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AMUSE

ADVANCED MULTIMEDIA SERVICES FOR RESIDENTIAL USERS

AMUSE is a project of the multimedia services domain of the ACTS Program (Advanced Communications Technologies and Services) and stands for Advanced Multimedia Services for residential users. These services will be demonstrated in field trials carried out in different islands, using an end-to-end ATM infrastructure (from terminal equipment to multimedia server), through various types of access networks.

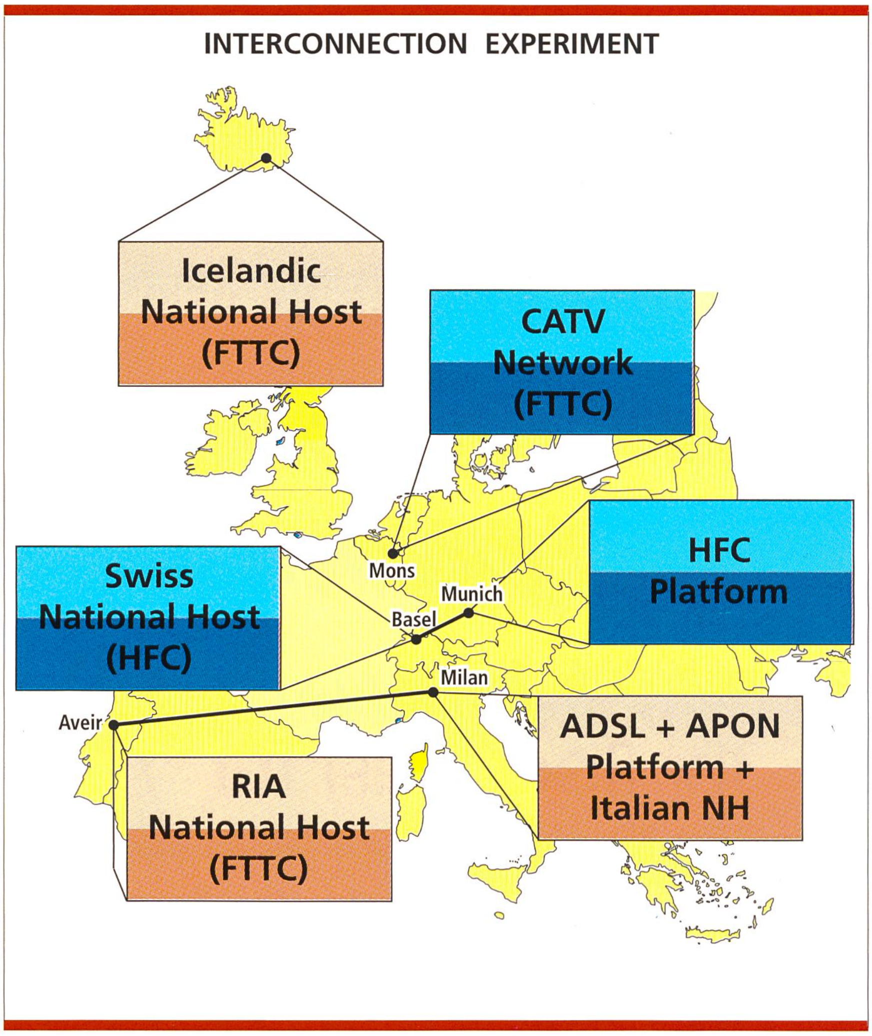

Fig. 1. Summary of the locations and the technology of each of the AMUSE trials.

The ACTS Program (Advanced Communications Technologies and Services) represents the European Commission's major effort to support pre-competitive RTD (Research and Technological Development) in the context

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of trials in the field of telecommunications during the period of the Fourth Framework Program of scientific research and development (1994–1998).

The multimedia services domain

If residential and small business information highways are to flourish, an open competitive market is vital. The provision of applications services has to be separated from the provision of the underlying transport networks, by vendor-independent standards. The large potential market for interactive services to the home and small business is being addressed by telecommunications operators, cable television operators, direct-to-the-home satellite broadcasters, and terrestrial broadcasters.

The provision of real-time, interactive multimedia services over advanced communications networks involves

