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THE EUROPEAN UNION ACTS PROJECT: AC094-EXPERT

PLATFORM FOR ENGINEERING RESEARCH AND TRIALS

The project AC094-EXPERT is one of more than 150 projects in the European Union's 4th Framework Programme ACTS, Advanced Communications Technologies and Services. It is managed by the Association Swiss Telecom PTT/Ascom (ASPA[1]) and is unique in being the only project in the ACTS Programme to be coordinated by a non-EU organization.

Based in Basel and building upon the highly successful RACE[2] project R2061-EXPLOIT, EXPERT has a major role in enabling advanced application trials, which are showing the capabilities and advantages of new broadband services and the underlying ATM technology.

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This article describes the features that are already available on the EXPERT platform and the further enhancements that are being developed during the course of the project (1995–1998). The platform will become increasingly an excellent representation of a broadband network, on which real user trials of new services and functionalities are encouraged.

Introduction

The time frame and scope of the European Union Programmes RACE and ACTS are shown in *Figure 1*. The position of EXPERT (and the predecessor project EXPLOIT) can be clearly seen from this diagram. At the completion of the European Union RACE Programme (end of 1995), the EXPLOIT project partners had established in Basel a sophisticated testbed, incorporating six ATM switches, a variety of traditional and broadband terminals, and interworking units. This testbed was regularly interconnected with other 'broadband islands' throughout Europe for the purpose of testing and demonstrating new broadband applications and for performing traffic experiments in the ATM-sensitive areas of traffic control, resource management, and network performance.

The follow-on EU Programme to RACE (ACTS) is intending to build upon the technology already developed in RACE and to ensure the effective application by carrying out work in the context of so-called 'Operational Trials', encouraging more dialogue between researchers, developers and users. Towards this objective, the ACTS project EXPERT is supporting and extending the testbed in Basel for the performance of such trials, validating new ATM-based access network systems (a passive optical network and an integrated services switch) and defining the relationship between user Quality of Service and network performance, as managed by an integrated control framework operating in a mixed real-time and non-real-time traffic environment.

As seen in *Fig. 5*, the EXPERT platform includes not only the ex-EXPLOIT (R2061) testbed in Basel, Switzerland, but also the ex-TRIBUNE (R2081) testbed in Leidschendam, The Netherlands. This dual-site feature enables many aspects of interoperability and the effects of propogation delays to be investigated in a realistic environment.

Taking into consideration the enhancements and additional aspects that will be developed during the project, the platform will become an excellent representation of a broadband network, consisting of various types of interworking to legacy equipment, new multimedia terminals and a total of 10x ATM switches from the private network, the access network, and the public switching environments. The platform is also very closely associated with both the Swiss and Dutch National Hosts, which consequently facilitates connectivity to the commercial telecommunications networks (e.g. ATM, Frame Relay, N-ISDN, satellite) of the local operators.

The EXPERT platform will be used for trials with a range of applications that demonstrate the advantages of the new broadband services. Of particular interest will be scenarios supporting mixed real-time and non-real-time traffic. In addition, EXPERT will demonstrate the capabilities and advantages of advanced broadband services in the context of international and intercontinental trials between

[1] ASPA is an association comprising employees of the Swiss Telecom PTT in Bern and Basel and employees of Ascom Tech AG in Bern. The management board of ASPA consists of Messrs. W. Steinlin (Head of Research, Swiss Telecom PTT) and Beat Lüscher (Head of Broadband Technology, Ascom Tech AG).

[2] Research and development of Advanced Communications in Europe.

