upstream bandwidth is much smaller (1,6 Mbit/s). Up to four user devices can be connected to the same link, sharing the downstream and upstream bandwidths. A grant-based TDMA mechanism for the upstream transmission is implemented.
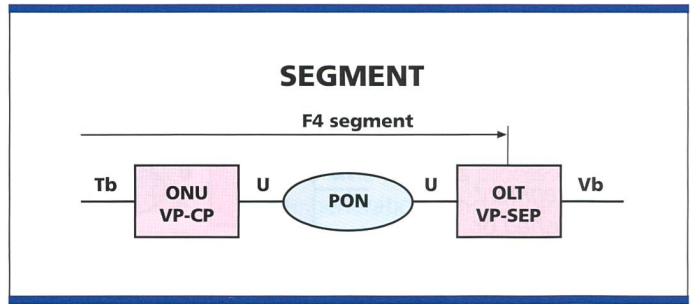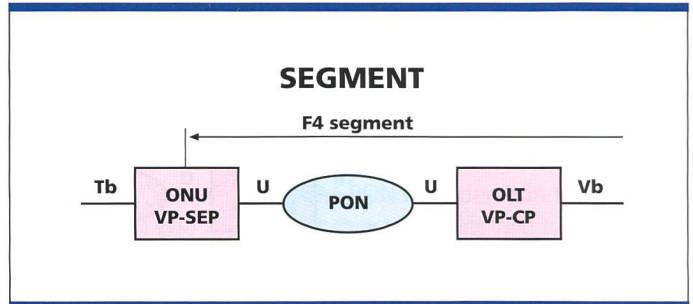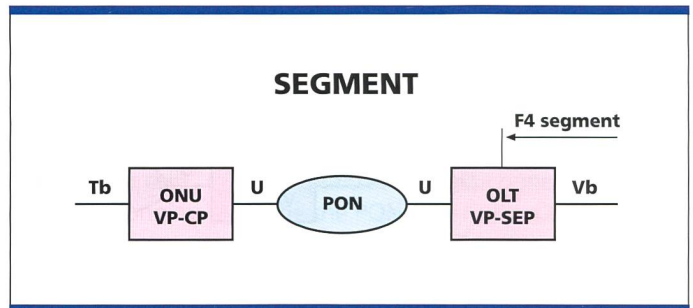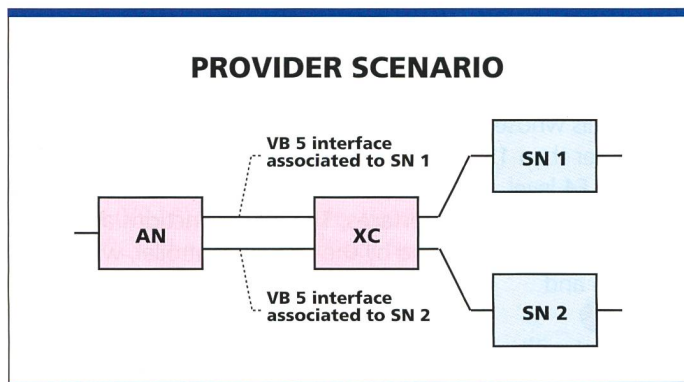

Fig. 12. Multiservice provider scenario.

There a few differences respect to the DAVIC specification to allow for the use of existing components for the mo-de-modulation (VDSL chip set, AT&T). The main differences concern the upstream frame format and the absence of the Reed Solomon error correction algorithm. The sign on mechanism for the connection of a new user terminal (set-top box) is also not supported. Downstream rate scaling can be attained by changing the modulation scheme (from 16-CAP to 4-CAP) and not by frequency scaling. Samples of this boards are available.

VB5 Interface

As the access systems constitute a large share of the market of telecommunication equipment, multiple actors in terms of manufacturers, vendors, network providers and value added service providers are very active in the access area. To allow interconnection between the entities (access nodes, service nodes) of a telecommunication network as shown above, operated by different providers (AN provider, SN provider), the interfaces between these entities must be open and standardised.

In this context, which is often referred to as open network provision (ONP), ETSI has defined the broadband access interface VB5. The VB5 interface is based on the same principles adopted for the V5

interfaces, already specified for narrow-band systems. Two types of VB5 interfaces have been defined.

The VB5.1 interface is related with the VP-VC cross-connect functionality in the Access Network and operates under complete control of the management plane. VB5.1 aims at maintaining consistency between the SN management representation of the AN and the actual AN administrative and operational states of users ports. Real time operation and management of services is done via the Real Time Management Co-Ordination Protocol (RTMC).

