The AMUSE Residential Multimedia Trials: Network Architecture and First Results[†]

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Abstract. The European ACTS project AMUSE (Advanced Multimedia Services to Residential Users) carries out ATM-based multimedia field trials in a heterogeneous environment. The AMUSE infrastructure is tested in six European countries under different technical and regulatory circumstances.

The network architecture, starting at a generic system configuration, adopts different options in the four domains of Server, Core Network, Access Network and Customer Premises Equipment. A media server provides Video on Demand as well as other interactive multimedia services. Additional gateways are provided for high-speed internet access and digital access to broadcast TV. The range of access networks used includes Hybrid Fibre-Coax (HFC) and Asymmetric Digital Subscriber Line (ADSL).

Service usage and user acceptance have been evaluated by automatic monitoring tools and by user questioning after the trial. In addition, traffic measurement results including packet size distribution and packet interarrival distributions are available from the first trials.

Keywords: Field Trial, ATM, Multimedia, Network Architecture, Access Network, Measurement

1. Introduction

1.1. Multimedia Trials in the European Environment

Several Interactive Multimedia field trials involving real residential users have been and will be conducted within the European ACTS project AMUSE (*Advanced Multimedia Services to Residential Users*). The trials, located in different European countries, all depend on ATM as the basic transfer mode. Parts of the trial equipment and some applications are shared between trials whereas others are site dependent.

Section 2 explains the general reference configuration and the specific HFC-based trial configuration. Section 3 lists the services offered in the trials and section 4 presents service usage and traffic statistics obtained from automatic monitoring from two trials, carried out in Munich, Germany and in Basle, Switzerland.

1.2. The AMUSE Consortium

The AMUSE consortium comprises several companies, telecom operators, research institutes and universities, combining their knowledge and experience from hardware

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development to content provision and from theoretical studies to the implementation of user interfaces.

Equipment and Content Providers		**Telcos and Cable Operators**	
ITALTEL Spa (prime contractor)	I	IDEA S.C.	B
McCann Erickson Italiana Spa	I	Swiss Telecom PTT	CH
Siemens Nixdorf Information Systems	D	Deutsche Telekom AG	D
Siemens AG	D	Portugal Telecom / CET	P
Siemens Switzerland Ltd	CH	Telecom Italia Spa	I
ATEA	B	Post and Telecom Iceland	IS
Acorn Computers Ltd	GB		
GPT Ltd	GB	**Universities**	
Videotime	I	NTUA Institute of Communication	
Nyherji Ltd	IS	and Computer Systems	GR
Orckit	IL	University of Bonn	D
Research Institutes		University of Stuttgart / IND	D
Sirti Spa	I	University of Iceland	IS
Instituto de Engenharia de Sistemas e Computadores	P		

Table 1: The AMUSE Consortium

2. Network Architecture

The AMUSE trials implement different options for residential access to ATM-based broadband services. Figure 1 shows the Reference Configuration, which indicates the options used in the different network parts and the DAVIC reference points [1] in between. The server side consists of a *Video on Demand* (VoD) and interactive multimedia server, which will have a billing system attached in future trials. Optionally, there is a gateway to cable television offering *Switched Video Broadcast* (SVB). Internet access is provided either through a WWW proxy server in the Multimedia Server or by a separate Internet Gateway.

