Technical University of Budapest
Department of Telecommunications and Telematics

SIGNE RULE-BASE SUBSYSTEM FOR MULTIMEDIA TELESERVICES

– Diploma Thesis –

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Nyilatkozat

Alulírott Farkas Károly, a Budapesti Műszaki Egyetem hallgatója kijelentem, hogy ezt a diplomatervet meg nem engedett segítség nélkül, saját magam készítettem, és a diplomatervben csak a megadott forrásokat használtam fel. Minden olyan részt, melyet szó szerint, vagy azonos értelemben de átfogalmazva más forrásból átvettem, egyértelműen, a forrás megadásával megjelöltem.

Budapest, 1998. Május 15.

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Farkas Károly

Abstract

Distributed multimedia teleservices comprise numerous resources in the terminals and the network. The more of these resources are available the more complete the service session is. However, if all of these resources can not be reserved for the service, the resulted partial configuration should be valid, i.e. it has to fulfil different rules.

The main goal of this diploma thesis is to present an abstract service description *framework* for multiparty, multimedia teleservices and an intelligent *resource reservation scheme* for networks providing resource reservation mechanisms. This scheme maximises the completeness of the configuration but keeps the service specific rules set by the service provider and it is built into the SIGNE Rule-Base Subsystem.

In the first chapter I give a brief overview about related research work in the area of resource management then I present the main goal of the EMMA/SIGNE project and define the common terminology used in it. The second chapter presents my resource reservation scheme. As an example, in the third chapter my algorithm is illustrated on three EMMA multimedia services such as Multimedia Conference, Tele-University and Multimedia Library. And finally, in the last chapter I summarise my thesis and the future perspectives of my work is presented.

Conditions

When this document was written I was a fifth year student at the Department of Telecommunications and Telematics and a member of the EMMA/SIGNE Group which performs a joint research activity between Telia Research AB, Network Research Department (Haninge, Sweden) and the High Speed Networks Laboratory (Technical University of Budapest, Hungary). The project was established in 1995 and aims the development of an experimental platform for multimedia services.

Acknowledgments

I would like to express my gratitude and appreciation to István Cselényi for his great work done in managing this project, to Gergely Záruba for his support and help and to Nils Björkman for making our staying at Telia Research possible. I would also like to thank dr. Tamás Henk for his guidance and to the Hungarian colleages in the EMMA Group for the creative and stimulating atmosphere throughout the project.

Áttekintés

Az elosztott multimédia táv-szolgáltatások számos erőforrás meglétét igénylik úgy a terminálok, mint a hálózat részéről. Minél több rendelkezésre áll ezen erőforrások közül, annál teljesebb a multimédia szolgáltatás. Gyakran előállhat azonban olyan szituáció, amikor a szolgáltatáshoz szükséges összes erőforrás lefoglalása lehetetlen, viszont a létrejövő részleges konfigurációnak ki kell elégítenie bizonyos, előre megadott szabályokat.

Ez a diplomamunka egy olyan univerzális, erőforrás lefoglalási sémát mutat be, amely a rendelkezésre álló erőforrások függvényében a megadott szabályokat kielégítő, legteljesebb részleges konfigurációt eredményezi. Ezen algoritmus alapját képezi a SIGNE rendszer erőforrás lefoglalási stratégiájának is. Példaképpen a séma működését három EMMA multimédia szolgáltatáson illusztrálom, a Multimédia Konferencia, Táv-Egyetem és a Multimédia Könyvtár szolgáltatásokon.

Diplomamunkám első részében egy rövid áttekintést nyújtok az erőforrás-menedzsment terén folyó legfrissebb kutatásokról, majd tömören bemutatom az EMMA/SIGNE rendszert. A második részben ismertetem erőforrás-lefoglalási algoritmusomat, majd a harmadik részben bemutatom használatát a fent említett szolgáltatások esetében. Végül, a negyedik részben összegzem az elért eredményeket, és néhány továbbfejlesztési lehetőségre mutatok rá.

A Budapesti Műszaki Egyetem Távközlési és Telematikai Tanszékének V. éves hallgatójaként készítettem ezt a diplomamunkát az EMMA/SIGNE project keretén belül, amely a Budapesti Műszaki Egyetem Nagysebességű Hálózatok laboratóriuma és a svédországi Telia Research AB vállalat közös kezdeményezésére indult 1995-ben elosztott multimédia szolgáltatások kifejlesztését és az ezzel kapcsolatban felmerülő kérdések vizsgálatát tűzve ki célul.

Végül hálámat és nagyrabecsülésemet szeretném kifejezni Cselényi Istvánnak a project menedzselésében végzett pótolhatatlan tevékenységéért és diplomamunkám elkészítésében nyújtott segítségéért, valamint Záruba Gergelynek folyamatos támogatásáért. Ezen felül köszönetem szeretném kifejezni dr. Henk Tamásnak a tanszéken végzett munkámhoz nyújtott segítségéért, valamint az EMMA csoport magyar tagjainak a project folyamán biztosított kreatív és inspiráló légkörért.

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1. Introduction

Best-effort networks aim for better network utilisation by using intelligent transport protocols which work autonomously and provide no interface toward the application for setting quality of service (QoS) [1,2]. Because of the lack of this interface, basic internet applications have to adapt to network conditions similarly to mobile applications [3,4].

In case of broadband networks which provide QoS guarantees and mechanisms [5,6] for resource reservation (e.g. B-ISDN), there is no need for adaptive applications – the application and the user will get what they asked for, if the resources are available. However, in case of lack of resources, the session setup request will be rejected (call blocking) or a negotiation process will be started between the application and the network. Considering the latter, more effective solution, the duration of negotiation process can be significantly reduced and the task of the application can be simplified, if the network has an intelligent reservation scheme for selecting the valid service configurations [7,8].

An abstract model describing the service session, the relation between the parties and the importance of the service components; a rule set and the specification of resources consumed by service components are needed for this resource reservation scheme.

In this chapter (Introduction) I give a brief overview about related research work in the area of research management then I present the main goal of the EMMA/SIGNE project and define the common terminology used in it. The second chapter (Rule-Base) I present my resource reservation scheme and offer some ways to use it. In the third chapter (Applying the Rule-Base) my algorithm is illustrated on three EMMA multimedia services such as Multimedia Conference, Tele-University and Multimedia Library. And finally, in the last chapter (Epilogue) I summarise my thesis, give some procedures to test my algorithm and the future perspectives of my work is presented.

1.1 Related Work

1.1.1 A Fair Buffer Allocation Scheme

An appropriate service for data traffic in Asynchronous Transfer Mode (ATM) networks requires large buffers in network nodes. However, large buffers without a proper allocation scheme may lead to an unsatisfactory Quality of Service. Most present allocation schemes either necessitate a complicated queuing system or they do not offer sufficient fairness. In this paper [9] the authors describe a rather simple buffer management scheme that results in fair allocation of bandwidth among competing connections by using only a FIFO buffer.

ATM is the basis for future high-speed telecommunication networks. The strength of ATM lies in its superior flexibility which enables a wide variety of services and applications to be efficiently integrated in one network. The control of multiple types of traffic with different service requirements especially has proven to be very difficult. The basic idea of the Fair Buffer Allocation scheme is that the buffer implementation should be as simple as possible, whereas it is possible to allow a relatively complex algorithm to decide whether an incoming cell should be accepted or rejected. If this acceptance algorithm is sufficiently fair, there is no need to use more complex queue disciplines than FIFO for ABR or UBR class of service.

Let us suppose that incoming cells to an ATM node are generated by several sources, all of which send AAL5 frames. The algorithm can be defined as follows:

- The first cell of an AAL5-frame is dropped if:

  $$Y_i \cdot Q \cdot (X - R) > Z \cdot (K - R) \cdot q_i \cdot X ,$$

  where X is the number of cells in the buffer, R is a limit for buffer occupancy, K is the buffer capacity in cells, Z is a free parameter (typically from 0.5 to 1), Y_i is the number of cells of the connection in the buffer, q_i is the weighting coefficient and Q is the sum of the weighting coefficients of active connections.

Applying this algorithm it is possible to attain a high fairness by using FIFO buffers. It is especially suitable for the allocation of UBR connections, because they react accurately and quickly during an overload situation.

1.1.2 Dynamic Management of Guaranteed Performance Multimedia Connections

In this paper the authors [10] present a management scheme that can be used to dynamically manage *Guaranteed Performance Connection* (GPC) services in *Integrated Services Networks.* These services are required to support the wide range of Quality of Service parameters desired by many useful applications. The GPC services provide performance guarantees in terms of throughput, delay, delay jitter and loss rates. In such an approach, resource allocation and route selection decisions are usually *static*. This static approach limits the flexibility of these GPC services. This work presents a solution, the Dynamic Connection Management (DCM) Scheme, to this lack of flexibility.

DCM provides the network with the capability to dynamically modify the traffic characteristics, the performance requirements, and the route of any existing guaranteed-performance connection. It consists of three algorithms and two mechanisms. The algorithms are the *Channel Administration* algorithm, the *Transition* algorithm and the *Routing* algorithm and the mechanisms are the *Transparency* mechanism and the *Fast Establishment* mechanism.

The Channel Administration algorithm is used to establish an *alternate channel* (along a specified route), conforming to the specified traffic and performance parameters, between a source and a destination host. The Transition algorithm ensures that the transition from the *primary* to the alternate channel does not violate the DCM *modification contract*. The Routing algorithm determines a shortest-path route between the source and destination host that meets the constraints imposed by the traffic characteristics, the performance requirements, and the administrative requirements pertaining to the channel. The Transparency mechanism permits a transparent transition between the primary and alternate channel, while the Fast Establishment mechanism reduces the latencies associated with channel establishment and modification. A complete description of the DCM scheme can be found in [11].

The DCM algorithms and mechanisms offer a powerful solution to modify the performance parameters of the route of an entire channel dynamically. Control can be applied at the link (or local) level or at the route (or global) level so the DCM scheme can be utilized for both local and global modification.

1.1.3 Session Reservation Protocol for Guaranteed-Performance Communication in Internet

In this paper [12] the authors describe a resource reservation protocol called SRP (Session Reservation Protocol). SRP is defined in the DARPA Internet family of protocols. It allows communicating peer entities to reserve the resources, such as CPU and network bandwidth, necessary to achieve given performance objectives (delay and throughput). The immediate goal of SRP is to support “continuous media” (digital audio and video) in IP-based distributed systems. However, it is applicable to any application that requires guaranteed-performance network communication.

SRP is based on a workload and scheduling model called the DASH resource model. This model defines a parameterization of client workload, an abstract interface for hardware resources, and an end-to-end algorithm for negotiated resource reservation based on cost minimization. SRP implements this end-to-end algorithm, handling those resources related to network communication.

SRP can be viewed as a “network management protocol” operating at the internetwork (IP) layer. It is directly responsible for reserving only network resources so it is used in the process of establishing an end-to-end session with resources involved in an IP-based communication between a sending and a receiving client. This end-to-end session is associated with a connection of a particular IP-based protocol (for example, a TCP connection). The performance guarantees of the end-to-end session apply to the data traffic from the sending to the receiving client on the associated connection.

The main advantages of SRP that it is independent from transport protocols (SRP can be used with standard protocols such as TCP or with new real-time protocols) and compatible with IP (header fields of IP packets are not added or modified).

1.1.4 Conclusion

In this section a brief overview was given about some resource reservation schemes. The first and second scheme offer a low level (transport/network level) reservation while the third one gives a complete protocol to reserve network resources. The approach chosen in EMMA/SIGNE system is closer to the last one than the others because resources are managed on the service layer. However, the proposed reservation schemes are not in contradiction with but rather extending each other.

There are several aspects in each which could be built in to the ultimate resource reservation subsystem of SIGNE. This is objective of my further research.

1.2 EMMA/SIGNE Overview

1.2.1 Intentions of the EMMA/SIGNE Project

Most telecommunication networks use different networks for voice, video and data services. Therefore it is desirable to provide a large variety of services to the subscribers through a single standard network. B-ISDN (Broadband Integrated Service Digital Network) will meet this need and the transfer mode which is used in this network will be the Asynchronous Transfer Mode (ATM) that provides the capabilities to handle any kind of information, voice, video and data in an integrated and transparent manner.

The Swedish telecommunication company, Telia AB is involved in the ATM network servicing as the traffic carrier and as the provider of the basis on which Value Added Services (VAS, e.g. video conference, video on demand) can be built. Before introducing a new telecommunication service to the market, the telecommunication service provider must investigate the highest volume of utility from the applications of its services with the lowest prices. The aim of Telia Research AB's *Signaling Emulator* (SIGNE) [13,14] and the *Experimental Multimedia Middleware for ATM* (EMMA) [15] projects is to build an experimental environment where a variety of principles for telecommunication call/service control and realization can be evaluated. The main areas of research are the following:

- Distribution of Service management functions between the terminal and the network.
- Optimal reservation of terminal and network resources using abstract information about the teleservice session.
- Protocol for abstract level session management.
- Guaranteed Performance Connection with a simple Quality of Service interface toward applications.
- Platform independent service launching approach.