The VB5.2 version adds the possibility of VC and VP connections dynamic allocation, enabling concentration on a call basis, without requiring direct access to the Call and Connection Control (C3) procedures in the AN system. The Bearer Channel Control Protocol (BCCP) is adopted to convey C3 related information.

The VB5 concept is depicted in figure 12. In this scenario the AN and the SNs may be connected via networks of different operators, the SNs may belong to different service providers and the equipment may be supplied by different vendors.

The VB5 interface is based on the logical port concept (e.g. a logical user port is the of VPCs associated to a certain user and to a certain SN; a logical service port is the set of all VPCs associated to a certain SN) and on a mechanism which in-

forms the SNs about the operational and administrative status of the AN "ports". Thanks to the direct participation in the ETSI VB5 special experts group (SEG), the project has been able to closely follow and contribute to the progress and to import the latest results on the VB5 interface. In BONAPARTE the focus is on VB5.1 interface, while the VB5.2 will be implemented in the project EXPERT/VIKING (making use of the results of BONAPARTE).

Figure 13 shows how the VB5.1 interface has been implemented: the impact is restricted to the ANEMOS and AN system controller (COM board).

The information model represents the AN based on I.751 type Managed Objects (MOs), together with objects representing the network specific hardware and VB5 specific objects as defined in the VB5.1 management standard. The RTMC block represents the VB5.1 Real Time Management Co-Ordination (RTMC) protocol mechanisms as described in SDL diagrams in the VB5.1 interface specification. The SAAL provides the adaptation of the RTMC messages to ATM cells, including error handling of erroneous ATM connections. The ATM layer represents the VPI/VCI on which the RTMC protocol messages are carried. The physical layer represents the hardware and the physical connection to the peer side of the VB5 interface (the SN).

Availability Enhancements
Availability is determined by system reliability and the restoration time after the
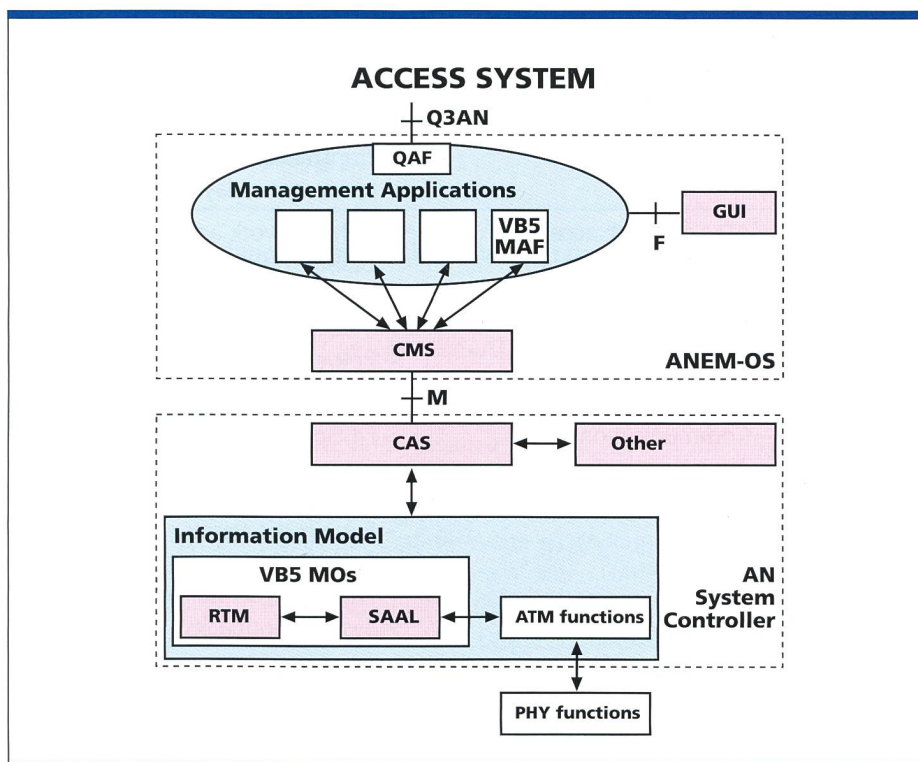
Fig. 13. Impact of VB5 on the BONAPARTE access system.