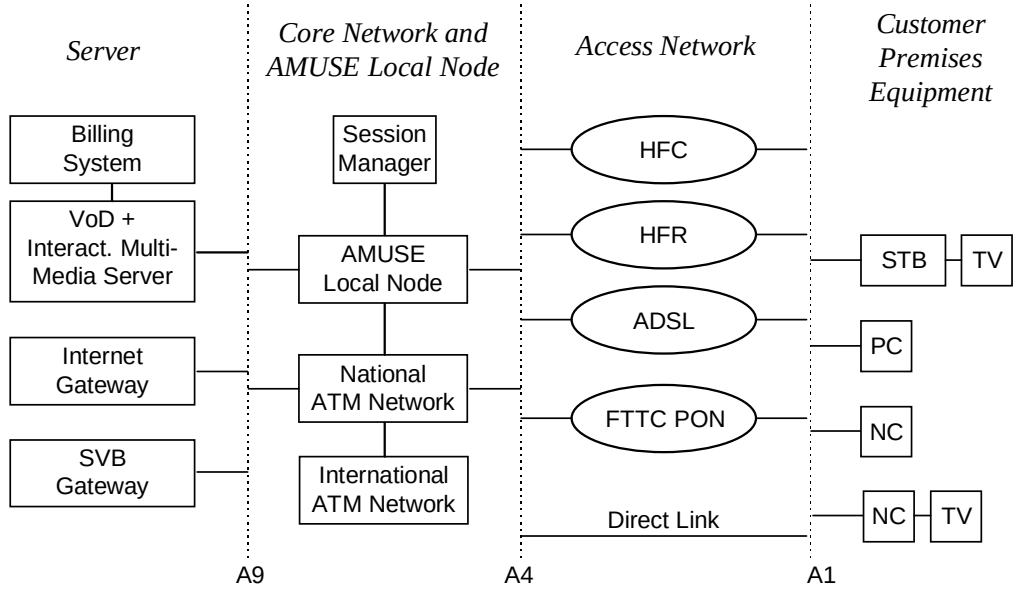

Figure 1: AMUSE Reference Configuration

The core network consists of a core switch (the *AMUSE Local Node*) and can optionally use parts of the national and international ATM network infrastructure. For the implementation of DSM-CC UN control functions, a session manager will be attached to the Local Node.

The access networks used in the different trials are based on existing infrastructure like HFC (*Hybrid Fibre Coax*, using TV cable networks) or ADSL (*Asymmetric Digital*

Subscriber Line, using the customer's telephone line) or use new infrastructure like HFR (*Hybrid Fibre Radio*, replacing the HFC coax network by a radio link) or PON (*Passive Optical Network*). Another option is not to use a special access network but to place a small ATM switch into the basement of each home to be connected ("direct link").

At the customer side, the usual equipment is a Set Top Box with a remote control, connected to a TV set, but the standard ATM interface allows also multimedia PCs or NCs (*Network Computers*) to be connected.

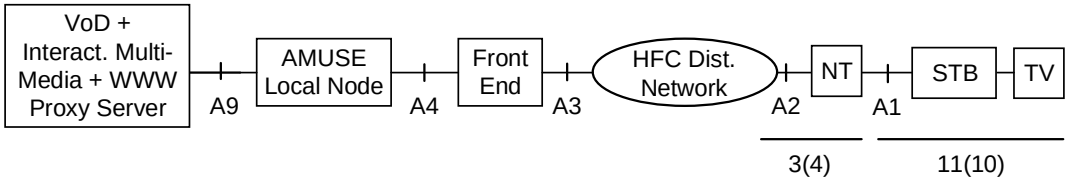

Figure 2: Munich and Basle Trial Configuration

The detailed results from the Munich and Basle trials reported in section 4 are based on the configuration shown in Figure 2, consisting of a video server with Multimedia server and WWW proxy server connected to an ATM switch at A9. The switch interfaces with an HFC access network serving three (four) houses with a total of 11 or 10 residential homes in Munich (Basle), which use the STB/TV combination. International interworking experiments have been conducted which show that this ATM-based platform can be flexibly used also for long distance connections, except for the control protocols, which may have to be modified to allow for long round trip delays without impairment of the perceived reaction speed.

3. Services

A whole variety of services are or will be offered in the framework of the AMUSE trials. Some of the corresponding applications are still being developed; others have been in use since the first trial. The most heavily used services in the trials so far were

- Internet Access: the set top box WWW browser gives access to the world wide web using a remote control for navigation
- Video on Demand (VoD): a choice of several movies and other films
- News on Demand (NoD): recorded TV news broadcasts of the past seven days. This service is going to be improved by news classification and indexing, so that personalised news services can be offered.