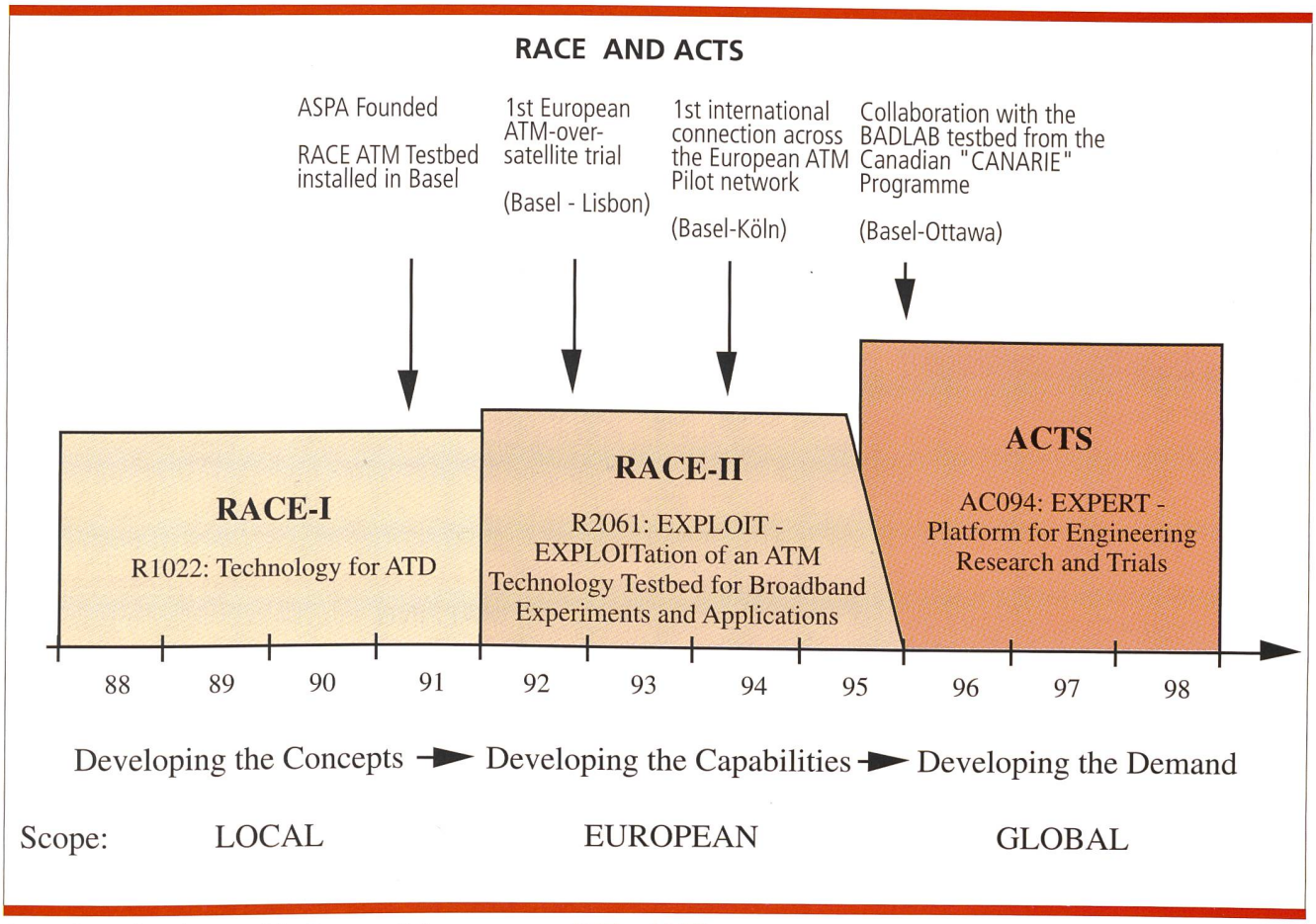

Fig. 1. Timescale and scope of the European Union programmes RACE and ACTS.

(for example) Basel and the BADLAB[3] testbed in Ottawa, Canada.

The EXPERT site in Basel

Located in a PTT building *(Fig. 2)*, the EXPERT testbed in Basel has access to all modern telecommunications services, including ATM, N-ISDN, MEGACOM (n×4 kbit/s) and satellite capabilities.

The EXPERT platform

The relationship of EXPERT to the testbeds obtained from EXPLOIT and TRIBUNE can be seen in *Figure 5.* The legacy equipment and the new developments within EXPERT can be identified. These are described in the following sections.

[3] The BADLAB (Broadband Application Demonstration Laboratory) has very similar aims as EXPERT, and is part of the Canadian CANARIE (Canadian Network for the Advancement of Research, Industry and Education) programme.

The legacy from EXPLOIT and TRIBUNE

Among the many achievements of the RACE projects EXPLOIT and TRIBUNE were the development of 'mappers', interworking units and broadband signalling capabilities. These items were essential in enabling the sites to be interconnected with others throughout Europe and in Canada.

The particular interworking units that were developed enabled Frame Relay networks or terminals to be interconnected via ATM and also full ATM-to-N-ISDN interworking at the Network Node Interface (NNI).