- Object Oriented modeling of multimedia teleservices.

Telia Research AB is investigating new services and applications on this ATM basis for the changing needs of Telia's future customers. However Telia would provide carrier only for the customers' B-ISDN applications but in the experimental environment phase it is desirable to develop some multimedia applications and services which meet the following expectations:

- The ability to show the multimedia capabilities of the computers used today.
- Easy modification for the experiments because of their availability in source code.
- Wide range network traffic related settings (required bandwidth, Quality of Service, cell loss and delay sensitivity, etc.) can be investigated.

The trend is toward a greater flexibility and more individual tailoring of services while ensuring optimum performance and user-friendliness. With these experimental applications the standardized interfaces for the third party Value Added Service providers can be investigated and implemented.

The SIGNE and EMMA projects were established in 1994 and 1995, respectively. The SIGNE system has been designed and developed by Swedish colleagues until the last year when that activity was taken over by the Hungarian EMMA Group.

1.2.2 The EMMA project

The goal of EMMA project is to extend the functionality of an ordinary multimedia terminal, at different levels in order to investigate several areas, such as signaling protocols required for service management and the binding of local and network resources. [8,16]

EMMA is a platform which supports experimental work focused on service control functions of a multimedia terminal. It is designed to vary freely the settings of the local and global resources in order to reach the optimal quality and performance. The EMMA terminal is connected to the B-ISDN network and communicates with the SIGNE system.

1.2.3 The SIGNE project

SIGNE is a flexible network emulator and service management system that supports experimental work focused on signaling functions. SIGNE provides the following main functions:

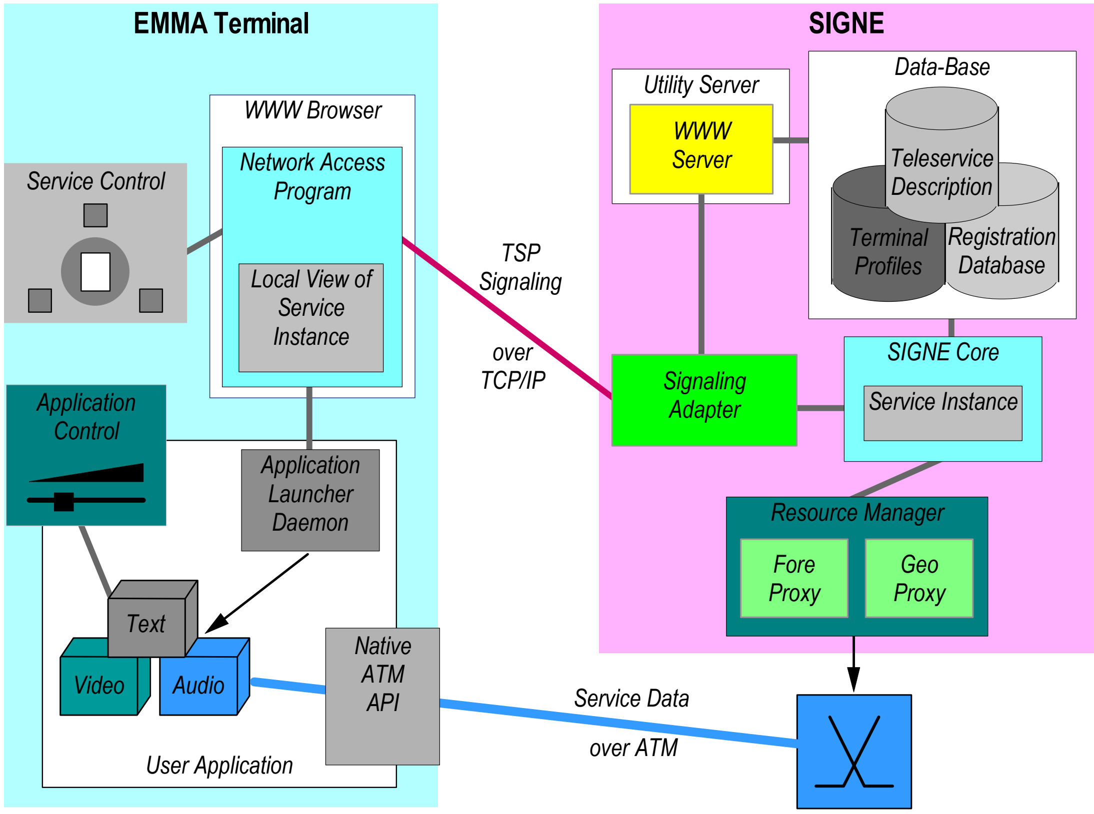
- Executing standardized and non-standardized ATM signaling protocols.
- Performing Session Management Controling establishment and release as well as reparameterization of connections in the underlying network.
- Using the RACE Project R2044 Multiservice Applications Governing Integrated Control (MAGIC) [17] based model to explore a separation of services and connections. SIGNE contains for each supported Telecommunication Service (TCS) a detailed description of the service. This description is used to create and control a call instance of the service. The service attributes are grouped into a number of objects according to the RACE MAGIC Service Description Framework.

1.2.4 Structural Overview

The structure of EMMA/SIGNE system, the relationship between its parts and the connections between network and terminal side are shown in Figure 1.

The main parts of EMMA are the following:

- *Service Control*, which provides an easy-to-use graphical user interface to the service user and service provider for controlling the service,
- *Network Access Program*, which controls the communication in the EMMA terminal and between EMMA and SIGNE,
- *User Application*, which handles the media (e.g. audio, video and white-board in case of multimedia conference) and provides a control interface to the user for changing the local parameters of the application,
- *Native ATM Application Programming Interface*, which provides the User Applications direct access to the ATM network.



EMMA	–	Experimental Multimedia Middleware for ATM	SIGNE	–	Signaling Emulator
ATM	–	Asynchronous Transfer Mode	WWW	–	World Wide Web
API	–	Application Programming Interface	TCP	–	Transmission Control Prot.
TSP	–	Telecommunication Service Protocol	IP	–	Internet Protocol

Figure 1. Terminal and Network Side of the EMMA/SIGNE System

The main parts of SIGNE system are the following:

- *SIGNE Core*, which is the most important part of SIGNE. It realizes the instances of the multimedia services and coordinates the communication of the parts of SIGNE. It constitutes the basis of the network side.

- *Data-Base Subsystem*, which contains several databases to give information about the capabilities of the terminals, the description of the service and the authenticated users for SIGNE Core.

- *Resource Manager*, which makes a mapping between the abstract connections and the actual network configuration.

The communication between the terminal and network side is based on the *Telecommunication Service Protocol* (TSP), which is used for registration of users, updating of databases, signaling for set-up and modification of a service session.

1.2.5 Components of EMMA

Service Control

The Service Control has a twofold task, as the user interface between the user and the EMMA terminal. Firstly, it has to present the components and available functions of the telecommunication service to the user. The easy understanding is supported by metaphors in a life-like framework (e.g. there is a conference table with a big paper in the middle in case of the multimedia conference service) [18]. Secondly, it has to retrieve the wishes of the user related to the parameters of the service. This is a translation mechanism indeed, where the high level, user friendly terms are translated to the teleservice model of the experimental system. The Service Control is implemented in Java, since the object-oriented methodology and the WWW approach are beneficial for a high level interface.

Network Access Program

The main tasks of the Network Access Program (NAP) are starting the components of EMMA, distributing and collecting messages inside the terminal and communicating with SIGNE through the TSP protocol. Although the name of NAP sounds like a functional part close to the physical layer, this is not the case. It is implemented as a Java applet which can be downloaded by the WWW browser of the service user. NAP supports parallel sessions, i.e. many Service Controls and User Applications can be started by the same NAP. The EMMA terminals have a partial view of the ongoing telecommunication service stored in the *Local View of Service Instance* (LVSI). The LVSI of each sessions are built up and updated by the NAP, which is a general component in EMMA, i.e. it is independent from the specific teleservice.

Modular User Application

The first User Application (UA) built on the EMMA platform is multimedia conference, which provides video, audio connection among participants and a shared, virtual working area, called

White-Board [19]. The User Application presents the multimedia information conveyed through the data connections between the parties [20,21]. In order to have a flexible terminal which supports not only one but several multimedia services, the UA is built up from general purpose components, so called *Application Building Blocks* (ABB). ABB is a small software component with a control and configuration interface for the handling of a specific medium. For instance a multimedia conference service consists of audio, video and white board ABBs. Using the control and configuration interfaces of the ABBs, it is easy to link them up to construct a multimedia application with a very complex behaviour. The *Application Launcher Daemon* starts the ABB of each specific media with a parameter set appropriate to the quality settings stored in the LVSI.

Native ATM Application Programming Interface

The service quality provided by best-effort networks are usually not acceptable by end users. However, many IP over ATM solution hide ATM's capability for ensuring QoS. With EMMA the ATM layer can be directly accessed and the performance of several protocol stacks and settings can be compared.

The EMMA Native ATM Application Programming Interface (NAAPI) is based on the ATM Forum's Native ATM Services recommendation [22]. The NAAPI (Figure 2) is a set of C library routines which can be used to access different adaptation layers of the ATM network interface card.

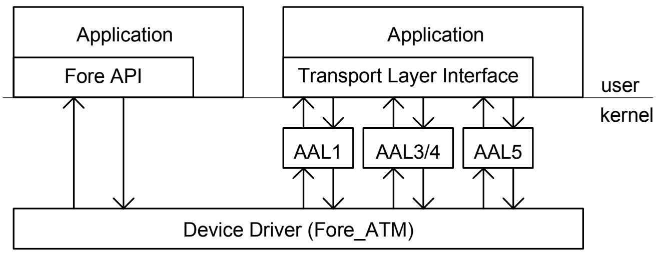


Figure 2. Environment of the Native ATM Application Programming Interface

There are interfaces specified between each major component of the EMMA system. For instance, the NAP can be accessed through an open interface which makes easy to extend the capabilities of the system with new Service Controls. Therefore third parties can support their new EMMA-based services by Service Controls developed by independent software vendors. Only the special

Application Building Blocks and the service specific Service Control should be added to the general components of the EMMA architecture in this case.

1.2.6 Components of SIGNE

SIGNE Core

The SIGNE Core coordinates the set-up and scaling of a teleservice. It communicates with the Connectivity Control Architecture through the Resource Manager, with the terminals through a Java-based protocol and evaluates the current configuration using the Data-Base Subsystem in order to optimize the resource allocation and user satisfaction, and keep consistency, compatibility and the rules prescribed for the teleservice. The scaling of teleservice resources is reflected in the *Service Instance* model which describes the parties involved in the session, the allocated network and terminal resources and the media used for communication.

Data-Base Subsystem

The Data-Base subsystem stores the *User Profile*, the *Terminal Profile* and the *descriptions of the available teleservices* (TCSD). User Profile contains the data of registered users. This database enables search for potential participants in a new service session. The capabilities of terminals are stored in the Terminal Profile database. The teleservice descriptions are stored in a generic format, based on a universal object oriented model, which is an extended version of the model proposed by the RACE MAGIC project. During the life-cycle of a service, the network has the complete view of it described by the Service Instance, which is built up similarly to the TCSD.

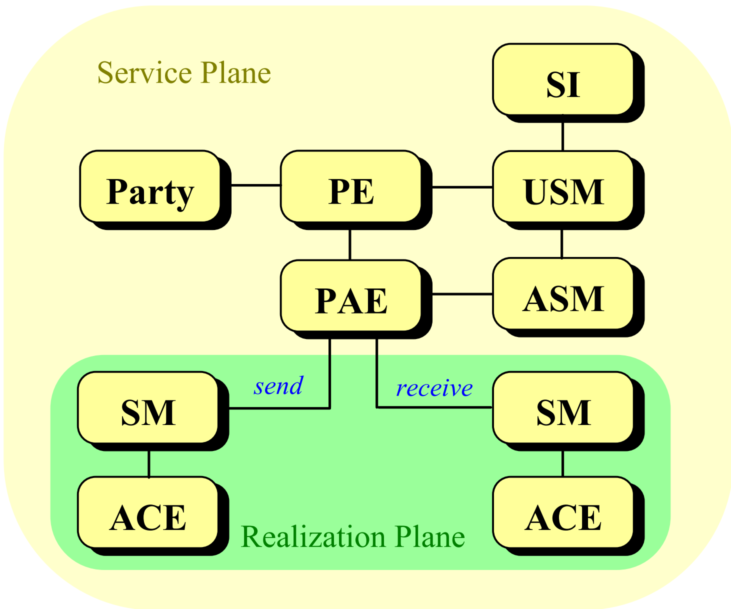
Each teleservice has a unique behaviour which should be given by the Application Provider in advance as a rule set. Firstly, these rules define the possible set of objects which are necessary for different service versions. The objects, which presence is essential for the service, are marked as mandatory while the others are marked as optional. Secondly, the downgrading or scaling scheme of the service should be described on each object level as well. Thirdly, the rules determine the permissions of different party types. The Rule-Base subsystem contains these rules and it is stored in the Data-Base subsystem with TCSD.