Other services offered are home shopping, home banking, tele games, info commercials on demand, travel information, travel agency and tele-voting services.

The amount and range of contents offered in the trials is a vital point also in the discussion of service usage results due to the limited number of different videos which could be offered in such a trial.

4. Trial Results

4.1. Service Usage Observation from Automatic Monitoring

One of the methodologies used within the AMUSE trials to evaluate the service demonstrations is the automatic monitoring of user actions. The objective of the automatic monitoring is to establish a usage profile to get an exact picture of when the participant uses the system and what services he uses most frequently. All relevant actions of the users are permanently monitored and evaluated automatically without additional effort for the user. Each action (e.g. selection, start, stop of a video, retrieval of a WWW document) is

recorded in a log-file together with information like time stamp, STB user Id, amount of data transferred, type of data/filename of document, etc. This allows for a detailed offline analysis of various aspects concerning the service usage.

Questions on the usability of the system, the attractiveness and the user acceptance of the new services are best investigated by methodologies like heuristic evaluation, user observation, user interviews and questionnaires. Those methodologies are applied in the AMUSE trials as well as the automatic monitoring, but this paper focuses on the presentation of analysis results of the monitoring data. For more information on the other issues the reader is referred to [2] or [3].

Due to the fact that at the time of preparation of this paper the first two AMUSE trials in Munich (May - August 1996) and Basle (October 1996 - January 1997) have been finished, the description of results is focused on a comparison of both trials to point out similarities and differences. A comprehensive summary of results of the Munich trial can be found in [2] or [4], a detailed description of all results will be found in the AMUSE deliverables (up to now reported in [5]).

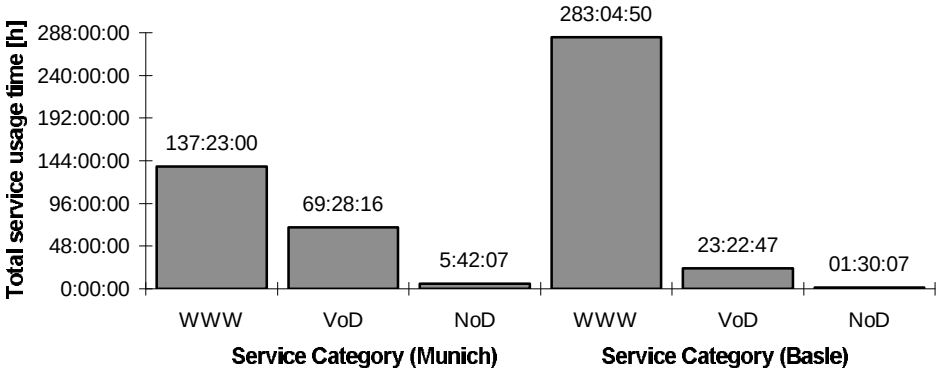

Figure 3: Total service usage for all service categories, Munich and Basle

Figure 3 shows the total usage time (in hours) for each of the three service categories provided (WWW, VoD and NoD) in the trials of Munich and Basle. Although the numbers give the total time for different trial period length and a different number of residential set top boxes (Munich: 98 days, 11 users; Basle: 105 days, 10 users), a breakdown of numbers to an average per day and single user allows to derive the same conclusions. A big large difference in terms of usage time spent on each service category shows that in both trials, the user interes focuses on particular services: The WWW service clearly is the most interesting service for the residential users. VoD is on second rank, followed by NoD usage, again with considerable difference. It is an interesting fact that the usage of WWW in Basle is much higher than in Munich, but on the other hand the usage of VoD and NoD in Basle is much lower than in Munich.

To compare the profile of interest of the individual users in a particular service, the following figures present the average usage time per day for each residential user of Munich and Basle trial (identified by their set top box STB Id.). The bars labelled as „M“ and „B“ show the average time per day over all STBs in Munich and Basle respectively.