'Mappers' are lower-level devices which enable ATM cells to be transported over traditional transmission systems, but without any interworking between the control planes. The principle of 'mapping' and the functional partitioning is shown in *Figure 3.*

'Mappers' enabled the early interconnection of geographically separated ATM testbeds via 2-Mbit/s PDH (Plesiochronous Digital Hierarchy) systems for the purpose of demonstrating applications and performing experiments. Since mid-1994, the principle of 'mapping' has been used to transport ATM cells throughout Europe via 34-Mbit/s PDH and 155-Mbit/s Synchronous Digital Hierarchy (SDH) transmission systems.

Interworking units enable existing networks not only to act as 'pipes' for ATM data (or vice versa) but also facilitate the communication of control signals between networks. A particular example is that of (on-demand) call establishment across both an N-ISDN network and an interconnected ATM network. This requires that the signalling messages used in the N-ISDN network are converted (by the interworking unit at the network-network boundary) to signalling messages appropriate to the ATM network. This is shown diagramatically in *Figure 4.*

ITU-T Capability Set 1 and ATM Forum v.3.1 broadband signalling are currently supported on the testbeds in Basel and Leidschendam, enabling ATM connections to be established

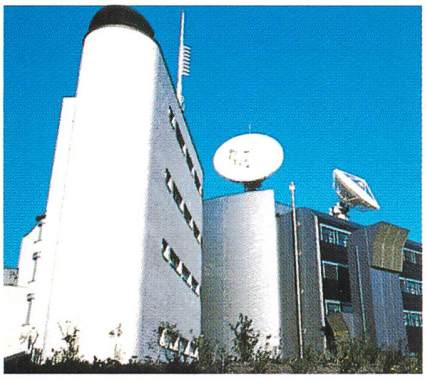

Fig. 2. The EXPERT site, Basel.

and released directly by the application/service without the need for manual intervention by the network operator.

The EXPERT developments

During the course of the EXPERT project, the following hardware and software enhancements will be produced:
- ATM access equipment (an ATM Passive Optical Network)
- an integrated services switch
- enhanced signalling capabilities and service-enabling functions
- an integrated traffic control framework for real-time and non-real-time services

ATM Passive Optical Network (APON) system

The new APON access network is intended for connecting approximately 100 small businesses and/or residential customers to a single 622-Mbit/s port (or 4×155Mbit/s ports) of the ATM local exchange. By employing passive components and a shared medium, the system is intended to be cost-effective and reliable. The transfer mode is ATM.

The incorporation of this development brings several major advantages to EXPERT, including:
- the addition of a new type of ATM switch architecture, which has different traffic multiplexing characteristics to take into account when considering Quality of Service (QoS) aspects

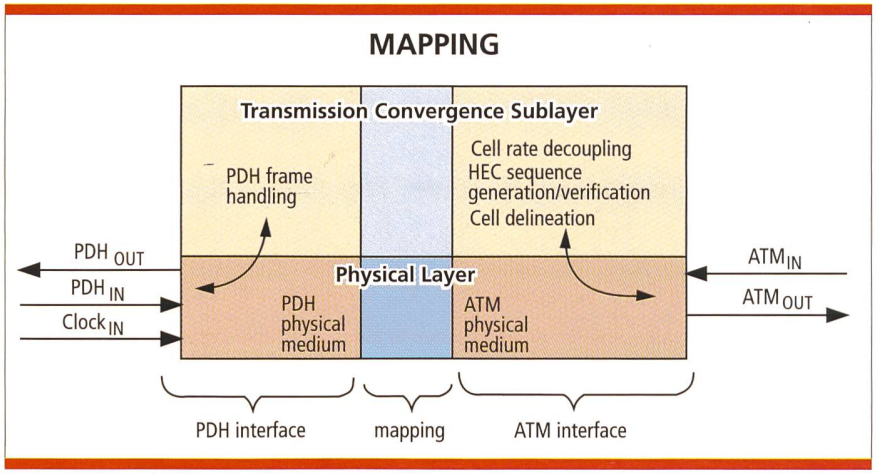

Fig. 3. The functional partitioning of mappers.