Resource Manager

The Resource Manager maps the abstract connection groups given by SIGNE Core to the actual network configuration. It checks the available resources and allocates them through the Network Control Architecture. It has several modules for different network types.

The Service Description

A universal object oriented model is used to describe a service, which is an extended version of the model proposed by the RACE MAGIC project. When the service is realized as an actual call named Service Instance (SI) then the attribute types will also be realized as an instance of attribute. This model are shown in Figure 3.



PE	–	Party Edge	ASM	–	Abstract Service Module
PAE	–	Party Abstract Edge	SM	–	Service Module
USM	–	User Service Module	ACE	–	Access Control Element
		SI – Service Instance			

Figure 3. The TCS Objects and Their Relationship in a Service Instance

The objects of this model are the following:

- *Service Instance (SI):* This object model contains attributes used to describe the overall structure and operation of the service. Its attributes can be: *Session type identifier, USMs to be* *synchronised, List of subset/superset compatible services, Session supplementary service list*, etc.

- *Party:* The Party object is used to describe the different behaviour of the various types of a party. Its attributes can be: *Party type identifier, Mandatory instances, Maximum instances and Permissions: Add/drop party, Session modification, Self deletion, Session deletion, Session creation.*

- *User Service Module:* The USM is the basic building block of a service. It provides a function combining one or more information types of a service into a single grouping *understandable to a user*. Its attributes can be: *USM type identifier, Configuration, Symmetry, ASMs to be synchronized, USM supplementary service list, Mandatory instances, Maximum instances*.

- *Party Edge:* The PE is used to define the relationship between the Party types that may take part in the service and the USM that comprise the service. Its attributes can be: *Mapping mode, Permissions: USM creation/deletion/modification*.

- *Abstract Service Module:* The ASM represents the basic information types that may be used in a multimedia service and essentially encapsulates the attributes of the *application layer of the service*. Its attributes can be: *ASM type identifier, Combining algorithm, Quality of Service.*

- *Party Abstract Edge:* The PAE object is used to describe the relationship between the ASMs and the Party Edge and maps direction (send and/or receive) to SMs. Its attributes can be: *PAE type identifier, Name, Caller/Invited, Terminal Address and Receive/Send*.

- *Service Module:* The SM represents the protocols used to implement a basic information type of a multimedia service. Protocols from the ATM Adaptation Layer to the presentation layer are specified. The SM is used to implement the service indicated in the ASM. Its attributes can be: *SM type identifier, Traffic type, Presentation/Session/Transport/ Network layer protocol, AAL layer protocol, Timing end-to-end, Connection mode, Service class, Quality of Service, Application Building Block (ABB) parameters, SM protocol type, SM protocol subtype, Number of streams to combine, Number of stream to distribute, Redistribution*.

- *Access Control Element:* The ACE defines the characteristics of the bearer connection that is used to transport a SM across the access. It encompasses the user information protocols in the protocol stack of the Physical Layer and the ATM Layer. Its attributes can be: *ACE type identifier, Peak cell rate, Mean cell rate, Structure, Information transfer capability, ATM layer protocol, Physical layer protocol, Direction*.

The SM and ACE objects represent uni-directionality so it is one of them for sending and another for receiving in a bi-directional connection.

1.2.7 Operation

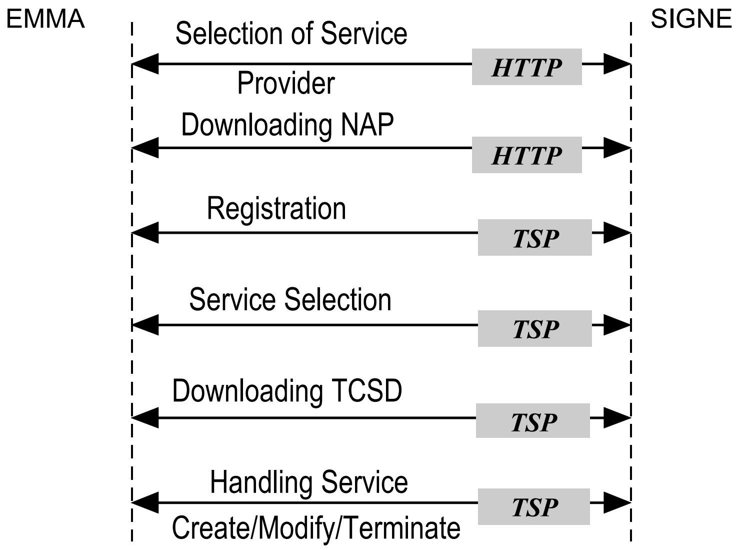
The user of the EMMA/SIGNE system does not need more hardware than a multimedia workstation equipped with video, audio extensions and an ATM network interface card. Moreover, a Java capable WWW browser, the Application Launcher Daemon with ABBs and the Native ATM API should be installed on the user's machine. A platform independent media handling extension, called Java Media API, is said to be available to Java soon, thus the whole User Application could be downloaded from the network similarly to the Service Control in the near future.

Users who would like to participate in telecommunication services supported by the EMMA/SIGNE experimental system should browse the Web site of the network operator at first and activate the NAP by clicking on the *EMMA Services* link. NAP can prevent the unauthorised usage of services. After registration the user can wait for an incoming invitation or create a new service session. In the latter case, the initiator user can select one from the services offered by the service provider and linked to the WWW server. Than the service specific Service Control is started on his machine and the *TCSD model is downloaded.* The Service Control uses this model to present the framework icons and dialogue boxes necessary for service configuration. The user can set up the service parameters by giving the names of parties to be invited and the media to be used among them. The order of the initiator user is translated into TSP by NAP and sent to SIGNE for evaluation, which informs the invited participants as well. The called parties have right to accept, reject or downgrade the ordered service session. Their answers are reviewed and the description of the resulted service session is sent back to the initiator and to every involved parties.

During the negotiation among the EMMA terminals, SIGNE and the invited users, the NAP steadily updates the LVSI on each terminals. When the agreement is made SIGNE gives the parameters of the allocated connections and the NAP invokes its UA through the Application Launcher Daemon to start the information transfer on these connections.

High Level Signaling

One of the key functions in B-ISDN is signaling. However, *service oriented messages* are not supported yet by the current standards (e.g. signaling capability set 1). Therefore a new, high level signaling had to be developed for EMMA, namely the *Telecommunication Service Protocol* (TSP). It is operating over TCP/IP and implements the signaling required for the establishment and control of multimedia services. This protocol contains primitives for call set up, modification, management and release. The major steps of service set-up are summarised in Figure 4:



EMMA	– Experimental Multimedia Middleware for ATM	SIGNE	– Signaling Emulator		
HTTP	– Hyper Text Transfer Protocol	WWW	– World Wide Web		
TSP	– Telecommunication Service Protocol	NAP	– Network Access Program		
TCSD – TeleCommunication Service Description					

Figure 4. Main Steps of Communication Between Terminal and Network

2. Rule-Base

In this chapter I present my resource reservation scheme and offer some ways to use it.

2.1 Service Description Framework

The multimedia teleservice session consists of several media connecting several sets of participants in my model. Every multimedia service could have a number of service specific rules concerning the media, the parties and their connections, which have to be given by the provider or designer of the teleservice in advance. However, there are some generic rules which concern all multimedia teleservices and they can constitute the basis of my reservation algorithm.

2.1.1 Notations

My reservation algorithm can be represented by a graph. This graph is a state-space in which every state contains a valid service configuration fulfilling the rule set (see in Section 2.1.2) and the branches denote the required resources to achieve the available states from a state-node. Figure 5 represents the model of this graph.

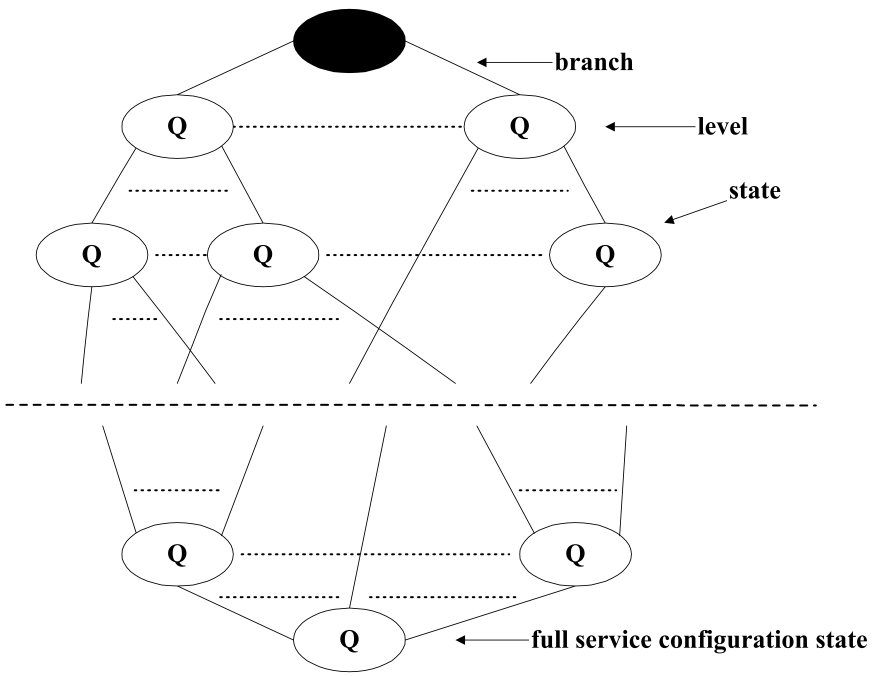


Figure 5. Model of the Resource Reservation Graph

The expressions and notations used in this section and their meaning are presented in Table 1.

Notation	**Meaning**
service session	a realized instance of the service
media object	a realized instance of a media, corresponding to ASM in the TCSD
media type	the type of a media set (e.g., audio, video, picture, etc.)
media priority level	USM in the TCSD
$\mathbf{p}$	Party Vector
$\mathbf{b}$	Mandatory Party Number Vector
$\mathbf{m}$	Minimum Party Number Vector
$\mathbf{f}$	Media Mapping Vector
$\mathbf{L}$	Minimum Media Number Matrix
$\mathbf{M}$	Media Matrix
$\mathbf{C}$	Connection Matrix
$\mathbf{Z}$	Party Filter Matrix
$\mathbf{Q}$	State Matrix
$\mathbf{R}$	Resource Matrix
T	Resource Threshold
V	Configuration Complexity
D	Resource Requirement
MMON	Minimum Media Object Number
Moreover, let's assume, that the number of the media types is H; the number of the media priority levels – see in section 2.1.2 – is G; the number of the participants of the service session is N and the number of the media objects is X.	

Table 1. Used Expressions and Notations

Media object, *media instance* and *media* are used in the same meaning in this chapter.

The sign '•' denotes the generic rules concerning all multimedia teleservices in section 2.1.2.

Other notations follow general conventions.

2.1.2 Rule Set

The importance of different media for the service is expressed by *priority levels*.

- The media objects of a priority level can be created only if every media object is realized on the higher priority levels.

  Some special services can contain several instances of a media type. These instances differ only in the involved parties and the connections between them. The service designer can specify the necessary number of the instances of every media type, so called MMON: *Minimum Media Object Number*. Every media type and the media object belonging to that type have a category as *mandatory* or *optional* on each priority level.

- In order to get a valid service session, every mandatory media type of a priority level should be created. In order to create a media type, the required number of its media objects (i.e. MMON) should be created. Moreover, optional media types can be added to the service session only if the necessary amount of their media objects (i.e. MMON) is created.

The *Minimum Media Number Matrix*, **L** contains the category and MMON of every media type. **L** has a size of $2 \times H$. Every column of this matrix represents a media type. The first element in a column indicates the category whose value can be 2, 1 expressing whether the appropriate media type is mandatory or optional and the second element denotes MMON of the media type. Every media type and media object have an identifier. The *Media Mapping Vector*, **f** stores the mapping between the media types and the media objects. **f** is a row vector of X elements, where every column represents a media object and each value denotes a media type. The participants can also be mandatory or optional from the specific media object's point of view.

- Firstly, every mandatory participant has to be involved in a media object.

- If a party can be involved in both any mandatory media object and any optional media object of a priority level then the party has to be involved in the mandatory media firstly, and in the optional media after.
- If a party can be involved in more than one mandatory media on a priority level then the involvement has to be happened simultaneously.

There is an additional configuration rule giving the *minimum number of parties* for each media. This requirement is expressed in the *Minimum Party Number Vector*, $\mathbf{m}$ which is a row vector and it has X elements.

- The x^{th} media cannot be realized if the number of parties is less than $\mathbf{m}(x)$ or the mandatory participants of that media are not present.

2.1.3 Session Request

The service users can request a service session by giving the configuration, i.e. the number and type of media, parties and connections. This session request can be described using the following configuration matrices.