References

[i] ITU-T-recommendation G.703, "Physical/Electrical Characteristics of Hierarchical Digital Interfaces", Geneva, 1991

[ii] ITU-T-recommendation G.704, "Synchronous Frame Structures Used at Primary and Secondary Hierarchical Levels", Geneva, 1991

[iii]ITU-T-recommendation G.804, "ATM Cell Mapping into Plesiochronous Digital Hierarchy (PDH)", Geneva, November 1993

[iv] specifications af-phy-0040.000)

[v] DAVIC, "DAVIC 1.0 Specification Part 08 – Low Layer Protocols and Physical Interfaces", revision

occurrence of a failure. Reliability and restoration time have been enhanced by both refining existing hardware and software functions (inherited from the BAF project) and implementing new functions. Relevant features have been selected on the basis of the trade-off between implementation effort and obtained availability improvement. All features are listed below with a brief statement on the result of the work. Some more details are given for the new functionality developed in the projects. Enhancement of existing functions:

– Bit slot synchroniser (BSS) ASIC
Objective was to improve the generated peak-to-peak jitter and reduce the power dissipation. The new BSS has been successfully manufactured and tested. The overall performance in the real system is equivalent to the one of the old BSS, indicating the existence of other sources of jitter (probably the burst mode receiver), however the component itself exhibits the expected performance (300 ps jitter and 4,7 W of typical power dissipation) making it suitable for industrial exploitation.

– Optical U interface board in the ONU
Objective was to allow correct and complete control of the optical signals injected in the optical distribution network

in all states of the systems (start-up, reset, micro-interruptions, switch-off). The new board has been successfully integrated and tested in the system. Robustness to microinterruptions has been greatly improved and now is very good (the board never hangs up and the ONU is always reachable). Start-up and reset operations are also optical-spike free. Coarse ranging phase shift caused by temperature changes has been reduced. The board provides facilities for automatic testing making it suitable for industriale exploitation.

– Coarse Ranging
Objective was to reduce the standard deviation of the coarse ranging procedure. The new multi-tone software procedure has been implemented and suceessfully tested. Lab experiments showed that standard deviation has been reduced by a factor 2,5.

New functions:

– COM board
A new OLT board has been developed, containing the new system controller, which takes over the central control function from the legacy BAF-OS. This allows the network element to stay operational in case the network element manager (ANEM-OS) is not connected, and allows for fast and autonomous re-

covery from a number of system failures. The hardware has been successfully tested and integrated in the OLT.

– Automatic Failure Recovery
Automatic failure recovery procedures have been implemented to allow a faster recovery and improve restoration time of the system and of the user connections. Failures in the OLT, ONU and ANEM-OS were considered: a typical recovery action is an automatic restart and reconfiguration of the faulty function; in case of a failure of the ANEM-OS the system stays operational thanks to the presence of the autonomous system controller (COM board) in the OLT. It is clear that failures may have a different impact on the system: a failure of the OLT transmitter (PON side) affects all users, a failure of one ONU transmitter (PON side) may affect all upstream traffic, a failure of a UNI interface normally affects just the user connected through that UNI. The automatic failure recovery procedure is autonomously invoked by the OLT system controller, thus not requiring manual intervention of the operator. Whenever the integrity of the management remote databases is not preserved, these have to be rebuilt from the management central database and the actual recovery time can be rather long. The recovery

Management ensemble	Management application functions		
	Q_{3nn}	Q_{3an}	**M**
Equipment	no	no	yes
Physical layer	no	no – SDH physical layer	– PON physical layer management – Transmission convergence layer

ATM layer management	– ATM network access
	  points configuration
	– VP Connection configuration
	– Retrieval and modify
	  of configuration data
		– ATM network access
		  points configuration
		– VP Connection configuration
		– Retrieval and modify
		  of configuration data
			– ATM network access
			  points configuration
			– VP Connection configuration
			– VP Segment configuration
			– Retrieval and modify of
			  configuration data

Fault management	– Communications
	– Alarm reporting at
	  ATM layer
		– Communications
		– Alarm reporting at
		  ATM layer
			– F4 Flow (ATM layer)
			– Communications alarm,
			  all three layers
			– Equipment alarms
			– Failure recovery
			– Protection switching
			– System loopbacks

Performance management	no	no	F4 Flow (ATM layer)
VB5.1 management	no	no	yes

Tab. 1. Management application functions.

time depends on the configuration of the system and, presently, can range from few minutes to even hours. Instead, whenever the integrity of the management databases in maintained, the automatic protection switching to a standby OLT can be invoked, which simply re-range all ONUs: in this case the down-time for a fully equipped system is much shorter, in the order of the minute or even some tens of seconds, independently of the number of connections active at the moment of the failure. 9.4

Rajko Porobic *graduated in 1977 at Faculty of Electrical Engineering of University of Zagreb. He then joined the Research & Development Department of Nikola Tesla (major national manufacturer of telecommunication equipment). He has worked for Ericsson, Ascom, Sophia Antipolis Technology Park before joining Telscom AG (Berne). At the present he is working as a project manager for ATM Access Network and he is responsible for developing such a network compatible with FSAN architecture and for implementing open access network interface VB5 at the Basel Testbed within the ACTC project VIKING. He has served as an advisor to Swisscom in the area of ATM Access Network and Network Management. He has many publications into his credit.*