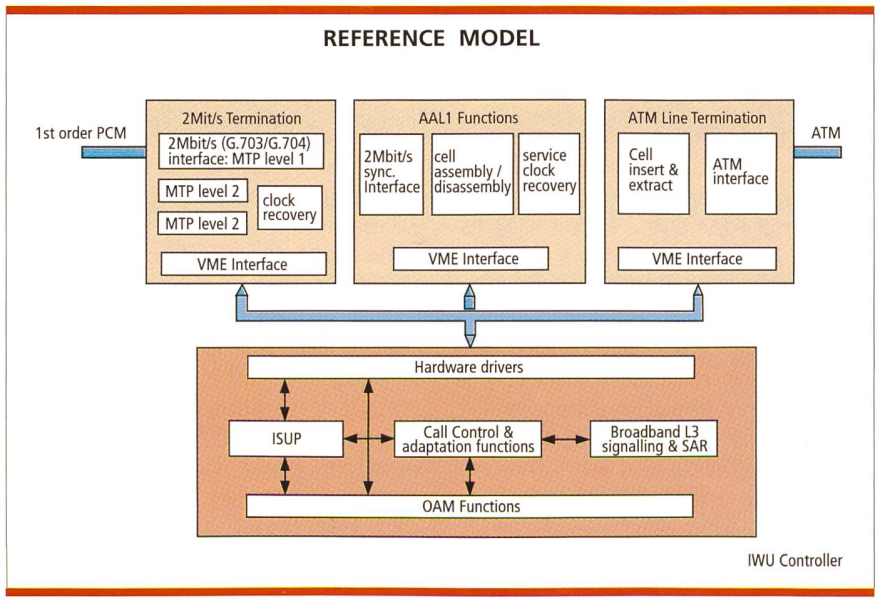

Fig. 4. Functional reference model of the ATM/N-ISDN Interworking Unit.

- the opportunity to implement and validate the features associated with the interface between an access network and a local exchange, which is currently being standardized. This interface (the so-called V_{B5}) is extremely important for regulating the attachment of access networks from different vendors to the same local exchange (and for the attachment of the same access network to local exchanges from different vendors).
- additional user accesses

The topology of the APON is 'tree-and-branch' *(Fig. 6)*. The Line Termination (LT) is located at the head end, and users are connected via a Network Unit (NU). The system offers both Fibre-To-The-Home (FTTH) and Fibre-To-The-Curb (FTTC) configurations.