The *Media Matrices,* $\mathbf{M}_1..\mathbf{M}_G$ indicate the involved participants of a media according to the different media priority levels. In case of E media of the priority level g, $\mathbf{M}_g$ has a size of $E\times N$. Every row of these matrices represents a media and the elements in a row indicate the priority of involved participants in that media. The value of an element can be 2, 1, 0 expressing whether the appropriate party is mandatory, optional or not involved. The *Party Vector* $\mathbf{p}_x$ gives which participants are attached to the x^{th} media. Every $\mathbf{p}$ vector corresponds to a row of the media matrices thus it is a row vector of N elements. The *Mandatory Party Number Vector*, $\mathbf{b}$ indicates the number of mandatory participants in a media. $\mathbf{b}$ is a row vector of X elements, where every column represents a media.

The connections between the participants within the x^{th} media are given in the *Connection Matrix*, $\mathbf{C}_x$. Every $\mathbf{C}$ matrix has a size of $N\times N$, where each row and column represent one participant. The elements of a connection matrix denote the values of the connections which can be 3, 2, 1, 0 expressing whether the connection is between mandatory-mandatory, mandatory-optional, optional-optional participants or there is no connection. Also the direction of the connections are denoted in the matrix thus the element **C**(*i, j*) indicates a connection where participant *i* is the sender and participant *j* is the receiver party.

There could be other values used in **C**, **p** and **M** which could express more priority levels or different importance of the priority levels.

2.2 Resource Reservation Scheme

A *resource reservation graph* can be built up according to the following algorithm, using the aforementioned rule set and configuration matrices. Each state-node of this graph represents a valid configuration of the teleservice which fulfils the rule set. There are some basic procedures for making the graph nodes:

Participation check I: if the session request contains the involvement of the selected party in any mandatory media on the appropriate media priority level – the suitable **p** vector contains this information – but it has not happened yet, then the party fails the check, otherwise the party passes the check.

Participation check II: if the session request contains the involvement of the selected party in any mandatory media which has been already initialised – see procedure b) – on the appropriate media priority level – the suitable **p** vector contains this information – but it has not happened yet, then the party fails the check, otherwise the party passes the check.

a) In this procedure a party will be involved in a media. All connections between this party and the present participants of the media should be created. The connections are notified in the appropriate **C** matrices.

b) To get the *initial configuration* of a mandatory media, firstly the mandatory participants of the media have to be added. If their number is greater than or equal to the value **m**(*x*) – where *x* identifies the media – then all connections between these parties have to be established, otherwise the connections between the mandatory and additional **m**(*x*)-**b**(*x*) optional parties should be created for the initial configuration. The connections are notified in the appropriate **C** matrices.

c) To get an *additional configuration* of a mandatory media, one of its optional participants which was not selected previously has to be selected and the *participation check II* has to be applied on it. Then procedure a) has to be applied on this media with the selected party. If the party fails the check then procedure a) has to be applied also on every realized mandatory media with this party in which it could be involved.

d) To get the *initial configuration* of an optional media, firstly the mandatory participants of the media have to be added and the *participation check I* has to be applied on them. If any of these participants fails the check then the initial configuration of this media can not be produced at this moment. Otherwise, if the number of the selected participants is greater than or equal to the value **m**(x) then all connections between these parties have to be established. If their number is less than the value **m**(x) then additional **m**(x)-**B**(x) optional parties have to selected which pass the *participation check I* and all connections between the mandatory and these optional parties should be created for the initial configuration. The connections are notified in the appropriate **C** matrices.

e) To get an *additional configuration* of an optional media, one of its optional participants which has not been selected previously has to be selected and the *participation check I* has to be applied on it. If this participant fails the check then another optional participant has to be selected, otherwise the procedure a) has to be applied on this media with the selected participant.

These procedures has to be applied on every media given in the session request as follows:

Step 1. Firstly, the required number of the media objects of every mandatory media type (given by MMON) have to be selected and procedure b) has to be applied on them simultaneously. Then *participation check II* has to be applied on the participants of the initial configuration of these media. If any of them fails the check then every created connection of these media has to be deleted, otherwise the result will indicate a valid service configuration.

Step 1 has to be repeated until the first ‘level’ of the graph contains ‘states’ representing all combinations of the initial configurations of mandatory media fulfilling the appropriate MMON rules.

Step 2. A media has to be selected.

- If it is a mandatory media and

  ⇒ it is not initialised then procedure b) has to be applied on it. After this procedure the *participation check II* has to be applied on the participants of the initial configuration of this media. If any of them fails the check then every created connection of this media has to be deleted, otherwise the so retrieved configuration should be joined to the previous state.

  ⇒ it was initialised previously, then procedure c) has to be applied on it and the so retrieved configuration should be joined to the previous state.

- If it is an optional media and

  ⇒ it is not initialised then procedure d) has to be applied on it and the so retrieved configuration should be joined to the previous state.

  ⇒ it was initialised previously, then procedure e) has to be applied on it and the so retrieved configuration should be joined to the previous state.

Step 3. The previous step should be repeated until we reach the state on every 'branch' containing the *full configuration* of all media on a priority level, i.e. the state in which each media on a priority level is attached to the maximum number of party given in vectors **p**.

Step 4. The previous steps should be repeated on every priority level until we reach the *full service configuration* state, i.e. the state in which each media of the service is attached to the maximum number of party given in vectors **p**.

The resource reservation graph can be used in many ways. If the whole graph is built up before the announcement of the teleservice, the initiator user can send a session request to the network which can firstly check the validity of the requested configuration using the graph, secondly it can downgrade the request if necessary by "going backwards" on the graph nodes.

Another approach is to make resource reservation and building of the graph in parallel after the session request is received. In this case, only a subset of the possible graph nodes has to be considered according to the requested service configuration as target node. The state-nodes should be built up one-by-one, i.e. the resources should be reserved gradually, until there are available resources. There is a straight forward strategy for achieving the best resource utilisation described in the followings.

2.3 Resource Reservation Strategy

There are two values assigned to each state-node, the *Configuration Complexity* denoted by V_i and a *Resource Requirement* denoted by D_i where i identifies the state. These attributes are assembled in the *State Matrix*, **Q** which contains a value pair for each state-node. Moreover, the so called *Resource Matrices,* $\mathbf{R}_1..\mathbf{R}_X$ can be defined. $\mathbf{R}_x$ has a size of $N\times N$ and it gives the resource requirements of each connections for the media indexed by x. In order to describe which parties are present in a media in case of the different states, the *Party Matrix.,* $\mathbf{Z}_i$ is defined for each state where i identifies the state. Every **Z** matrix is a binary matrix and they have a size of $E\times N$. Every row of them represents a media and every column indicates a participant. Moreover, the row vector $\mathbf{Z}_{x,i}$ indicates the participants of the x^{th} media in case of the i^{th} state thus it is the appropriate row of the matrix $\mathbf{Z}_i$. The values assigned to the i^{th} state-node are given by the following equations:

$$V_i = \mathbf{Q}(1,i) = \sum_{\forall x: x\in\Omega} \left(\mathbf{P}_x \cdot \mathbf{Z}_{x,i}^T + \mathbf{Z}_{x,i} \cdot \mathbf{C}_x \cdot \mathbf{Z}_{x,i}^T \right) = \sum_{\forall x: x\in\Omega} \left(\mathbf{P}_x + \mathbf{Z}_{x,i} \cdot \mathbf{C}_x \right) \cdot \mathbf{Z}_{x,i}^T \tag{1}$$

$$D_i = \mathbf{Q}(2,i) = \sum_{\forall x: x\in\Omega} \left(\mathbf{Z}_{x,i} \cdot \mathbf{R}_x \cdot \mathbf{Z}_{x,i}^T \right) \tag{2}$$

where Ω symbolises the set of media which are realized in state i.

The maximum amount of available resources in the network could be represented by a *Resource Threshold* value, T. In favour of simplicity, T can be assumed to be a constant during the reservation process. In this case the strategy of resource reservation is to find the most complex teleservice configuration which do not require more resources than T, i.e. the state with maximum V but $D<T$.

3. Applying the Rule-Base

In this chapter my algorithm is illustrated on some EMMA multimedia services.

3.1 Adopting the Rule-Base into SIGNE

The aforementioned service description framework and reservation graph can be implemented in SIGNE. Performing the algorithm and obtaining the actual service session description matrices SIGNE can create the resource reservation graph. Then this graph can be used to create the modifications of the service session and check the validity of further session requests. The actual version of SIGNE obtains the resource reservation graphs from configuration files, presented in Appendix B.

The operation of the algorithm is illustrated in this chapter on three different EMMA telecommunication services, such as Multimedia Conference, Tele–University and Multimedia Library. In case of each example the basic idea of the service is explained firstly, then the model and the rule set of the service is presented and a session configuration is given with the appropriate configuration description matrices and finally the creation of the resource reservation graph is illustrated. In favour of simplicity, the connections between the participants are represented as point-to-point connections in these services.

3.2 EMMA Multimedia Conference Service

3.2.1 Basic Idea

Multimedia Conference is the first implemented service of the EMMA/SIGNE system. This service offers a good collaborative work to its users. It consists of audio-, video conference and white-board tools so it enables visual and audio communication among participants on a computer network and gives the opportunity for users far from each other to edit documents, draw pictures, make graphs etc. together. These media are handled separately so they can be realized one by one. The participants of the conference can be classified into two party types as *chairman* or *member*. *Chairman* is the initiator user of the service and the *members* are the invited participants. Every user can reach the possibilities provided by the service through a Java-based user-friendly Graphical User Interface which contains easy-to-understand metaphors.

The first version of the Multimedia Conference service is prepared for only there participants, and utilises point-to-point audio, video and white-board connections because of the capabilities of available development tools.

3.2.2 Model and Rule Set

The model which describes the structure of EMMA Multimedia Conference service is depicted in

Figure **6**. This model shows the relations among the service objects. The letters *m* and *o* indicate the category of the objects (i.e., mandatory or optional).

Every multimedia service has some individual, service specific rules. These rules can concern media, parties and connections so they can specify the connections between the parties in a media, the directions of connections, the privileges of different party types, etc. These rules have to be given by the service designer or provider in advance.

The specific rules of the Multimedia Conference service are the following:

Media Rules

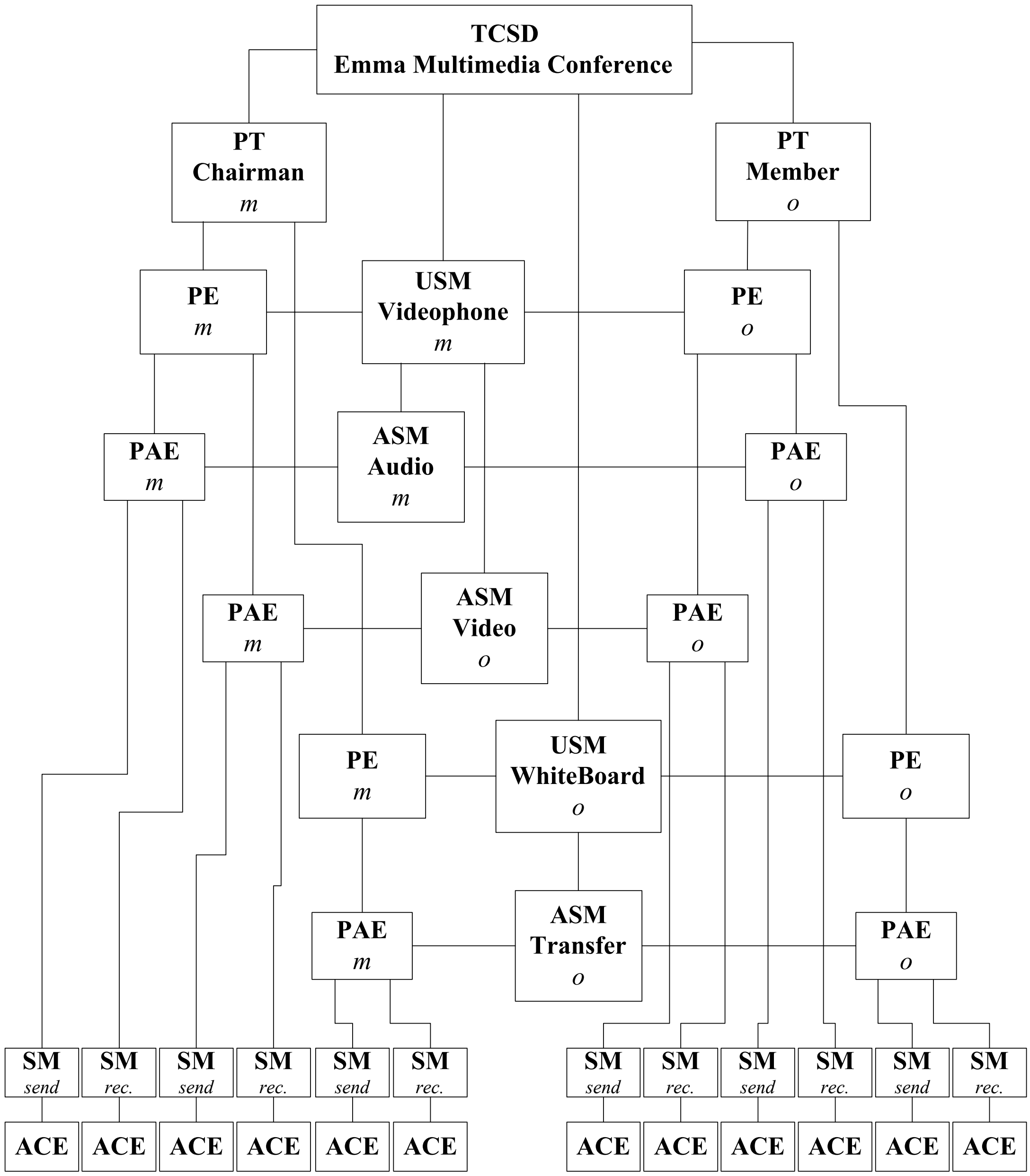
- Audio media is mandatory while video and white-board (transfer) are optional.
- Audio and video are located on the first priority level and white-board belongs to the second one.