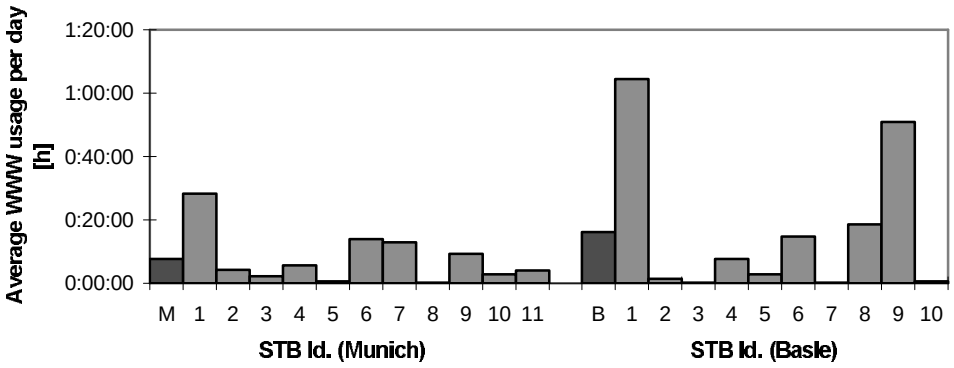

Figure 4: Average WWW usage per day for all Munich + Basle STBs

Figure 4 presents the profile for the WWW service. The users can be classified into three groups with distinct differences: There are a few top users with an average usage time high above the corresponding trial average (like users M1, B1 and B9), getting close to or even above 1 hour of usage per day. There are some more users ranging close to the trial average, like M6, M7, M9 or B6, B8). The rest (more than half of all users) have a rather small service usage time indicating little interest in the service (just to point at M8, B3 and B10, who even used the service less than one hour in total).

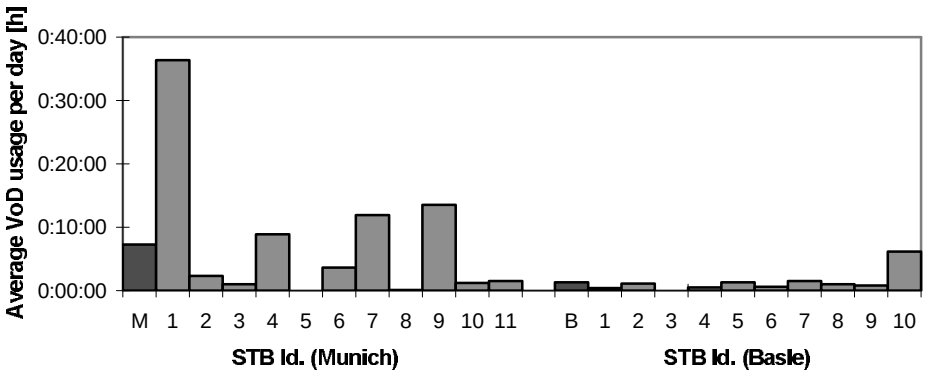

Figure 5: Average VoD usage per day for all Munich + Basle STBs

Figure 5 shows the profile for the VoD service, where the difference of general interest in this service between Munich and Basle becomes clearly visible again. Among the Munich participants, there is one top user (M1) and with considerable difference some medium users (M4, M7, and M9), who all range above the trial average. As with the WWW profile, the third and biggest group comprises of users with rather low usage (amongst those M5 and M8 with a total trial usage of less than one hour). In terms of absolute numbers, Basle has one top user (B10, who would be a medium user compared to Munich), all others are very similar to each other (even very low compared to Munich) and one user (B3) shows very little interest in the VoD service.

A figure of user profile for the NoD service is omitted because it is very similar to the one of the VoD service, but it stresses the above statements. To give a summarising interpretation of the figures for all three service categories, the differences in the usage profiles between Munich and Basle have to be pointed out: In Munich the user of STB 1 was the top user in all service categories WWW, VoD and NoD with a large distance to all other users. It has to be mentioned that the user of STB 1 in fact was a student who already had experience in using the Internet, and possibly was more open to experiment with new services than the others. In Basle there is no overall top user, in contrast to this the top user

for VoD and NoD (STB 10) was amongst the least interested users for the WWW service and the WWW top users of STB 1 and STB 9 were in the third group for VoD and NoD.