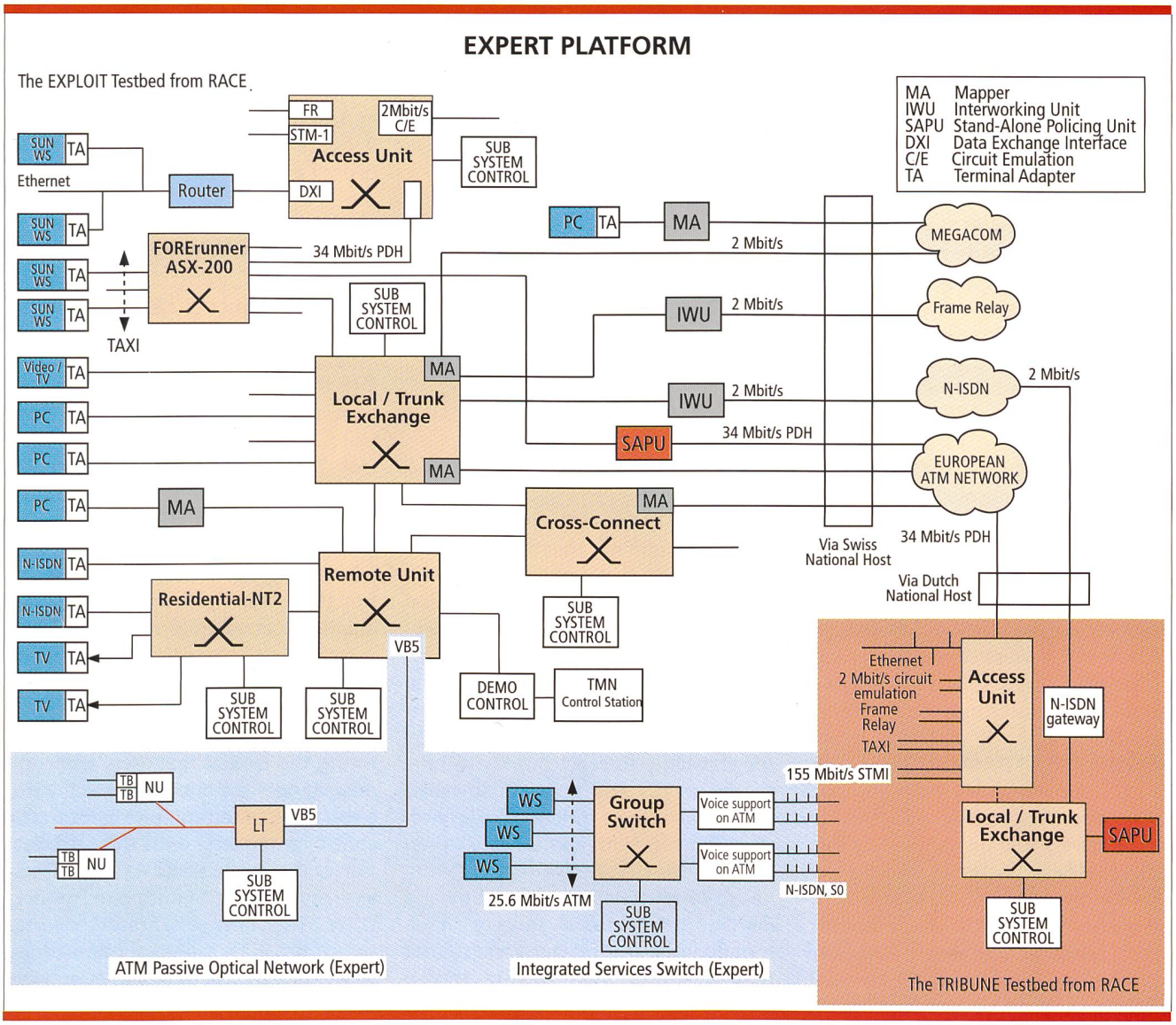

Fig. 5. The EXPERT platform.

The main characteristics of this access network are:

- 622 Mbit/s are available for users in the upstream and the downstream direction.
- Access to the upstream capacity is realized by means of a TDMA technique and a Medium Access Control protocol that allows the dynamic assignment of the available bandwidth.
- Approx. 100 users can be attached to the system. The user interfaces are currently of type ATM-in-SDH (at 155 Mbit/s). The incorporation of lower-speed user interfaces is being investigated.
- Four interfaces at 155 Mbits (ATM-in-SDH) are provided towards the local exchange.
- The 1300-nm wavelength window is used. The 1550-nm window is currently unused, but may be used in the future for (for example) CATV.
- The maximum fibre length between the LT and an NU is 10 km.
- The system is transparent for user-to-network signalling (i.e., all signalling is handled in the local exchange).
- The routing of ATM cells, Usage Parameter Control and cell header translation are based on the Virtual Path concept.
- The system supports V_{B5} interface capabilities.

Integrated services switch

The integrated services switch represents a convergence between Local Area Network (LAN) and Private Automatic Branch Exchange (PABX) functions. From a data service point of view, this switch behaves like an ATM-LAN switch. From a voice service point of view, the switch behaves like a PABX.

A preliminary market analysis has identified the following main requirements for corporate collaborative working and desktop video conferencing:

- STM-1 interfaces to the Wide Area Network
- 'low-speed' (e.g. 25.6 Mbit/s) interfaces to the desktop
- multiservice support: CBR (N-ISDN) and VBR
- ATM VPN capabilities
- configuration management and fault management.

In order to meet these requirements, the integrated services switch is being

realized *(Fig. 7)* with 155-Mbit/s ATM-in-SDH interfaces for interconnection with the ATM local exchange/access network, 25.6-Mbit/s ATM user interfaces for the connection of PCs or multimedia terminals, and N-ISDN S_0-interfaces. The switch performs both data switching/routing and voice switching based on ATM and by means of harmonized service stacks.

The major benefit of such an architecture is that by using ATM as the common underlying transport system one single-backbone network for voice and data can be achieved; moreover, since the switch can be connected directly to a public ATM network, this leads to a simplification of access structures and to an improvement of bandwidth utilization.

In the system being developed for EXPERT, telephony will be provided via a N-ISDN S_0 reference point with two B-channels, each of 64 kbit/s. In order to allow a full B-channel switching, each B-channel will be mapped to an individual VC connection. The isochronous operation of the S_0 interface is supported by the ATM Adaptation Layer AAL1. Signalling interworking between the N-ISDN terminals and the ATM network will be handled by software associated with the switch.