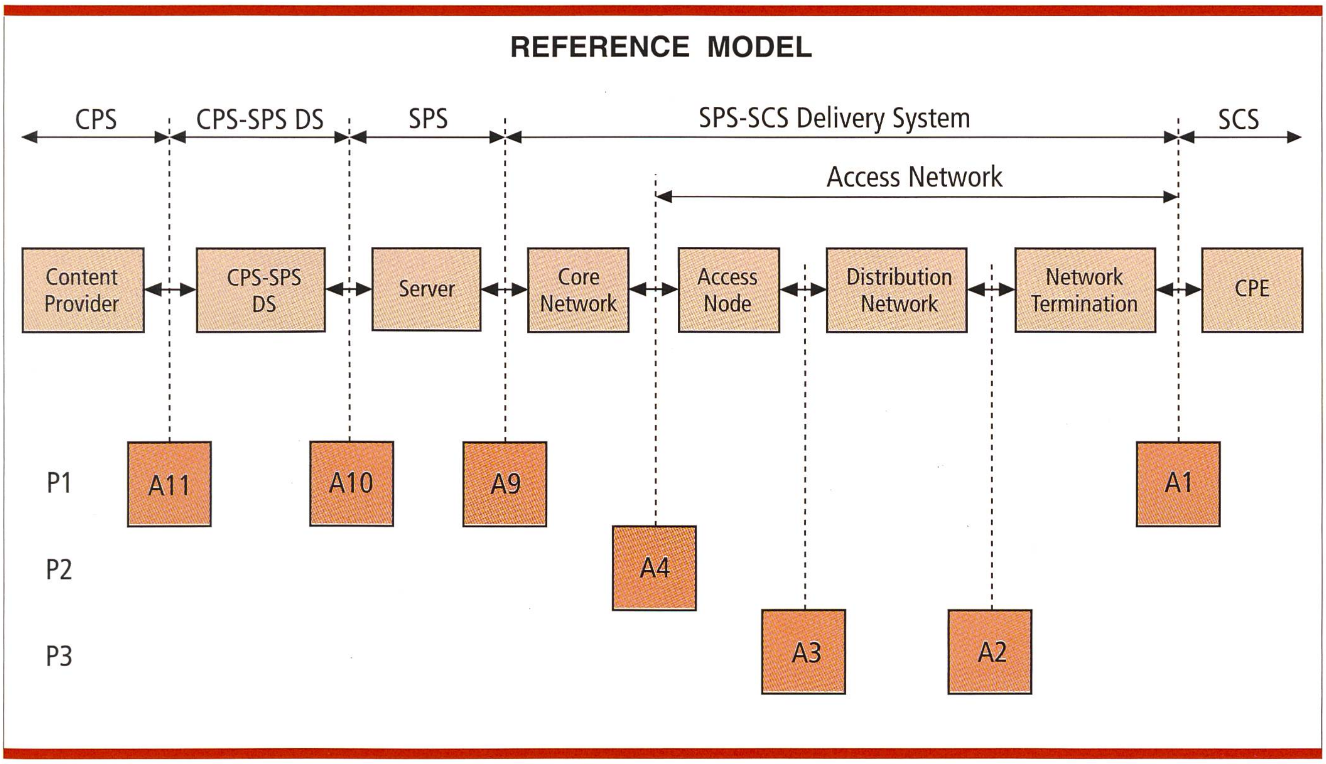

Fig. 2. The AMUSE reference model gives the building blocks of the whole multimedia chain from the content provider to the customer premises equipment as well as the reference points.

the development of a number of key technologies. 39 projects will work on these technologies. For practical reasons, they have been subdivided in the following three subdomains:

Subdomain 1:	Multimedia Content Manipulation and Management (MCM
Subdomain 2:	Interactive Distribution and Transmission (IDT)
Subdomain 3:	Server-Based Multimedia Services (SBMS)

AMUSE belongs to the SBMS sub-domain that addresses the provision of interactive audio-visual services over telecoms and CATV networks. A set of standard profiles that appears to offer a good chance of achieving open, vendor-independent provision, is fast being created by the *Digital Audio-Visual Council* (DAVIC). Support of and contribution to DAVIC is an integral part of AMUSE and of several other ACTS projects.

The AMUSE project

Main objectives of AMUSE

The AMUSE project aims at carrying out experiments on the provision of interactive and distributive multimedia services to real residential users (in the order of tens per trial island). These services will be demonstrated in field trials carried out in different islands, using an end-to-end ATM infrastructure (from terminal equipment to multimedia server), through various types of access networks. There are various AMUSE configurations used in the trial islands, and each configuration consists of different types of components, e.g. set-top boxes, ATM switches, access networks, and multimedia servers from different companies. Some of these components only exist in prototype versions, and they will be used for the first time in the planned configurations.

Participants to AMUSE

Table 1 gives the list of the companies and universities who participate in the AMUSE project.

Summary of trials

The trials involving real residential users rely on different national trial islands, characterized by different access network typologies (ADSL, HFC, FTTC/FTTB, ATM PON), service offering, categories of users and national regulatory rules and constraints. *Figure 1* summarizes the locations and the technology of each of the trials. The HFc-based trials in Munich, Basel and

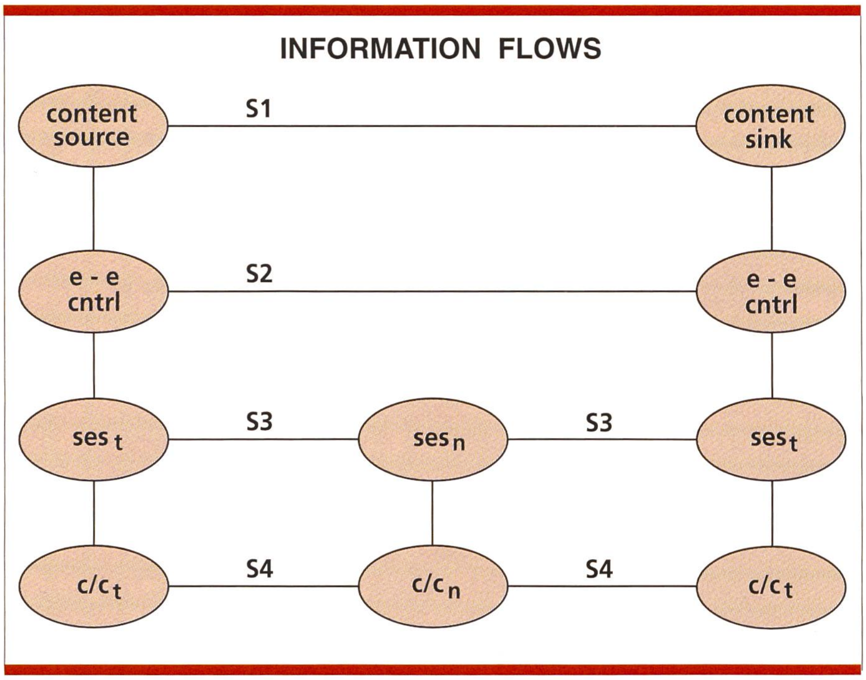

Fig. 3. Information flows and functional entities according to the DAVIC 1.0 Specifications.

Mons use an access network developed by Siemens AG and will take place sequentially with a rotation of the equipment.