Dr. Luoni Mario *has a degree in mathematics from the Swiss Institute of Technology (ETH) at Zürich, and obtained his Ph.D. degree from ETH at Lausanne, specialising in stochastic traffic modelling and call admission issues in ATM networks. He spent the following 4 years working in the central research labs of Fujitsu and of Hitachi in Tokyo, contributing mainly to dynamic routing in ATM networks and to buffer scheduling mechanisms in ATM switches. From August 1997 until August 1998, he was working with TELSCOM (Berne) where his main contribution was the implemention in C++ of the ATM-SAAL protocol stack to be used in the VB5.2 project. Since August 1998 he works with Swisscom's International Network Services Department as head of the traffic analysis and forecasting group.*

Zusammenfassung

BONAPARTE: Zugangsmöglichkeiten zum Passiven Glasfasernetz (ATM Passive Optical Network)

Das Projekt BONAPARTE hat gezeigt, dass ATM PON Systeme geeignet sind, den Zugang zur Breitbandkommunikation zu gewährleisten. Dies konnte durch die Realisierung eines ATM PON Anschlussnetzes (Access Network, AN) erreicht werden, welches dank der Entwicklung benutzerfreundlicher Multimedia-Applikationen und Tests mit echten Benutzern in den Bereichen Telemedizin und Fernunterricht in realen Kommunikationsumgebungen eingesetzt werden kann. Eines der Hauptergebnisse von BONAPARTE ist die Weiterentwicklung des ATM PON Prototyp-Systems, das nun neu auch in einem realistischen Umfeld benutzt werden kann. Das Resultat ist eine «Mischung» – neue Funktionen wurden zu den bereits bestehenden hinzugefügt. Wichtige neue Features sind: OAM F4 Datenflussunterstützung, automatische Störungsbehebung, VB5.1-Schnittstelle zwischen Zugangs- und Service-Knoten, neue Netzwerk-Interface-Karten für Benutzer sowie das Managementsystem, welches von der Netzelementschicht bis zur Netzschicht reicht.

Zweistelliges Wachstum

Nach einer Flaute von drei Jahren als Folge von Überkapazitäten geht es für die Halbleiterhersteller bei kräftig steigenden DRAM-Preisen derzeit wieder bergauf. So konnte beispielsweise die Firma Infineon Technologies im gerade abgeschlossenen Geschäftsjahr sein Ergebnis um fast 1 Mia. DM verbessern. Das amerikanische Marktforschungsunternehmen Dataquest nennt für den Halbleiterweltmarkt 2000 ein Plus von 17%, für 2001 sogar von 19%. Das wäre ab 1999 innerhalb von drei Jahren ein Wachstum von 50%. Von den früher einmal für die Jahrtausendwende vorhergesagten 300 Mia. US-$ Weltmarkt wird man allerdings weit entfernt sein: Für 2001 käme man dann nach den neuen Zahlen auf rund 215 Mia. US-$. Das kräftige Minus in den Jahren 1996 (-6%) und 1998 (-8%) hat tiefe Spuren hinterlassen. Obendrein ist man vorsichtiger geworden Prognosen abzugenben, weil das Gleichgewicht aus Angebot und Anfrage offensichtlich nur sehr schmale Abweichungen zulässt, ohne umzukippen. Und da kann schon ein einziger in Panik geratender Hersteller mit Dumpingpreisen den ganzen Markt ins Trudeln bringen, wie man in jüngster Zeit erst gesehen hat.

Dataquest
1290 Ridder Park Drive
San Jose
CA 95131-2398
U.S.A.
Tel. +1-408-437 8000
Fax +1-408-437 0292

Datenkompression mit 99%

Die in Tokyo ansässige Internetfirma Lattice Technology Ltd. hat ein Verfahren entwickelt, um 3D-Bilder auf 1% ihres Datenumfangs zu komprimieren. Man will das Verfahren vor allem an CAD-Firmen verkaufen und es bei der Entwicklung virtueller Kaufhäuser (Shopping Malls) einsetzen. Soweit den spärlichen Informationen zu entnehmen, handelt es sich nicht um «echte» 3D-Bilder, sondern um Pseudo-3D-Darstellung, die durch entsprechende Lichtführung einen 3D-Eindruck auf dem zweidimensionalen Bildschirm hinterlassen. Wen es interessiert, der kann sich diesen 3D-Betrachter kostenlos von der Webseite herunterladen unter http://www.lattice.co.jp.