The distinct gap in the usage volume between WWW and the video services (VoD, NoD) emphasises the problem of content provisioning and/or creation, which of course has considerable impact on the attractiveness of the service. Within providing the Internet access to the World Wide Web, a nearly unlimited source of contents is offered to the user, even in rather small technical trials like in the AMUSE project. But the provision of attractive and competitive contents for the video on demand service depends on the collaboration with commercial content providers. For the upcoming trials in other countries it is expected to have a broader choice of up-to-date movies and even a rather high content refresh rate. Thus, the study of the service usage will allow to investigate the impact of the content variety on the amount and frequency of service usage.

For the WWW service, which was used extensively, it was worth going into more detail for analysing the stochastic properties of the WWW traffic caused by the residential users and observed by the automatic monitoring. The results presented in the following subsection are the first step towards a detailed characterisation of the WWW traffic that future networks have to cope with.

4.2. WWW Traffic Analysis

The logging data of the field trials in Munich and Basle have been used to describe and visualise the characteristics of the produced WWW-traffic. The data allowed an evaluation of three different types of WWW-traffic: requests for data on the local AMUSE-WWW-Server, requests for data that was found in the local cache of the Proxy server and requests for data that had to be externally retrieved from the internet.

To understand the stochastic behaviour of the WWW data streams the probability distributions of the request sizes and of the request interarrival times have been investigated.

Request Sizes

The evaluation of the request sizes for the three types of WWW-traffic mentioned above showed that requests for local data have been of a very limited size. There were no large http data packets to be retrieved from the AMUSE-server. The local cache served data requests up to a size of 200 kbyte. The smaller the request size, the higher was the probability that it could be served by the local cache. While most externally served requests were quite small, there was a considerable number of large requests.

The complementary distribution functions for the request sizes of all http requests (regardless of how they were served) of the 12 STBs of the Basle trial are depicted in Figure 6 (left side). The curves show the probability of a request being of equal or greater size than drawn on the x-axis.

The curves can be categorised into two classes. Some STBs have never issued requests exceeding a request size of about 200000 bytes, whereas others requested documents with a size of more than 1 Megabyte. Again the STBs with the small request sizes are the ones that were rarely used and the busy STBs present the distribution functions including large request sizes. So the latter ones may be more representative of future users that really make use of the WWW. The evaluation of each STB of the Munich trial led to similar curves.

The thicker lines indicate the distribution function average of all STBs (all request sizes regardless of the issuing STB were taken to calculate the distribution function) and look very similar for both trials. The shape of this line has an unfortunate characteristic, since it doesn't indicate any upper bound for request sizes. It is difficult to define a mathematical function of a similar shape for the modelling of the WWW-traffic.

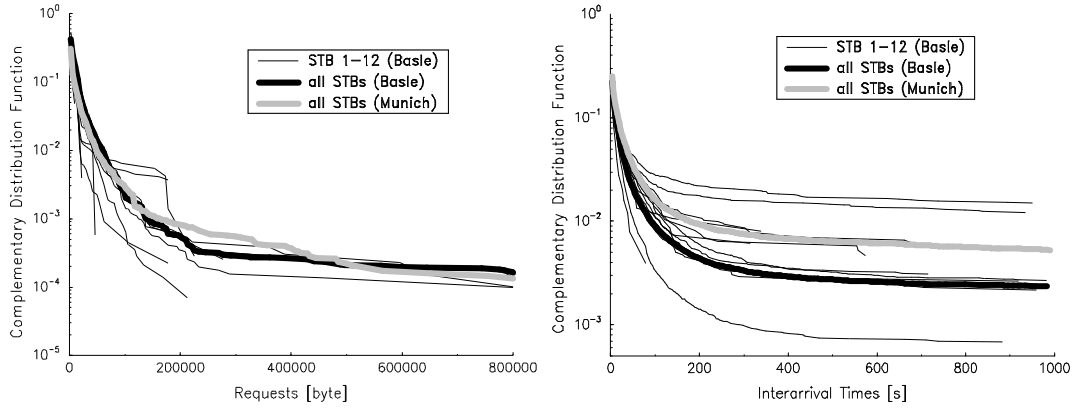

Figure 6: Complementary Distribution Functions for request sizes (left) and for request interarrival times (right), all http request types.