Technical approach

The project will consist of two phases, each one resulting in demonstrations as follows:

First demonstration phase
- services supported by switched ATM end-to-end connections
- ADSL, HFC and FTTC/FTTB access network technologies
- ADSL upgrade from 4 to 8 Mbit/s downstream and from 64 to 640 kbit/s to allow for higher interactivity
- low-medium interactivity services supported: VOD, Internet Access, Broadcast TV . . .
- MPEG1 audio/video
- provisioning of Switched Video Broadcasting (SVB), using multicasting capabilities and zapping control

Second demonstration phase
- extended support of DAVIC 1.0 specs
- advanced ATM PON access network in the Milan trial island
- more user-friendly and interactive services: Tourist/Cultural Info, Tele-Travel Agency . . .
- full MPEG2 audio and video
- low cost, highly integrated set-top box with enhanced user interface, developed with the funding of the OMI Program
- study of the impact of the advanced IN approach and of enhanced signalling capabilities for multimedia services support

AMUSE in Switzerland

Organizational issues

The description of the Swiss trial will be limited to the first phase of the AMUSE project.

The Swiss partners

Siemens Schweiz AG and *Swiss Telecom PTT* participate to the AMUSE project as associate partner of Siemens AG.
BALCAB offers its cable TV network to allow the distribution of the multimedia services to real subscribers.
The *Swiss National Host* in Basel provides the rooms and infrastructure necessary to receive the multimedia server, the ATM switch and the front end, as well as the test systems.

Objectives of the Swiss trial

The main objectives of the Swiss trial are:
- to gain experience in the distribution of multimedia services to residential users
- to test the prototype ATM HFC access network in a different real environment
- to characterize the ATM traffic generated by multimedia applications
- to evaluate the suitability of a CATV distribution network for offering point-to-point services
- to gain hands-on experience on the evolution capabilities of a state of the art CATV distribution network

Planning

The trial phase with real residential users is planned to take place from October 29, 1996 to January 20, 1997.

AMUSE reference model of the multimedia delivery system

The AMUSE reference model is strongly aligned to the DAVIC System Reference Model (DSRM) contained in the Rev. 5.0 of DAVIC 1.0 Specifications. The DSRM identifies the major system blocks of a general DAVIC system and reference points between them. However, there are reference points where the AMUSE systems will use a different set of protocols than specified in DAVIC.

Building blocks and referencer points

Figure 2 gives the building blocks of the whole multimedia chain from the content provider to the customer premises equipment as well as the reference points.

Information flows and functional entities

The information flows and functional entities are represented *in figure 3.* The DAVIC 1.0 Specifications define two basic information categories: content-information and control-information.

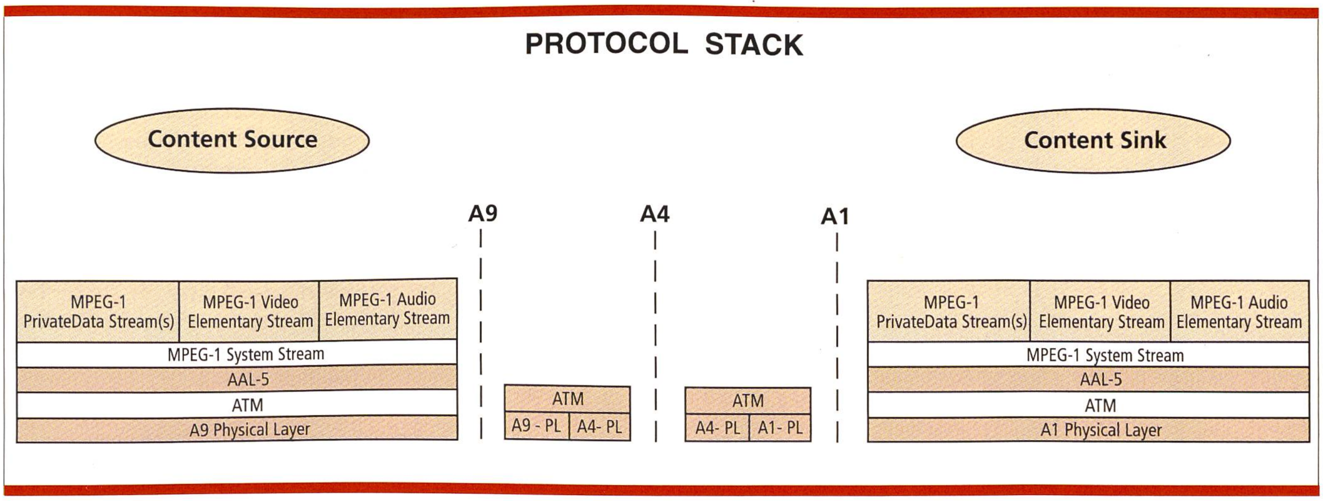

Fig. 4. Protocol stack for the S1 flow for audio-visual services.

S1 information flow

S1 is content-information flow from the content source to the source sink, for example audio, video, or data.

S2 information flow

S2 is a control-information flow, that is terminated by the control functional entities (e-e cntrl) which perform the service end-to-end control (e.g. VCR-like commands: pause, fast forward).

S3 information flow

S3 is a control-information flow. It is terminated by the session control functional entities (ses) that coordinate the manipulation of resources, for example the connections.

S4 information flow

S4 is a control-information flow, examples of S4 information flows include messages to establish or release connections, communicate addresses, port information, and other routing data. It is terminated by the call/connection control functional entities *(c/c)*.

Protocol stacks

The figures 4 and 5 give the protocol stack for the S1 flow for audio-visual services and S1/S2 flow for Internet access.