The European Computer Manufacturers Association (ECMA) is standardizing a Computer-Supported Telephony Application (CSTA) interface between PABXs and PCs. This interface specification will describe the functions needed to provide intelligent services in CPN environments when integrating voice and data communication.

Typical applications which will use the CSTA interface include:

Automatic Call Distribution (ACD)
- for the rapid distribution of incoming calls, including the management of waiting queues and appropriate announcements to the calling party.

Intelligent Call Distribution (ICD)
- for customer-specific or contents-specific distribution of incoming calls

Automatic Number Identification (ANI)
- providing background information or display of available data records about the calling party

Voice Response Unit (VRU)
- for the automatic answering and guiding of incoming calls based on multifrequency inputs

Enhanced signalling capabilities and service-enabling functions

Both the ATM Forum and the ITU-T are currently defining advanced features for broadband user-access signalling. The objective of these international activities is to establish the requirements and then to develop protocols to support sophisticated multimedia, multiconnection, and multipoint services. A further objective is to provide the flexibility to react quickly to new service needs and support so-called 'service-enabling functions'. Service-enabling functions can be considered as functions that the control network has to support in order to deploy and manage multimedia services in a broadband transport network, so that they are profitable to the service owner.

Within EXPERT, enhanced signalling capabilities and service-enabling functions will provide point-to-multipoint and statistical multiplexing facilities in line with the latest specifications, in particular based on Capability Set 2 of ITU-T and UNI version 4.0 of the ATM Forum. Switching hardware in the platform is already capable of supporting this functionality. The enhanced signalling capabilities will allow new traffic management experiments to be carried out, which will validate the support of such capabilities and examine the effects on a broadband network as a whole and on the overall end-to-end performance.

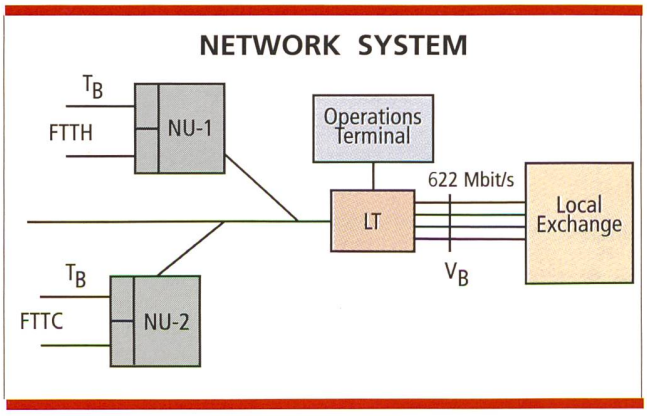

Fig. 6. The ATM Passive Optical Network System.

Integrated traffic control framework

Traffic experiments are being undertaken to validate existing theoretical models developed through studies into the ATM-sensitive areas of traffic control (Connection Admission Control [CAC] and Usage Parameter Control [UPC]), resource management, network performance and user QoS. The results from experiments in EXPLOIT have already shown that a framework of CAC and UPC control functions can protect other users against sources which are not obeying their originally specified traffic profile contract and that statistical multiplexing gain is possible.

The trials in EXPERT will involve monitoring the QoS of real users and commercial applications as well as investigating the added complexity of traffic control associated with the introduction of the Available Bit Rate (ABR) service and point-to-multipoint connectivity. The new integrated services switch provides the ideal opportunity to validate the capability to guarantee user QoS in an environment with mixed real-time and non-real-time traffic.

Traffic shaping is another important area being investigated by EXPERT. Tariffing schemes may well encourage users in order to reduce the cost of a service (i.e. to use the least network resources possible) and to employ traffic shaping. EXPERT partners have therefore already made an assessment of the limit to which the peak bandwidth of a number of different sources can be reduced until the QoS becomes unacceptable to the user. This approach allows the minimum necessary bandwidth for the connection to be obtained, which can then be used for peak rate shaping. In subsequent experiments, a more elaborate dual leaky-bucket mechanism will be adopted, once more knowledge of the traffic characteristics has been gained. The unique facilities offered by the EXPERT platform, mirroring the real network, enable trials to be performed on traffic carried from the private net-