Party Rules

- There are one chairman and maximum two member parties for each three media.
- At least two parties should use each media.

Connection Rules

- The chairman party of a media has to be connected to each realized member party of that media.
- Every party of all media has to be connected to all the other realized parties of that media.



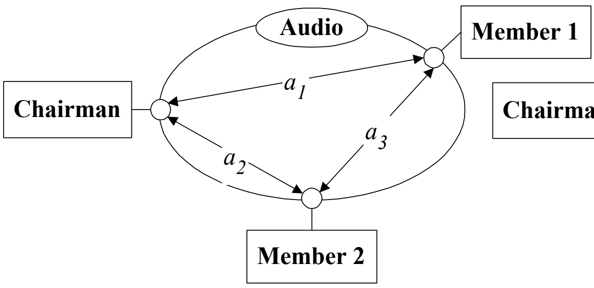
ACE	–	Access Control Element	ASM	–	Abstract Service Module
PAE	–	Party Abstract Edge	PE	–	Party Edge
PT	–	Party Type	SM	–	Service Module
TCSD	–	TeleCommunication Service Description	USM	–	User Service Module

Figure 6. TCSD Model of EMMA Multimedia Conference Service

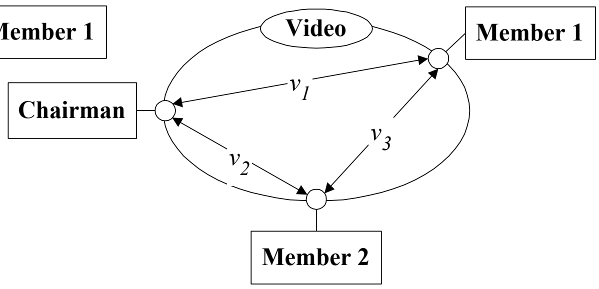
3.2.3 Session Configuration

Let's assume that the chairman requests a full multimedia conference session for three parties which could be realized in the first version of the service, i.e. all parties are involved in each media. This configuration is illustrated in Figure 7. In favour of simplicity, the connections in the media are labelled by a letter and a number succession referring to the type of the media. Every connection is bi-directional in this example. The media belonging to different priority levels are drawn separately.

Priority level 1:

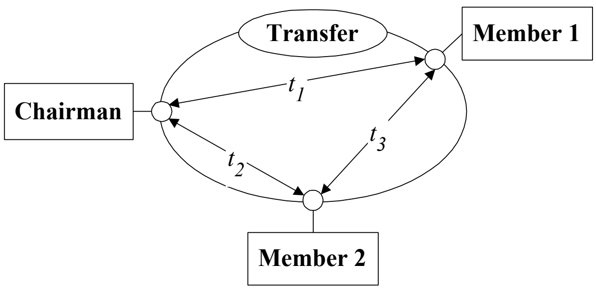


mandatory media



optional media

Priority level 2:



optional media

Figure 7. Session Configuration of the Three-Party EMMA Multimedia Conference Service

The chairman's session request has to be checked first based on the rules, than the following service description matrices and vectors are generated (Table 2):

$$\mathbf{L} = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}; \qquad \mathbf{f} = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}; \qquad \mathbf{m} = \begin{bmatrix} 2 & 2 & 2 \end{bmatrix}$$

$$\mathbf{M}_1 = \begin{bmatrix} 2 & 1 & 1 \\ 2 & 1 & 1 \end{bmatrix}; \qquad \mathbf{M}_2 = \begin{bmatrix} 2 & 1 & 1 \end{bmatrix}$$

$$\mathbf{b} = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

$$\mathbf{C}_1 = \mathbf{C}_2 = \mathbf{C}_3 = \begin{bmatrix} 0 & 2 & 2 \\ 2 & 0 & 1 \\ 2 & 1 & 0 \end{bmatrix}$$

Table 2. Session Description Matrices of the Three-Party EMMA Multimedia Conference Service

In order to explain these matrices, the mapping between the media identifiers and the names of the media has to be given. This concerns the parties, too. The mapping is notified in Table 3. The types of media and parties can be determined easily because their names refer to it. In the matrices and vectors the first row/column represents the media 1/party 1, the second one represents the media 2/party 2, etc.

Media name	Media ID
Audio	media 1
Video	media 2
Transfer	media 3

Party Name	Party ID
Chairman	party 1
Member 1	party 2
Member 2	party 3

Table 3. The Mapping Table of the Three-Party EMMA Multimedia Conference Service

3.2.4 Resource Reservation

From these matrices and vectors, the resource reservation graph can be generated according to the algorithm described in the previous section. The connections that have to be reserved to reach next states are indicated on the branches of the graph in Figure 8. The state **Q8** represents the full configurations of the media located on the first priority level (all audio and video connections are realized between all the three participants) and the state **Q11** represents the full configuration of the requested service session (all audio, video and white-board (transfer) connections are realized between all participants).

The configuration targeted in the session request is represented by the last state (**Q11**) of the graph. However, if the amount of total resources (*T*) of this state is not available, the last state-nodes of the graph (at the bottom) cannot be reached, the reservation stops in a preceding state-node. According to my reservation strategy, the i^{th} state has to be found where V_i is the maximum and D_i is the closest to *T*. In this case, the last state can be reach during a further modification request if the previously reserved resources are released.

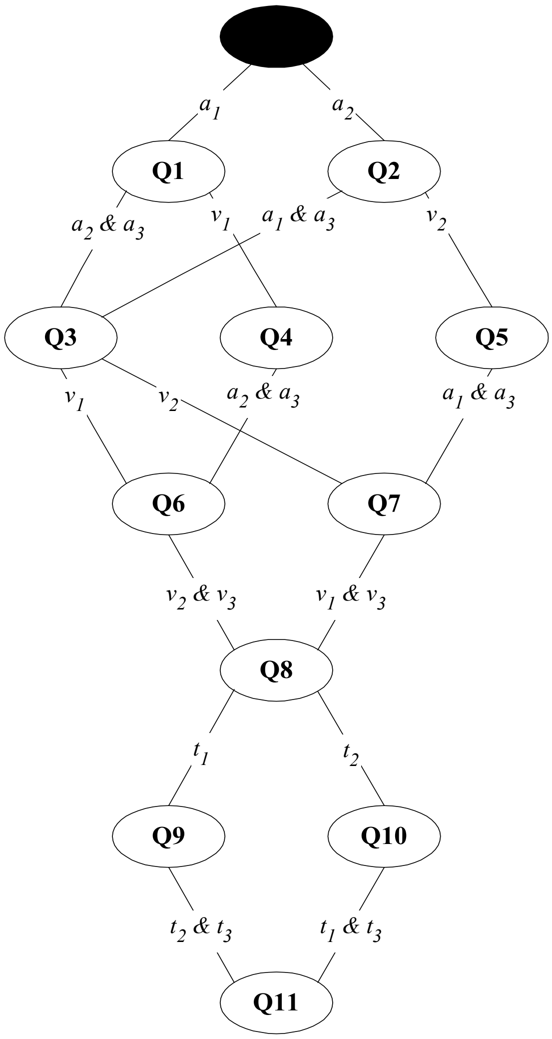


Figure 8. Resource Reservation Graph for the Three-Party EMMA Multimedia Conference Service

The amount of resources required by a specific connection of the x^{th} media are expressed in the $\mathbf{R}_x$ matrix which has *N*x*N* elements, one for each connection. If 64 kbps is assumed as one resource unit and the required bandwidth is 256, 2048, 64 kbps for audio, video, white-board (transfer) media respectively, then the resource matrices have the following form (Table 4):

$$\mathbf{R}_1 = \begin{bmatrix} 0 & 4 & 4 \\ 4 & 0 & 4 \\ 4 & 4 & 0 \end{bmatrix}; \qquad \mathbf{R}_2 = \begin{bmatrix} 0 & 32 & 32 \\ 32 & 0 & 32 \\ 32 & 32 & 0 \end{bmatrix}; \qquad \mathbf{R}_3 = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

Table 4. Resource Matrices of the Three-Party EMMA Multimedia Conference Service

If different quality levels are defined for a service then different resource matrices should belong to every quality level of a media.

The $\mathbf{Z}_i$ filter matrices in Table 5 are used to select the parties who are present in a media in case of the i^{th} state.

$$\mathbf{Z}_1 = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{Z}_2 = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{Z}_3 = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{Z}_4 = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{Z}_5 = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{Z}_6 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{Z}_7 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{Z}_8 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{Z}_9 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

$$\mathbf{Z}_{10} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}; \qquad \mathbf{Z}_{11} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Table 5. Filter Matrices of the Three-Party EMMA Multimedia Conference Service

The **Q** matrix in Table 6, which represents the states of the graph, can be calculated from the **R**, **Z**, **p** and **C** matrices using equations (1) and (2). It contains the *V* and *D* values of each state. In this service the video media can be the critical point from the resource reservation's point of view, because it requires much more resources than the other media. It can be observed that state **Q3** and the state **Q4** have the same complexity but the state **Q4** has a much more resource requirement because of the existence of video media.

$$\mathbf{Q} = \begin{bmatrix} 7 & 7 & 14 & 14 & 14 & 21 & 21 & 28 & 35 & 35 & 42 \\ 8 & 8 & 24 & 72 & 72 & 88 & 88 & 216 & 218 & 218 & 222 \end{bmatrix}$$

Table 6. Configuration Complexity and Resource Requirement Matrix of the Three-Party EMMA Multimedia Conference Service

3.3 EMMA Tele-University Service

3.3.1 Basic Idea

Tele-University is an educational service referring to the next generation of teaching tools. The basic idea of this application is to offer a remote consultation possibility to students. This is a very convenient way to expand one's knowledge.