Infrastructure of the Swiss trial

A schematic view of the infrastructure of the Swiss trial is given in *figure 6*. The video server with Internet access, the Siemens ATM switch and the front-end are located in the Swiss National Host. At the same location, one can find, a coaxial cable reel, a network termination, an Virata ATM switch from advanced telecommunications modules, set-top boxes and television sets that serve demonstration and test purposes.

Video server

The video server is based on a RM400 workstation from Siemens Nixdorf.

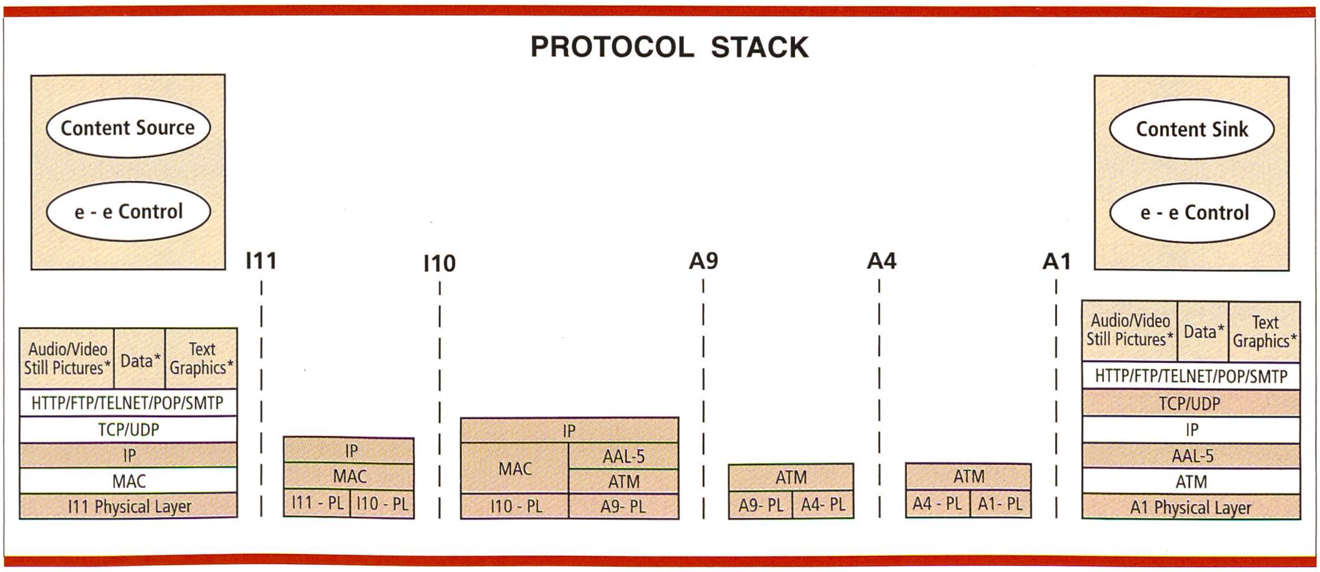

Fig. 5. Protocol stack for the S1/S2 flow for Internet access.

Figure 7 shows the functional building blocks of the video server that will be employed in the Swiss AMUSE trial island. Note that the server is at the same time an interactive application server and an Internet proxy server. The content of interactive applications is encoded according to the MPEG standard.

Customer premises equipment (Set-top box)

The set-top box manufactured from OnLine Media (England) has two main functions:

- To allow the display on a conventional television set of the digital information received from the network, e. g. for VOD, the set-top box receives from the network termination a MPEG1 program stream transported by ATM cells. It extracts and decodes the MPEG1 video and audio elementary streams and provides the television set with a PAL signal.
- To transmit on the network, encapsulated in ATM cells, the control commands issued by the subscribers with an infrared remote control, for example choice of the movie, play or pause.

As interface on the network side, a symmetrical ATM25 interface as specified by the ATM Forum will be used in all HFC trial islands.