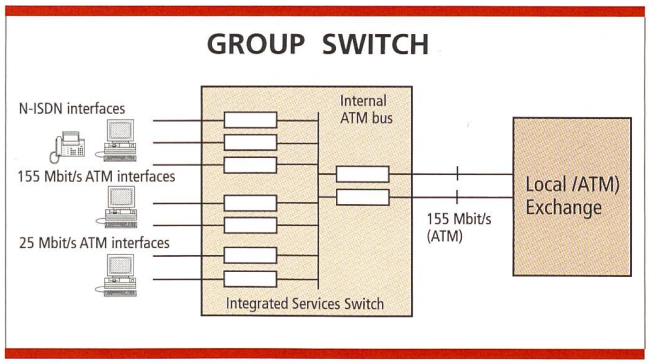

Fig. 7. Integrated Services Switch for voice and data.

work through the access network and the core network switches of the platform and into the public wide area network.

Relationship with the Swiss National Host

Details of the Swiss National Host are given in a separate article in this journal. The presence of the ATM platform and the expertise gained from EXPLOIT were a significant factor in the choice of the Grosspeter site in Basel to be also the location of the Swiss National Host. The relationship between EXPERT and the Swiss National Host can be seen from Figure 5. Essentially, EXPERT offers proprietary testbed-like facilities, whereas the Swiss National Host (managed by the Swiss Telecom PTT) provides commercial telecommunications services, including access to the ATM network and support for the accommodation of guest projects.

Conclusions

The EXPERT project offers probably the largest ATM platform in Europe for performing pre-service trials of new broadband services, applications, terminals and other equipment. It is well equipped, well supported and has access to sophisticated traffic generation and analysis equipment. The project is accustomed to cooperating with other projects and allows for collaboration in complementary areas.

For more information or to arrange to visit the site, a WWW server has been established:
http://www.elec.qmw.ac.uk/expert/

Acknowledgements

The achievements being made within the project EXPERT and the comprehensive development work being undertaken is only possible with the conscientious cooperation of all partners, together with the support of the Project Officer and funding from the Commission of the European Union, the Swiss Bundesamt für Bildung und Wissenschaft and other national bodies. The contribution of all these players is therefore gratefully acknowledged. 8.3

SUMMARY

The project AC094-EXPERT is one of more than 150 projects in the European Union 4th Framework Programme ACTS: Advanced Communications Technologies and Services. It is managed by the Association Swiss Telecom PTT/Ascom (ASPA[1]) and is unique in being the only project in the ACTS Programme to be coordinated by a non-EU organization. Based in Basel and building upon the highly successful RACE[2] project R2061-EXPLOIT, EXPERT has a major role in enabling advanced application trials, which are showing the capabilities and advantages of new broadband services and the underlying ATM technology. This article describes the features that are already available on the EXPERT platform and the further enhancements that are being developed during the course of the project (1995–1998). The platform will become increasingly an excellent representation of a broadband network, on which real user trials of new services and functionalities are encouraged.

Martin Potts received a BSc. degree in Electronic Engineering in 1971, and has been involved in the field of ATM since 1985. He is the project manager of the EU/DGXIII ACTS project 'EXPERT', which operates one of the largest ATM platforms in Europe. As a consequence of the important role played by EXPERT in the ACTS Programme, M. Potts is also Chairman of the so-called Chain: 'Global Network Inter-operability' and the parent Chain Group: 'Network Level Inter-operability and Management'.

Markus Tschanz studierte an der ETH Zürich und schloss sein Studium an der Abteilung Elektrotechnik, Fachrichtung Nachrichtentechnik, 1968 als dipl. El.-Ing. ETH ab. Als wissenschaftlicher Mitarbeiter am Institut für Höhere Elektrotechnik absolvierte er anschliessend ein Nachdiplomstudium in Informatik. Seit 1988 bei der Generaldirektion PTT, betreute er im Rahmen einer Stabsgruppe für strategische Studien die Erarbeitung der Grundstrategie des Fernmeldedepartementes sowie der Grundlagen des Projektes OFS-Telecom. In der Direktion Forschung und Entwicklung der Telecom PTT ist er seit 1991 als Adjunkt der Abteilung Technik der Fernmeldenetze unter anderem für die internationale Normierung im Rahmen von ETSI tätig und hat die Koordination der EU-Forschungsprojekte mit Beteiligung der Telecom PTT sowie die Schweizer Projektleitung eines solchen Projektes übernommen.