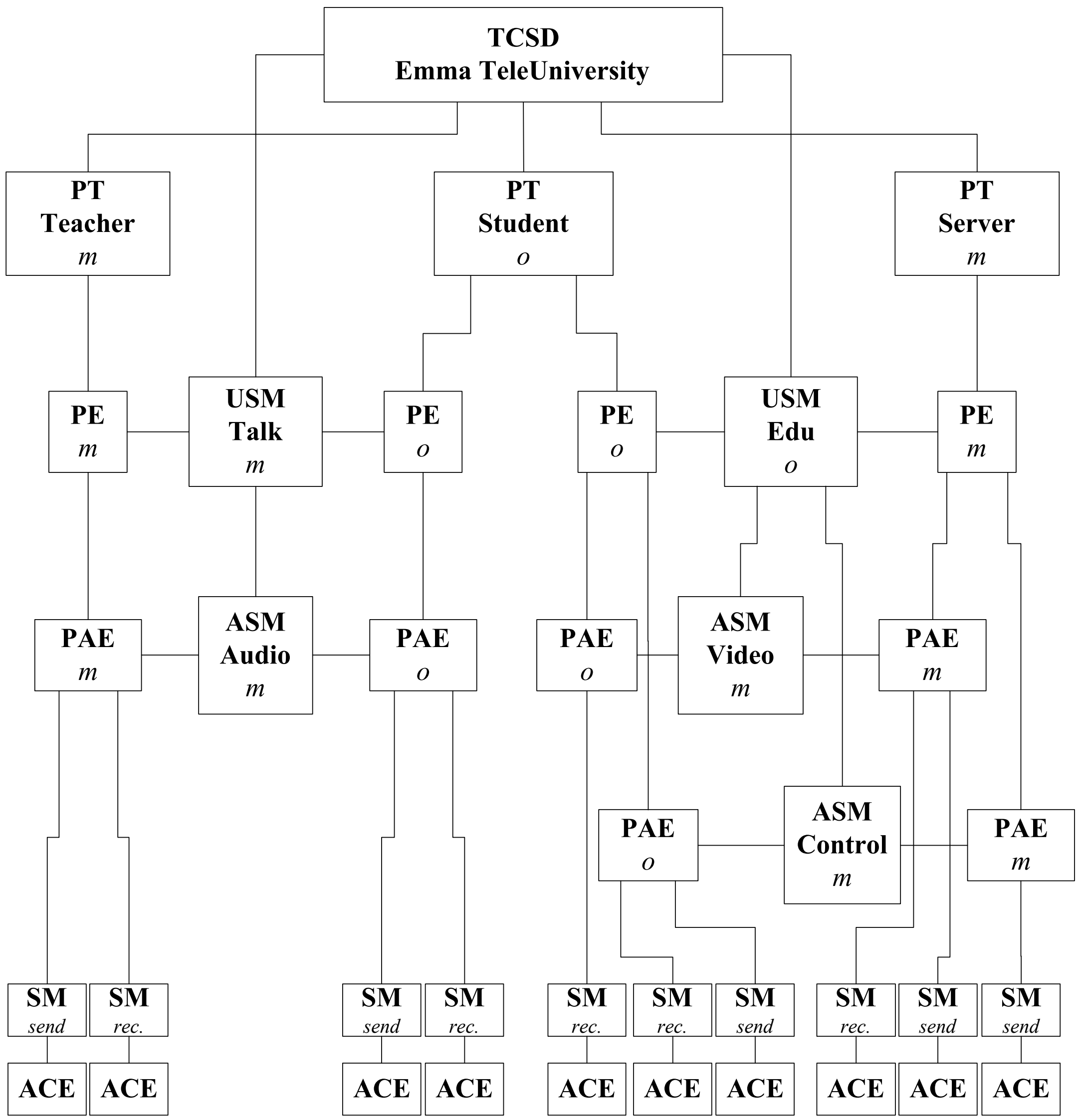
The student should not to get up so early in the morning and spend the valuable time with travelling, if he has an EMMA terminal and a network connection at home. He can browse the teleservice provider's Web page and select the Tele-University service, then he could give the name of the subject in which he wants to expand his knowledge or the name of the teacher with whom he wants to consult.

The structure of the service is very similar. If the number of candidates for a lesson is sufficient then the teacher can start the lesson and he will be connected with every students through an audio connection. If the student wants to raise a question then he has to notice it for the teacher and wait the selection. If the teacher wants to support his lecture with additional video material, he can initiate a connection from the students to a video server. The server can provide previously made video recordings which are attached to the actual syllabus.

If the student has no more questions to the teacher or he has no more time then he can exit from the lesson. If the teacher wants to finish the consultation then he can exit from the lesson and the service will be terminated automatically.

3.3.2 Model and Rule Set

The model which describes the structure of EMMA Tele-University service is depicted in Figure 9. This model shows the relations among the service objects. The letters *m* and *o* indicate the category of the objects (i.e., mandatory or optional).



ACE	–	Access Control Element	ASM	–	Abstract Service Module
PAE	–	Party Abstract Edge	PE	–	Party Edge
PT	–	Party Type	SM	–	Service Module
TCSD	–	TeleCommunication Service Description	USM	–	User Service Module

Figure 9. TCSD Model of the EMMA Tele-University Service

The Tele-University service contains some substantially different conditions from the previously described service. Since audio is the most important media; it is not allowed for the students to communicate with each other thus they can be connected to the teacher and the video server only. The teacher can manage the video media without participating in it, i.e. he has the right to allow and forbid the use of this media. The student can control the video server through the control media if the teacher allows the video for him. The minimum number of the students, who participate in the teacher's lesson, is two so at least two audio media have to be realized in a valid service session.

The service specific rules given by the service provider are the following:

Media Rules

- Every media is mandatory.
- Audio media is located on the first priority level while video and control belong to the second one.

Party Rules

- There are one teacher party and one student party for the audio media.
- The same teacher party has to be involved in all audio media, i.e. only one teacher party can be exist in a service session at the same time.
- There are one server party and one student party for the media video and control.
- If a video connection is realized between the student and the server then a control connection has to exist between them, too.
- At least two parties should use each media.

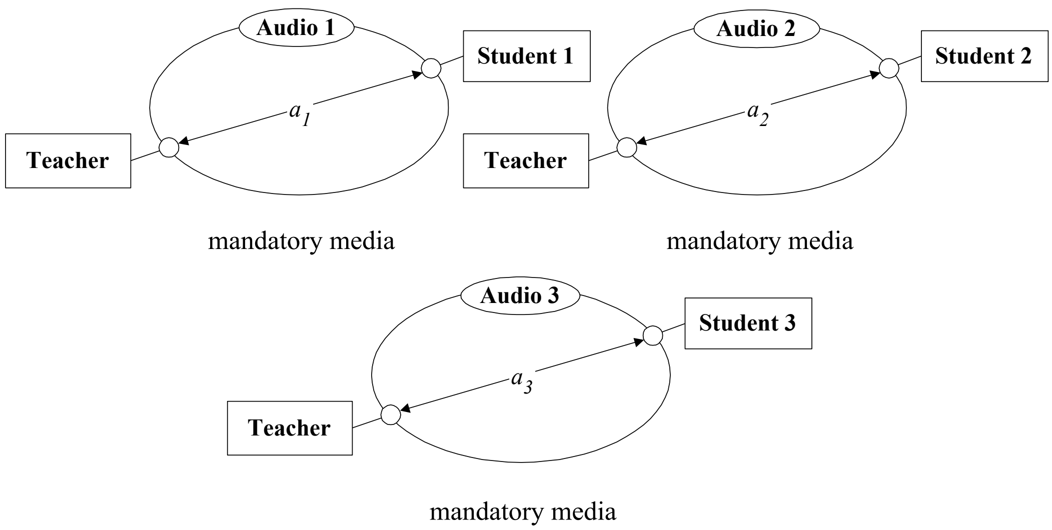
Connection Rules

- The video connections have to be uni-directional.
- The video and control connections between the student and the server party have to be realized simultaneously.

3.3.3 Session Configuration

Let's assume that the teacher requests a full tele-university configuration session for three students, i.e. all students have audio, video and control connections. This configuration is illustrated in Figure 10. The connections in the media, similarly to the previous example, are labelled by a letter and a number succession referring to the type of the media. Video connections are uni-directional according to the rule set. The media belonging to different priority levels are drawn separately.

Priority level 1:



Priority level 2:

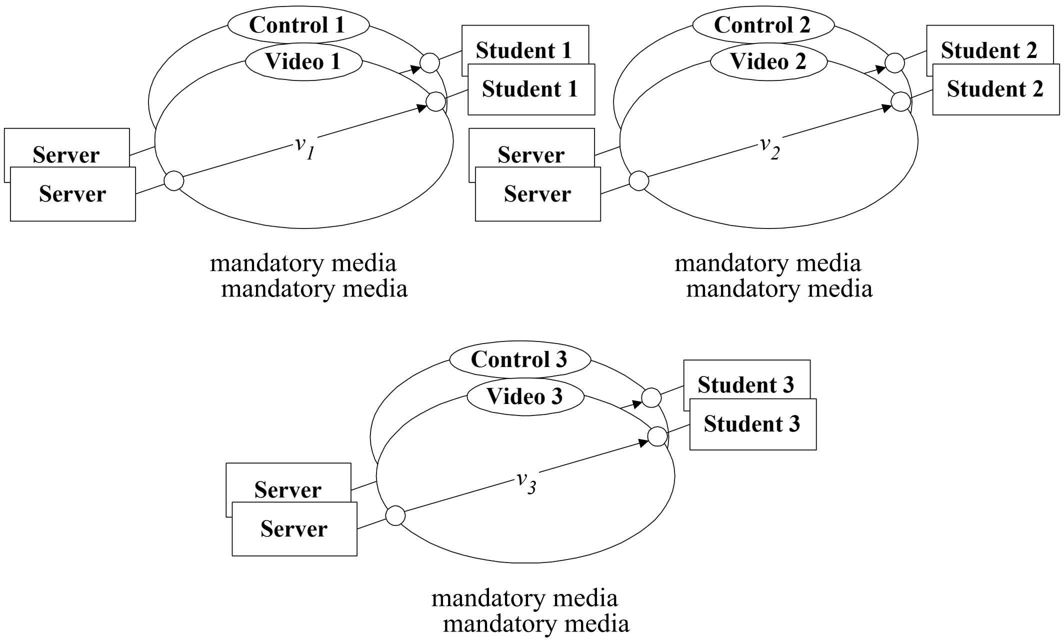


Figure 10. Session Configuration of the Three-Student EMMA Tele-University Service

The session request has to be checked first based on the rules, than the following service description matrices and vectors are generated (Table 7):

$$\mathbf{L} = \begin{bmatrix} 2 & 2 & 2 \\ 2 & 1 & 1 \end{bmatrix}; \qquad \mathbf{f} = \begin{bmatrix} 1 & 1 & 1 & 2 & 2 & 2 & 3 & 3 & 3 \end{bmatrix}$$

$$\mathbf{m} = \begin{bmatrix} 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \end{bmatrix}$$

$$\mathbf{M}_1 = \begin{bmatrix} 2 & 0 & 1 & 0 & 0 \\ 2 & 0 & 0 & 1 & 0 \\ 2 & 0 & 0 & 0 & 1 \end{bmatrix}; \qquad \mathbf{M}_2 = \begin{bmatrix} 0 & 2 & 1 & 0 & 0 \\ 0 & 2 & 0 & 1 & 0 \\ 0 & 2 & 0 & 0 & 1 \\ 0 & 2 & 1 & 0 & 0 \\ 0 & 2 & 0 & 1 & 0 \\ 0 & 2 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{b} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$\mathbf{C}_1 = \begin{bmatrix} 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{C}_2 = \begin{bmatrix} 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{C}_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 2 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 2 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{C}_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{C}_5 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{C}_6 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{C}_7 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 \\ 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{C}_8 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \qquad \mathbf{C}_9 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 & 0 \end{bmatrix}$$

Table 7. Session Description Matrices of the Three-Student EMMA Tele-University Service

The mapping between the media/party identifiers and the names of the media/parties are given in Table 8. The names of the parties/media refer to their types.

Media name	Media ID
Audio 1	media 1
Audio 2	media 2
Audio 3	media 3
Video 1	media 4
Video 2	media 5
Video 3	media 6
Control 1	media 7
Control 2	media 8
Control 3	media 9

Party name	Party ID
Teacher	party 1
Server	party 2
Student 1	party 3
Student 2	party 4
Student 3	party 5

Table 8. The Mapping Table of the Three-Student EMMA Tele-University Service

3.3.4 Resource Reservation

The resource reservation graph can be generated from these matrices and vectors. The connections that have to be reserved to reach the next states are indicated on the branches of the graph in Figure 11. State **Q4** represents the full configurations of the audio media located on the first priority level (all audio connections are realized between the teacher and the students) and state **Q11** represents the full configuration of the requested service session (all audio, video and control connections are realized between the teacher and the students resp. the server and the students).

The configuration targeted in the session request is represented by the last state (**Q11**) of the graph. If this state cannot be reached then the reservation stops in a preceding state-node. In this case it means that the video and control connections of some students could not be realized. The lack of these connections will not affect the others because every student-server link is accomplished with a separate media object.

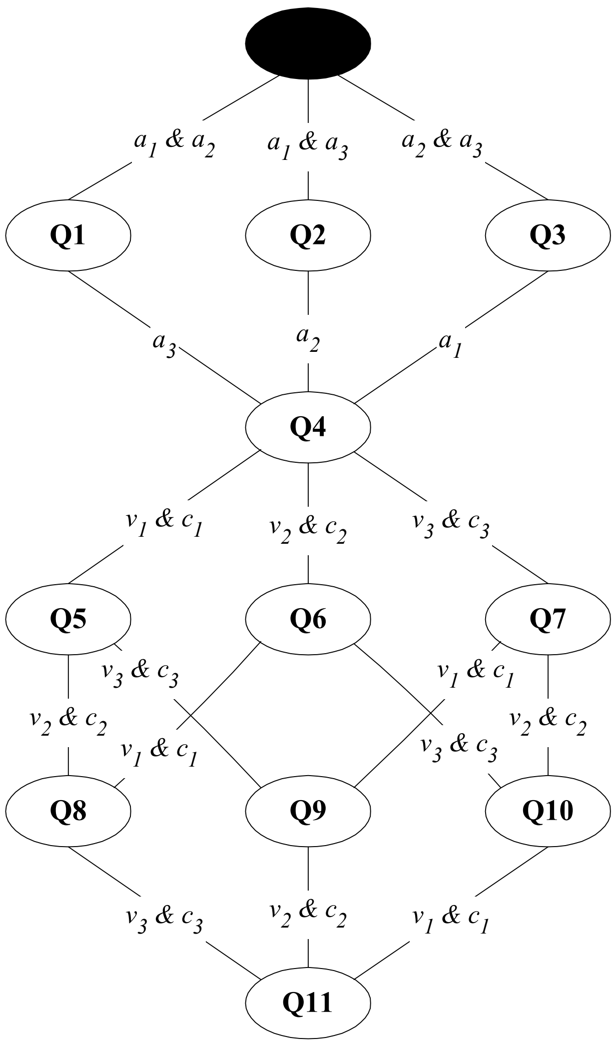


Figure 11. Resource Reservation Graph for the Three-Student EMMA Tele-University Service

The amount of resources required by a specific connection is given in Table 9. Similarly to the previous example, if 64 kbps is assumed as one resource unit then the required bandwidth could be 256, 2048, 64 kbps for audio, video, control media.