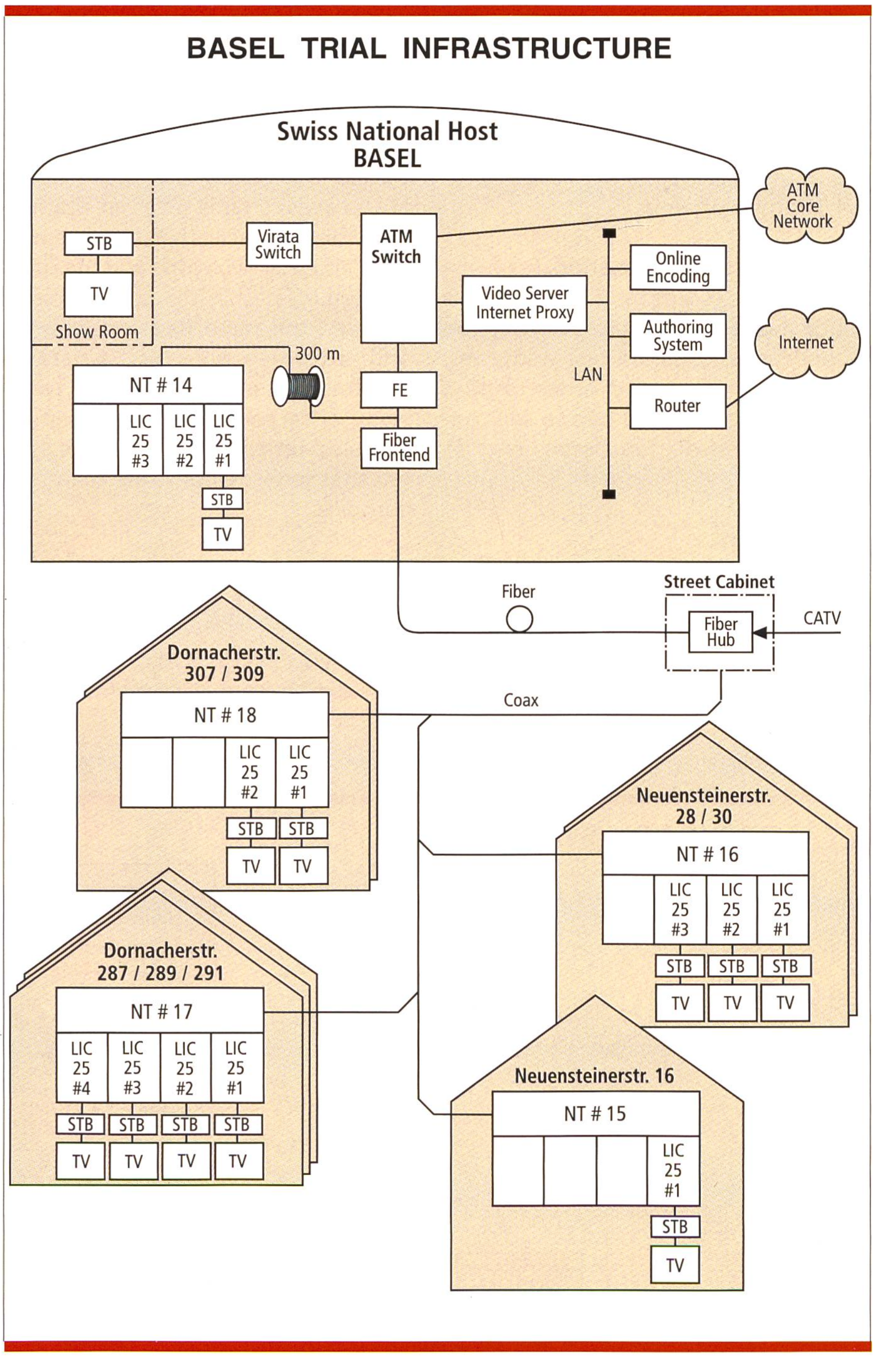

Fig. 6. Schematic view of the infrastructure of the AMUSE trial island located in Basel.

Delivery system

Core network
In the configuration used for the Basel trial, the core network functions are supported by the Siemens ATM switch CC-16 ACC V1.2+. The switch is equipped with three optical and one electrical STM-1 interfaces. One optical port is connected to the media server, an other one to the Virata ATM switch which will be used for test purpose, and the last one to the ATM network of the National Host. The electrical port is connected to the Front-End of the access network.

Access network
The front-end terminates the access network on the exchange side. It is connected to the core network via an STM-1 interface. Each front-end supports up to 32 network terminations in a point-to-multipoint configuration. The number of front-ends to be connected to a single ATM switch depends on traffic and performance parameters.
Each front-end together with its associated network terminations implements a distributed Virtual Path (VP) multiplexer that is controlled by the ATM switch. VP bandwidth allocation is static.
Multiplexing of cells in the upstream direction is based on a time-division multiple-access protocol. The cell transport system of each NT has a number of queues where upstream cells are queued for transmission. Each upstream queue is polled periodically with a rate corresponding to the aggregate bandwidth of all VPs associated with that queue. A central con-

troller located in the front-end is responsible for the allocation of transmission permits to upstream queues.
The network termination has a modular architecture and is able to accommodate up to four line cards. Each line card contains the circuitry required for transmission over the in-house distribution network. A symmetrical ATM25 interface as specified by the ATM Forum will be used in all HFC trial islands. Hybrid Fibre Coax networks are derived from existing CATV networks. As shown in *figure 8,* an optical fibre feeder is used to transport interactive signals between the front-end and a fibre hub, where the optoelectronic conversion takes place. Commercial CATV equipment is used for optical transmitters, receivers and amplifiers within the fibre hub.

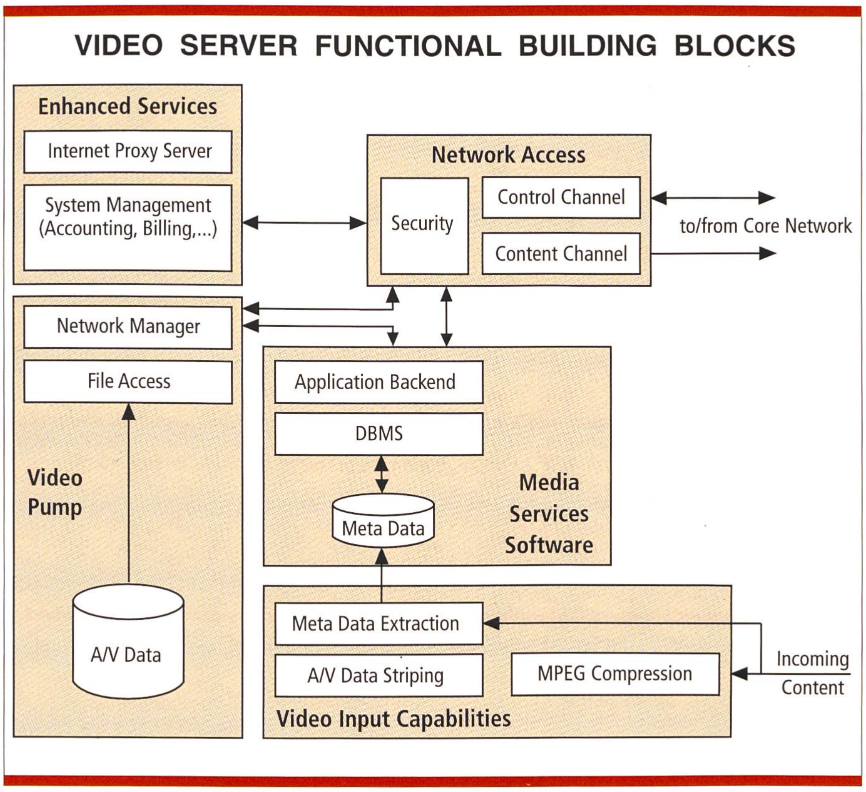

Fig. 7. Functional building blocks of the video server that will be employed in the Swiss AMUSE trial island.