Request Interarrival Times

The evaluation of the request interarrival times for the three http request types showed similar results for both trials. There was a comparatively high probability for a local request to have a large interarrival time. This may be due to the fact that at the beginning of a session the local server had to be addressed to get the home page. After this, the local server was rarely used during the following session.

For all STBs Figure 6 (right side) shows the probability of a request interarrival time being equal or greater than drawn on the x-axis. Like in the Munich evaluation, the curves show two regions. First the curves drop quickly for small interarrival times, but then almost stagnate at a certain probability level. This behaviour results from the fact that the logging data contains the interarrival times within a WWW session as well as the time spans between the sessions.

Like the request size distributions, the distribution function of the interarrival times proves that some STBs were rarely used whereas others were used intensively. The thicker lines denote the average interarrival times of all STBs of the Basle trial and the Munich trial. They stagnate at a probability for very large interarrival times of about 0.23% and 0.5% respectively.

4.3. Summary

The results achieved and the experiences gained by using an automatic monitoring mechanism for the services usage have to be separated into technical and service related aspects. On the technical point of view, the tools for monitoring the service usage worked very well for all services, taking into account that the VoD/NoD and WWW services are provided by different control processes on the Multimedia server, respectively generating monitoring data separately. Altogether, the concept and methodology of automatic monitoring as being set up for the trials within the AMUSE project seems to be well suited for future trials with a larger number of users involved.

The issue of limited number of users is the main drawback for giving a solid interpretation of the results from the service point of view, gaining information on a typical usage profile and getting answers on the acceptance of the services. In addition, the behaviour of the user heavily depends on further issues like the quality of the contents provided within the service and the tariffs used.

It is interesting that the WWW traffic generated by users in Munich and Basle produced almost identical characteristics. The uncommonly heavy tails of request size distribution functions can be found in both trials. Also the two phases of the interarrival time

distribution functions that can be attributed to the time spans between requests within a WWW session and the time spans between the sessions shows up in Munich and Basle.

The collection of usage data by automatic monitoring will continue for all future trials of the AMUSE project. This will increase the data basis available for the analysis and we will be prepared to do a comparison of results from the different trials which together may allow for a more sophisticated interpretation.

5. Conclusions

Network architecture and first results from the interactive Multimedia trials carried out within AMUSE were presented. The architecture based on ATM technology allows flexible utilisation and interconnection of the equipment and it can deliver broadband network access to residential homes via access networks based on the HFC or ADSL technology. More trials are planned with improved technology, enhanced services and more users.

The collection of usage information by automatic monitoring provided the opportunity to present results on the service usage of the residential users in the Munich and Basle trial. The results vary widely between the users, but in general indicate that all users at least showed a curious experimenting character in using the new services. The ultimate goal of deriving a profile of user behaviour and indicating the acceptance of the services was not achievable due to the very small number of users. Nevertheless, the experiences with establishing the monitoring mechanism and performing the evaluation showed that the concept of monitoring within the AMUSE trials is feasible also for use in trials with a larger number of users and in such an environment will hopefully allow for drawing more general conclusions from the evaluation.

The stochastic analysis of WWW traffic shows common properties of request size and interarrival time distributions observed in the AMUSE environment. The amount of data available for evaluation will grow with more AMUSE trials being monitored and evaluated. Our aim is to produce a stochastic model from the observed data by distinguishing between inter- and intra-session interarrival times and use this model for stochastic simulation and performance evaluation considering a larger user population, so that dimensioning criteria for core and access network as well as for the servers can be derived.

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