It can be noticed that the number and the size of these matrices are unfortunately huge. This is comprehensible because of the large number of media objects and participants.

$$\mathbf{R}_1 = \begin{bmatrix} 0 & 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \quad \mathbf{R}_2 = \begin{bmatrix} 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \quad \mathbf{R}_3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 4 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 4 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{R}_4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 32 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \quad \mathbf{R}_5 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 32 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \quad \mathbf{R}_6 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 32 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{R}_7 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \quad \mathbf{R}_8 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}; \quad \mathbf{R}_9 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{bmatrix}$$

Table 9. Resource Matrices of the Three-Student EMMA Tele-University Service

The $\mathbf{Z}_i$ filter matrices in Table 10 are used to select the parties who are present in a media in case of the i^{th} state. There are eleven **Z** matrices according to the number of the states. In spite of the large size of these matrices, it can be easy to store them because they are binary matrices and contain a lot of zeros. A good technique to store them, if only their non-zero elements are denoted in a data structure, or they can be converted into hyper-matrices which contain several zero-matrices. This concerns the other matrices of the service, too.

The **Q** matrix calculated from the **R**, **Z**, **p** and **C** matrices using equations (1) and (2) represents the states of the graph. It contains the *V* and *D* values for each state. In this service the video media has the greatest resource requirement again. If the network is overloaded and cannot satisfy this demand then it can be a good solution for the service provider to extend the number of the service quality levels and to define a medium or a low quality level for video media. The required bandwidth of these levels can be less than the bandwidth of the good quality video (e.g., 1024 kbps, 512 kbps, etc.). This quality downgrading cannot reduce the worth of the service because the basic idea of the service is to offer a remote consultation possibility for the students which means only the existence of the on-line audio connection between the student and the teacher.

$$\mathbf{Z}_1 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0 \end{bmatrix};\ \mathbf{Z}_2 = \begin{bmatrix} 1&0&1&0&0\\ 0&0&0&0&0\\ 1&0&0&0&1\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0 \end{bmatrix};\ \mathbf{Z}_3 = \begin{bmatrix} 0&0&0&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0 \end{bmatrix};\ \mathbf{Z}_4 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0 \end{bmatrix}$$

$$\mathbf{Z}_5 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&1&1&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&1&1&0&0\\ 0&0&0&0&0\\ 0&0&0&0&0 \end{bmatrix};\ \mathbf{Z}_6 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&0&0&0&0\\ 0&1&0&1&0\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&1&0&1&0\\ 0&0&0&0&0 \end{bmatrix};\ \mathbf{Z}_7 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&1&0&0&1\\ 0&0&0&0&0\\ 0&0&0&0&0\\ 0&1&0&0&1 \end{bmatrix};\ \mathbf{Z}_8 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&1&1&0&0\\ 0&1&0&1&0\\ 0&0&0&0&0\\ 0&1&1&0&0\\ 0&1&0&1&0\\ 0&0&0&0&0 \end{bmatrix}$$

$$\mathbf{Z}_9 = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&1&1&0&0\\ 0&0&0&0&0\\ 0&1&0&0&1\\ 0&1&1&0&0\\ 0&0&0&0&0\\ 0&1&0&0&1 \end{bmatrix};\quad \mathbf{Z}_{10} = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&0&0&0&0\\ 0&1&0&1&0\\ 0&1&0&0&1\\ 0&0&0&0&0\\ 0&1&0&1&0\\ 0&1&0&0&1 \end{bmatrix};\quad \mathbf{Z}_{11} = \begin{bmatrix} 1&0&1&0&0\\ 1&0&0&1&0\\ 1&0&0&0&1\\ 0&1&1&0&0\\ 0&1&0&1&0\\ 0&1&0&0&1\\ 0&1&1&0&0\\ 0&1&0&1&0\\ 0&1&0&0&1 \end{bmatrix}$$

Table 10. Filter Matrices of the Three-Student EMMA Tele-University Service

The **Q** matrix has the following form in this example (Table 11):

$$\mathbf{Q} = \begin{bmatrix} 14 & 14 & 14 & 21 & 35 & 35 & 35 & 49 & 49 & 49 & 63 \\ 16 & 16 & 16 & 24 & 58 & 58 & 58 & 92 & 92 & 92 & 126 \end{bmatrix}$$

Table 11. Configuration Complexity and Resource Requirement Matrix of the Three-Student EMMA Tele-University Service

3.4 EMMA Multimedia Library Service

3.4.1 Basic Idea

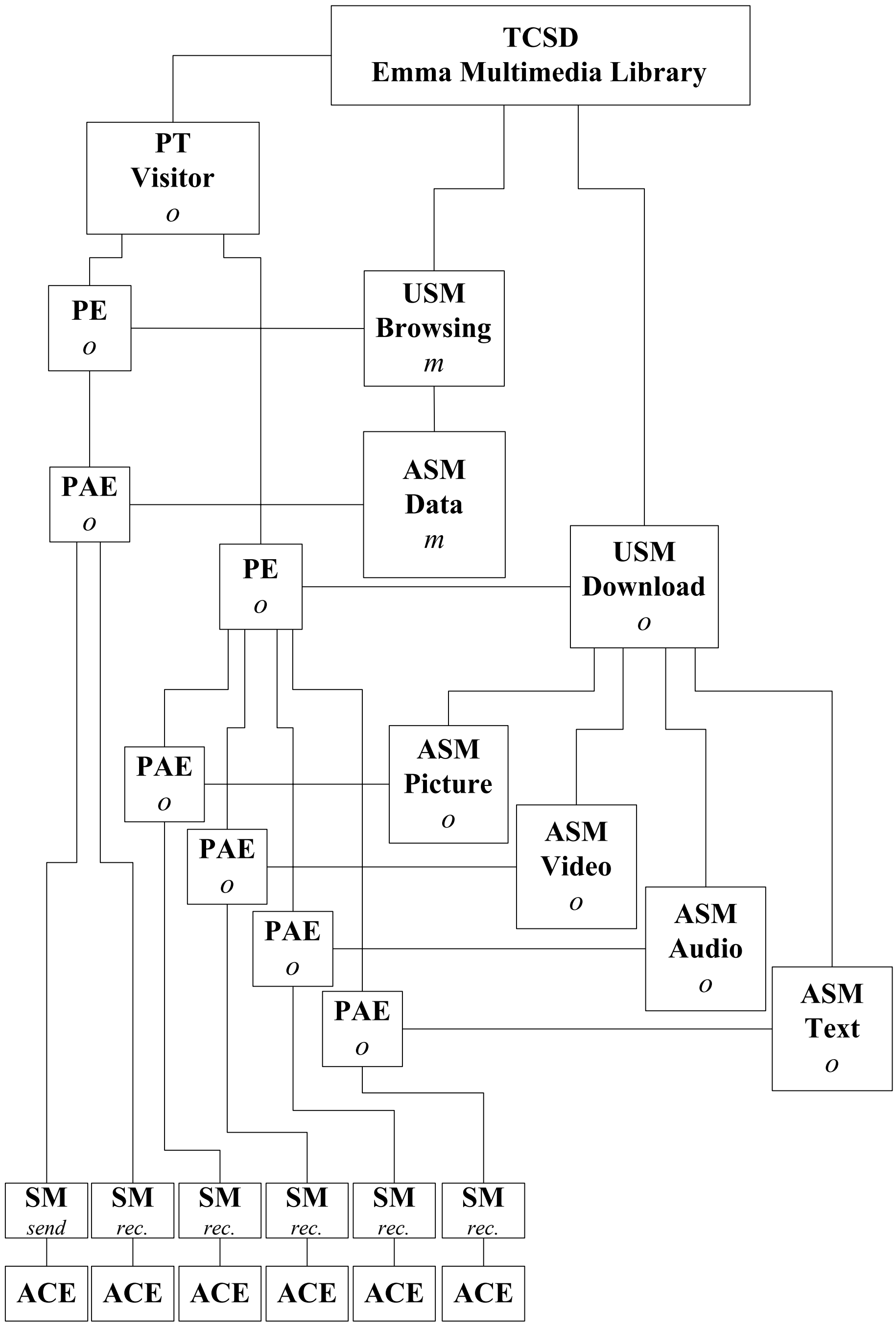
Multimedia Library is one of the telecommunication services which can take advantages of the high speed networks. With the help of this service, the user sitting in an arm-chair is able to walk through a virtual library. The greatest benefit of this application that it does not require a building to store the valuable books, papers, video recordings, archival data what can be very expensive to maintain. On the other hand, it requires only a multimedia server with a big storage capacity to store these data in digital form and network connections to it.

This library contains several media types such as still-picture, motion picture, audio and text. The service offers high quality for downloading these media because the connections are realized through resources reserved in advance. The user can download more media types at the same time. Another nice property of the service is to provide a separate connection for the user to browsing from the data collected in the library.

The service can be controlled in a user-friendly way. It is provided by easy-to-understand metaphors on a Java-based Graphical User Interface, which helps the naive user to use all benefits of this multimedia application.

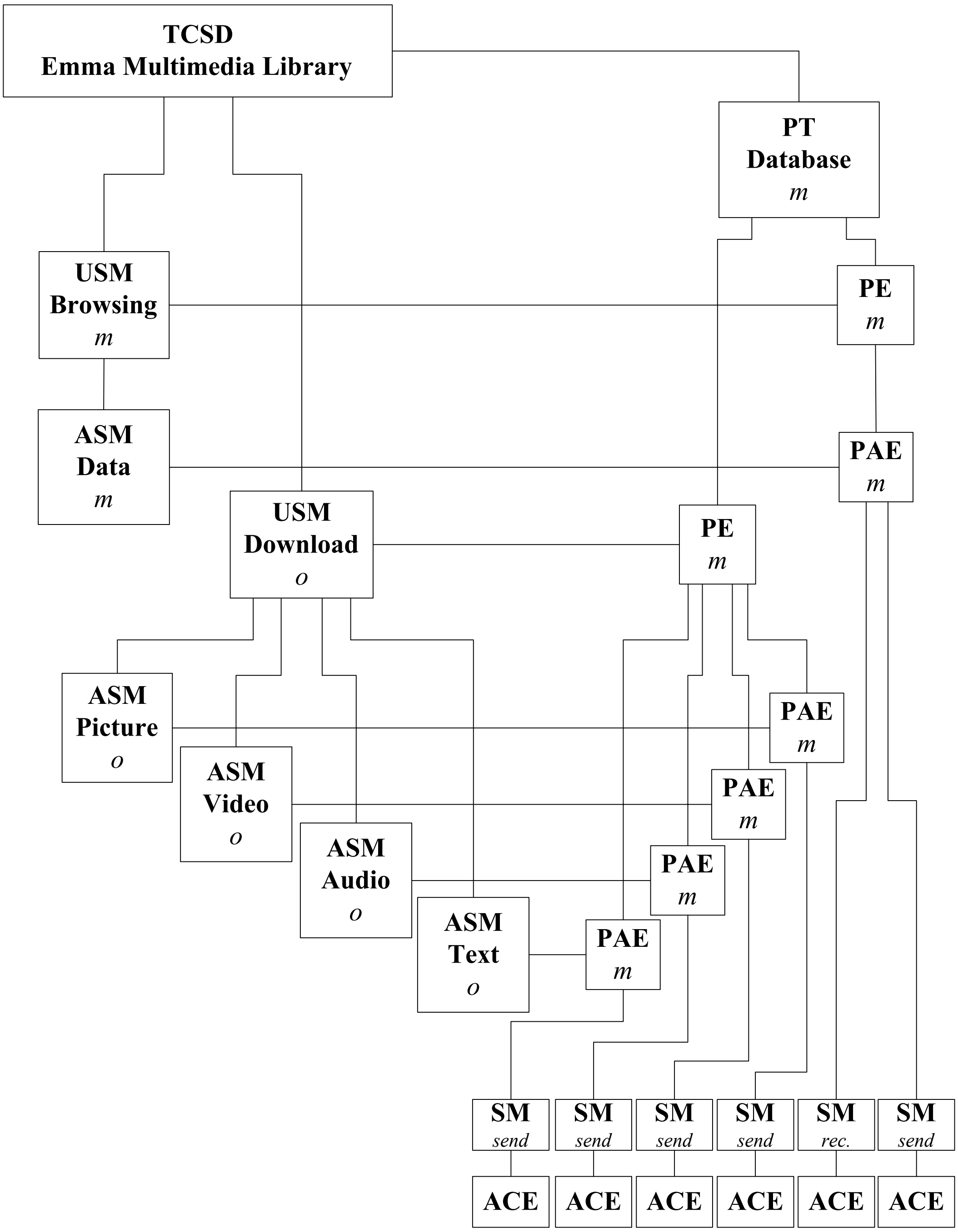
3.4.2 Model and Rule Set

The model which describes the structure of EMMA Multimedia Library service is depicted in Figure 12 and Figure 13. Figure 12 shows the relations between the service objects from the Visitor party's point of view and Figure 13 shows them from the Database party's point of view. The letters *m* and *o* indicate the category of the objects (i.e., mandatory or optional).