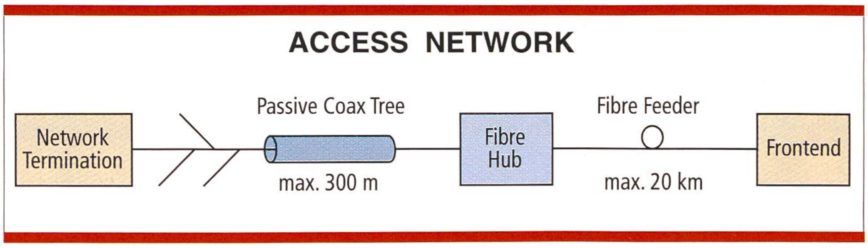

Fig. 8. Schematic view of a HFC-based access network.

Medium access control

As shown in figure 8, existing HFC access networks are generally based on 'tree and branch' topologies. They are originally designed for point-to-multipoint connections distributing TV programs, but in future they will be used also for logical point-to-point transmission of interactive multimedia services. This means that the shared medium is common to all subscribers connected to it resulting in multipoint-to-point connections towards the network site. Due to this fact, such networks based on multipoint configurations require extra functions for Medium Access Control (MAC) incorporated into their physical layers.

Zones of MAC communications
The MAC procedure covers a certain zone of a network where multipoint access is provided. Within this zone, the MAC is based on a bi-directional communication between two MAC access points 1 and 2 as it is shown in *figure 9.* In the HFC system used in Basel, the MAC access points 1 and 2 are located at the front-end and at the network termination respectively.

Upstream channels
The upstream channel is carried at the higher end (high-split system) of the spectrum.
Concerning the spectral allocation of interactive channels, a high-split architecture is used for the upstream channel. This approach does not only avoid the noisy return channel band (5 to 45 MHz), it also provides a much higher capacity for the upstream channel. Using a robust QPSK modulation, a full STM-1 return channel can be realized, which is shared by several subscribers through a TDMA protocol. A bandwidth of 160 MHz is occupied by the return channel.
With respect to the medium access scheme, the TDMA based procedure offers the highest flexibility in bandwidth allocation in conjunction with ATM.
The TDMA technique is used for communication between two entities connected by a physical link where more than one customer share the medium. It utilizes a slotting methodology which allows the transmit start times to be synchronized to a common clock source. Synchronizing the start times increases message throughput of messages since the message packets do not overlap during transmission. The period between sequential start times are identified as slots. Each slot is a period in time when a message packet can be transmitted over the link.
The time reference for slot location is received via a downstream channel generated at the operating centre at the network site and received simultaneously by all customers equipment attached to this centre. Since all customers equipment reference the same time base, the slot times are aligned

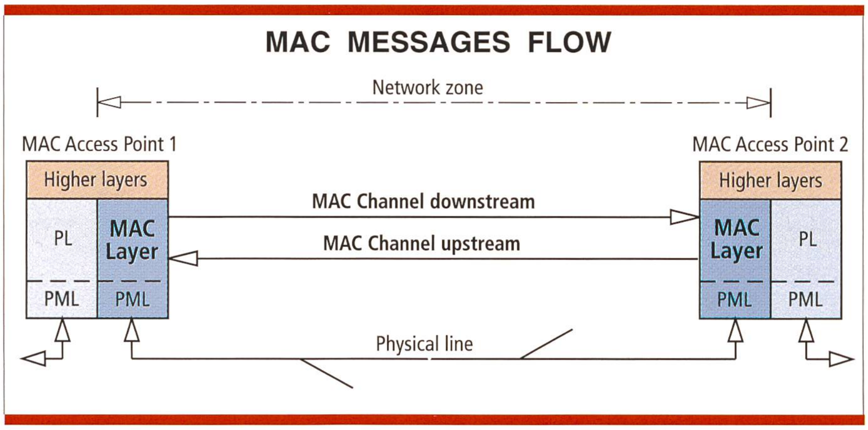

Fig. 9. General flow of Medium Access Control messages between two MAC access points.

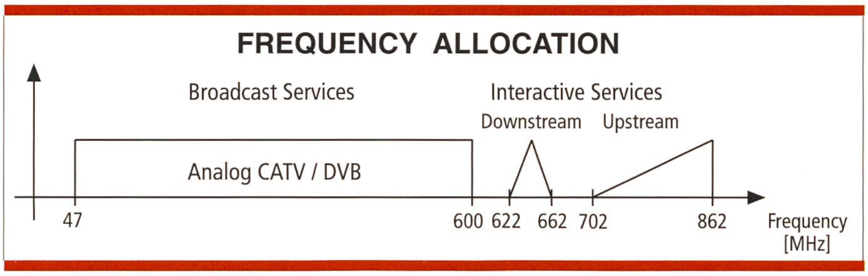

Fig. 10. Frequency allocation in the HFC-based access network.

for all customers equipment. However, since there is propagation delay in any transmission network, a time base ranging method accommodates deviation of transmission due to propagation delay.

Downstream channels
Carrier modulation techniques are used to multiplex broadcast and interactive signals. The downstream channel is transmitted using a highly efficient modulation technique (64-QAM), allowing a data rate of 155 Mbit/s to be carried inside a bandwidth of 40 MHz.
Quadrature Amplitude Modulation (QAM) is used as a means of encoding digital information over wireline, or fibre transmission links. The method is a combination of amplitude and phase modulation techniques. QAM is an extension of multiphase phase shift keying which is a type of phase modulation. The primary difference between the two is the lack of a constant envelope in QAM versus the presence of a constant envelope in phase shift keying techniques. The technique is used as a result of its performance with respect to spectral efficiency.
QAM is closely related to the original Non-Return-to-Zero (NRZ) baseband transmission. All QAM versions can be formed by generating two multilevel pulse sequences from the initial NRZ sequence, and applying these to two carriers that are offset by a phase shift of 90 degrees. Each modulated carrier then yields an QAM signal with suppressed carrier. Since carrier multiplication in the time domain corresponds to a shift in the frequency domain, the modulated spectrum maintains the shape of the two-sided baseband signal spectrum.
The spectrum of a QAM system is determined by the spectrum of the baseband signals applied to the quadrature channels. Since these signals have the same basic structure as the baseband PSK signals, QAM spectrum shapes are identical to PSK spectrum shapes with equal numbers of signal points.

Frequency allocation
As consequence of the technical choices made for the upstream and downstream channels, the frequency spectrum is allocated as presented in *figure 10.*

Preparation of the trial

Choice of the subscribers

Two types of requirements had to be considered. On one side there are requirements for the characteristics of participants. On the other hand there exist some limits due to the used equipment.

Characteristics of participants:
- several potential participants per household
- permission for automatic monitoring of user interactions
- willingness to fill out questionnaires and participate in interviews
- permission to install needed in-house installations (twisted pair)

Technical constraints:
- all participants have to be connected to the same street cabinet
- distance between street cabinet and head-end in SNH <20 km
- distance between street cabinet and network termination in basement of users premises <200 m
- length of twisted pair for in-house installation <250 m
- possibility to access one network termination during trial for technical experiments

Method of selection

Information about the project have been made available on the service channel of cable network operator and the WWW server of the Swiss National Host. As a reaction more than 100 interested users applied for participating in the trial. Unfortunately, they were spread all around the city of Basel. There were no ten interested users living at the same location fulfilling the technical constraints. Therefore in a next step a location had to be selected in which a small group of the interested users was living. Through direct information in this location additional potential participants have been found.

Integration tests

The phase integration test mainly covers technical tests on the cooperation of the system components and the functionality of the complete system. Some components have been developed just for the AMUSE trials, so their cooperation has to be tested for the first time.

Installation tests

The second phase, called installation test phase, is focused on testing the system components during installa-

List of acronyms and abbreviations

A/V	Audio/Video	NNI	Network Node Interface
A1–A11	Reference points	NRZ	Non Return to Zero
AAL	ATM Adaptation Layer	NT	Network Termination
ACTS	Advanced Communications Technologies and Services	OAM	Operation Administration and Maintenance
ADSL	Asymmetric Digital Subscriber Line	OMI	Open Microprocessor Systems Initiative
AMUSE	Advanced MUltimedia SErvices for residential users	OSI	Open Systems Interconnection (Reference Model)
AN	Access Network	P1–P3	Partition level of the DAVIC System Reference Model
ATM	Asynchronous Transfer Mode	PCR	Peak Cell Rate
CATV	Cable Television	PL	Physical Layer
CCITT	Comité Consultatif International Télégraphique et Téléphonique	PML	Physical Medium dependent Layer
CDV	Cell Delay Variation	PON	Passive Optical Network
CP	Control Plane	POP	Post Office Protocol
CPS	Content Provider System	PSK	Phase Shift Keying
DAVIC	Digital Audio-Visual Council	QAM	Quadrature Amplitude Modulation
DBMS	Data Base Management System	QPSK	Quadrature Phase Shift Keying
DS	Delivery System	RTD	Research and Technological Development
DSM-CC	Digital Storage Media – Command and Control	SBMS	Server-Based Multimedia Services
DSRM	DAVIC System Reference Model	SCS	Service Consumer System
DVB	Digital Video Broadcast	SL0	Principal Service Layer identifier
ESC	End Service Consumer	SL1	Application Service Layer identifier
ESCS	End-Service Consumer System	SL2	Session and Transport Service Layer identifier
ESP	End Service Provider	SL3	Network Service Layer identifier
ESPS	End-Service Provider System	SMTP	Simple Mail Transfer Protocol
FE	Front End	SNH	Swiss National Host
FTP	File Transfer Protocol	SPS	Service Provider System
FTTC/FTTB	Fibre to the Curb/Fibre to the Building	SSCOP	Service Specific Connection-Oriented Protocol
HDTV	High-Definition Television	STB	Set-Top Box
HFC	Hybrid Fibre Coax	STU	Set-Top Unit
HTTP	HyperText Transfer Protocol	SVB	Switched Video Broadcasting
IAT	Inter-Arrival Time	TBD	To Be Defined
IDT	Interactive Distribution and Transmission	TC	Transmission Convergence
IN	Intelligent Network	TCP	Transmission Control Protocol
IP	Internet Protocol	TDMA	Time Division Multiple Access
ISP	Intermediate Service Provider	TS	Transport Stream
LAN	Local Area Network	TV	Television
LIC	Line Interface Card	UDP	User Datagram Protocol
MAC	Medium Access Control	UNI	User Network Interface
MCM	Multimedia Content Manipulation and Management	UP	User Plane
MHEG	Multimedia and Hypermedia information coding Experts Group	VCR	Video Cassette Recorder
MP	Management Plane	VOD	Video On Demand
MPEG	Moving Picture Experts Group	VP	Virtual Path
NMS	Network Management System	WWW	World Wide Web

tion at the specific location of the trial islands. This has to be done stepwise in order to prove the functionality of single components and their cooperation. Beginning with the basic system components like the ATM switch, the installation test should construct the overall system out of tested components.
The method of stepwise testing is necessary in order to verify the functionality of components which couldn't be tested in the laboratory, and it takes into account that environmental conditions are different from the laboratory conditions.

Services

Video on demand

VOD refers to a network-delivered service that offers the functionality of the home VCR (as a player only) without having need to get a copy of the chosen material. The user has the ability to use the following features: select/cancel, start, stop, pause.
Due to the experimental character of this trial and to the small number of users (10), only a limited number of movies and documentaries will be offered.

World wide web browser

The users will have the possibility to surf on the WWW by using a keyboard with infrared link and a WWW browser integrated to the set-top box.

Experiments

Technical experiments

Three types of technical experiments will be carried out:
- ATM traffic characterization
- network performance measurements
- mid and higher level protocols testing

The traffic characterization experiments investigate the ATM layer traffic characteristics of both, the video and Internet traffic flows. The experiments shall deliver important information as regards bandwidth utilization and cell clumping/dispersion under normal and under load conditions.
The traffic shall be characterized as follows:
- PCR (Peak Cell Rate)
- CDV (Cell Delay Variation)
- cell IAT (Inter-Arrival Time)
- burstiness

The Network performance measurements shall measure the ATM layer network performance under normal and load conditions. Two measurement methods exist for estimating ATM cell transfer performance, either in-service method using OAM performance monitoring cell or out-of-service method by transfering a known data stream (test stream) at the source and measuring it at the destination measuring point. The latter method is the only feasible method that can be used in the current AMUSE functionality.
Measurements of the ATM performance parameters will be performed for both, upstream and downstream directions. The following performance parameters shall be measured:
- cell error rate
- cell loss rate
- cell misinsertion rate
- cell transfer delay
- cell delay variation
- bit error rate

Service-related experiments

- User attitudes and practices shall be examined by pre-experimental interviews.
- Automatic monitoring on the video server will perform the collection of usage information and the determination of service rush-hours.
- Users interviews shall deliver data on user satisfaction and acceptance of the offered services.

Table 1. List of the companies and universities who participate in the AMUSE project.

Company name	Country
Italtel SpA	Italy
ATEA	Belgium
Autor – Tecnologias Multimédia	Portugal
CSELT	Italy
Deutsche Telekom AG	Germany
GPT	United Kingdom
IDEA	Belgium
INESC	Portugal
McCann Erickson	Italy
NTUA	Greece
Nyherji	Iceland
OnLine Media	United Kingdom
Orckit	Israel
Portugal Telecom/CET	Portugal
Post and Telecom Iceland	Iceland
Siemens AG	Germany
Siemens Nixdorf	Germany
Siemens Switzerland	Switzerland
Sirti	Italy
Swiss Telecom PTT	Switzerland
Telecom Italia	Italy
University of Iceland	Iceland
University of Paderborn	Germany
University of Stuttgart	Germany
Videotime	Italy

Conclusion

The demonstration phase on the AMUSE trial island located in Basel has not begun yet. It is therefore not possible to present here any results at this stage. The participants to this project hope to gain valuable information and experience on

- the distribution of multimedia services to residential users
- the use of HFC networks for offering point-to-point services
- the end-to-end use of ATM for the distribution of broadband services.

References

This article is based mainly on the deliverables of the AMUSE project and on Rev. 5 of DAVIC 1.0 Specifications. Very informative articles on Residential Broadband Services and on the distribution of Video on Demand can be found in the September/October 1995 issue of 'IEEE Network'.

Acknowledgement

The author wishes to acknowledge the help of the collaborators from Swiss Telecom PTT, Siemens Schweiz AG, from Siemens AG, the AMUSE consortium and the financial support from BBW for the AMUSE project. 7

Bischoff Jean-Claude, Dipl. El.-Ing. and Dr. sc. techn. (EPFL) is an engineer in the group FE234 'Broadband Networks' since 1994. In 1986–1987, he has been a visiting scientist with Bell Communications Research, USA. He then joined, as scientific collaborator, the Institute for Micro and Optoelectronics, Department of Physics of the Swiss Federal Institute of Technology in Lausanne. Still in the domain of microelectronics, he was with Rolex, Geneva, in 1990–1991. He entered in 1991 the Swiss Telecom PTT, as engineer in the group FE221 'Optical Fibre Cables'. Besides the participation to the ACTS/AMUSE project, his present activities include contributions to technical specifications and test for the VC-switching pilot and evaluation of ATM test equipment.

ZUSAMMENFASSUNG

AMUSE – Advanced Multimedia Services für Privatteilnehmer

AMUSE ist ein Projekt der Multimediadienste des ACTS-Programms (Advanced Communications Technologies and Services). Eine Demonstration dieser Dienste erfolgt in Feldversuchen, die in verschiedenen Versuchsinseln mit einer durchgehenden ATM-Infrastruktur (vom Endgerät bis zum Multimedia-Server) über verschiedene Netzzugänge durchgeführt werden. Das ACTS-Programm ist ein wichtiger Beitrag der europäischen Kommission zur Unterstützung der Forschung und Technologieentwicklung (RTD) im Vorkonkurrenzstadium im Rahmen dieser Versuche auf dem Gebiet der Telekommunikation für die Dauer des vierten Rahmenprogramms für wissenschaftliche Forschung und Entwicklung (1994 bis 1998). Die Demonstrationsphase auf der AMUSE-Versuchsinsel in Basel ist noch nicht angelaufen. Aus diesem Grund sind zu diesem Zeitpunkt noch keine Resultate erhältlich. Die Projektteilnehmer hoffen jedoch, wertvolle Informationen und Erfahrung in der Verteilung von Multimediadiensten an Privatteilnehmer, im Einsatz von HFC-Netzen für Punkt-zu-Punkt-Dienste und in der durchgehenden Benutzung von ATM in der Verteilung von Breitbanddiensten zu gewinnen.