ACE	–	Access Control Element	ASM	–	Abstract Service Module
PAE	–	Party Abstract Edge	PE	–	Party Edge
PT	–	Party Type	SM	–	Service Module
TCSD	–	TeleCommunication Service Description	USM	–	User Service Module

Figure 12. Visitor Leg of TCSD Model of the EMMA Multimedia Library Service



ACE	–	Access Control Element	ASM	–	Abstract Service Module
PAE	–	Party Abstract Edge	PE	–	Party Edge
PT	–	Party Type	SM	–	Service Module
TCSD	–	TeleCommunication Service Description	USM	–	User Service Module

Figure 13. Database Leg of TCSD Model of EMMA Multimedia Library Service

Multimedia Library service has a very simple structure. It is similar to a complex FTP service in which several different downloading connections are realized at the same time. In every service session there are only two participants, the visitor and the database. Database party represents the multimedia library and visitor party represents the user who wants to visit the library. Entering the library the user can select from the offering of the collected data. This is represented by the data medium which is mandatory and has to be realized firstly to supply the user's browsing. After selecting the suitable item, which can be still-picture, motion picture (video), audio or text (book), the appropriate media connection has to be created for downloading. There can be several, different media connection between the visitor and the database party but only one of each media type.

The service specific rules given by the service provider are the following:

Media Rules

- Data media is mandatory and picture, video, audio and text media are optional.
- Data media is located on the first priority level while picture, video, audio and text belong to the second one.

Party Rules

- There are one visitor party and one database party for each media.
- At least two parties should use each media.

Connection Rules

- The data connection has to be bi-directional.
- The picture, video, audio and text connections have to be uni-directional.

3.4.3 Session Configuration

Let's assume that the visitor requests a full multimedia library configuration session, i.e. he wants to download all the four kinds of media. This configuration is illustrated in Figure 14. The connections in the media are labelled by a letter referring to the type of the media. Data connection is bi-directional while picture, video, audio and text connections are uni-directional according to the rule set. The media belonging to different priority levels are drawn separately.

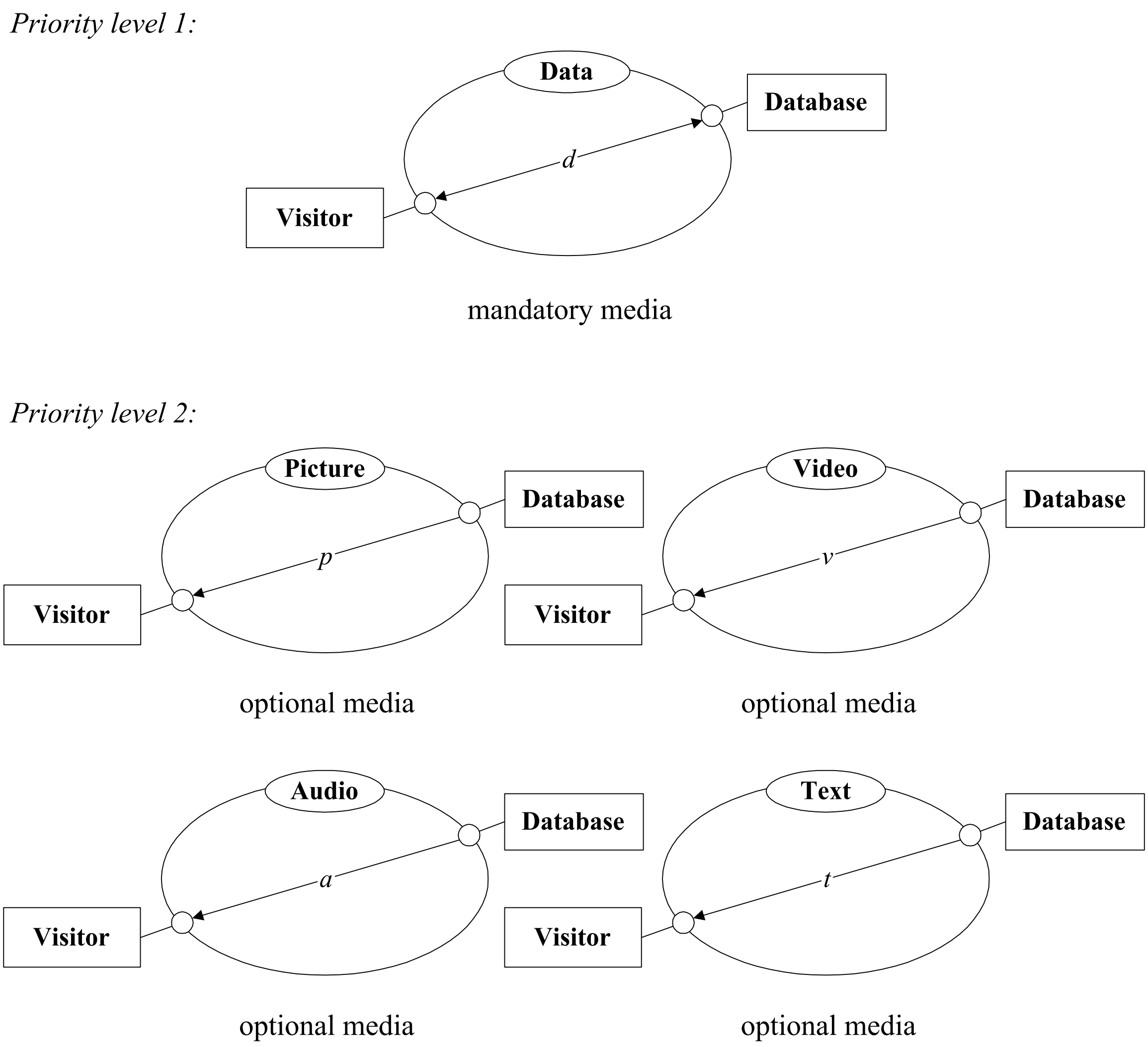


Figure 14. Session Configuration of the EMMA Multimedia Library Service

The session request has to be checked and the service description matrices and vectors are generated (Table 12). The size of these matrices are much friendlier than the matrices in the previous example because of the simplicity of the service.

$$\mathbf{L} = \begin{bmatrix} 2 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}; \quad \mathbf{f} = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 \end{bmatrix}; \quad \mathbf{m} = \begin{bmatrix} 2 & 2 & 2 & 2 & 2 \end{bmatrix}$$

$$\mathbf{M}_1 = \begin{bmatrix} 1 & 2 \end{bmatrix}; \quad \mathbf{M}_2 = \begin{bmatrix} 1 & 2 \\ 1 & 2 \\ 1 & 2 \\ 1 & 2 \end{bmatrix}$$

$$\mathbf{b} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

$$\mathbf{C}_1 = \begin{bmatrix} 0 & 2 \\ 2 & 0 \end{bmatrix}; \qquad \mathbf{C}_2 = \mathbf{C}_3 = \mathbf{C}_4 = \mathbf{C}_5 = \begin{bmatrix} 0 & 0 \\ 2 & 0 \end{bmatrix}$$

Table 12. Service Description Matrices of the EMMA Multimedia Library Service

The mapping between the media/party identifiers and the names of the media/parties are given in Table 13. The names of the parties/media refer to their types.

Media name	Media ID
Data	media 1
Picture	media 2
Video	media 3
Audio	media 4
Text	media 5

Party name	Party ID
Visitor	party 1
Database	party 2

Table 13. The Mapping Table of the EMMA Multimedia Library Service

3.4.4 Resource Reservation

The resource reservation graph can be generated in the usual way. The connections that have to be reserved to reach a next state-node are indicated on the branches of the graph in Figure 15. This graph is a completely symmetrical one because the priority of picture, video, audio and text media are equal. The states of the graph represent the realisation order of these media and every combination of them is allowed. State **Q1** indicates the configuration when the data media is realized and state **Q11** represents the full configuration of the requested service session (data, picture, video, audio and text connections are realized between the Visitor and the Database).

The configuration targeted in the session request is represented by the last state (**Q16**) of the graph. If this state cannot be reached then the reservation stops in a preceding state-node.

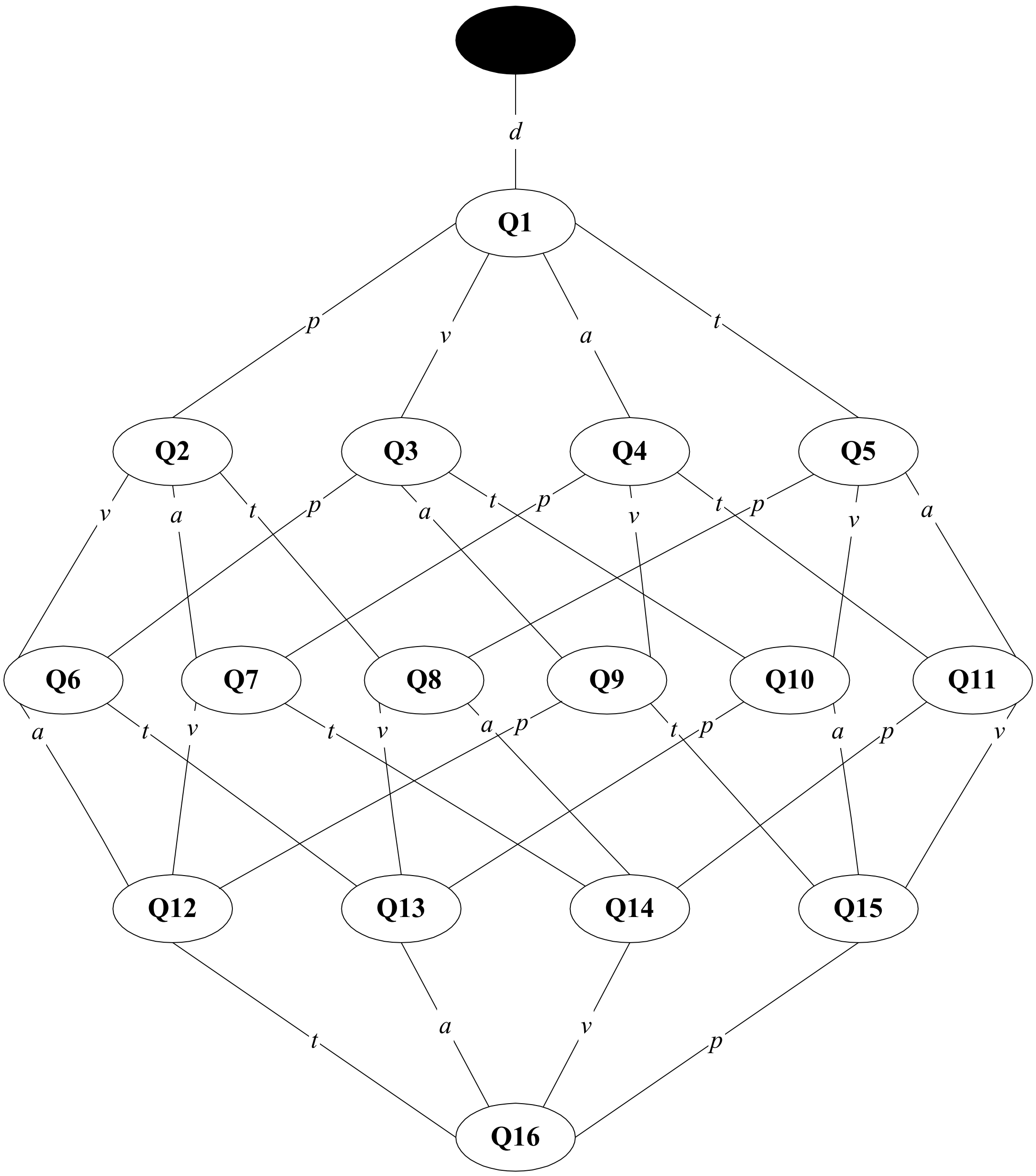


Figure 15. Resource Reservation Graph for the EMMA Multimedia Library Service

The amount of resources required by a specific connection is represented in Table 14. If 64 kbps is assumed as one resource unit then the required bandwidth could be 64, 512, 2048, 128 kbps for data, picture, video, audio, text media.

$$\mathbf{R}_1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}; \quad \mathbf{R}_2 = \begin{bmatrix} 0 & 0 \\ 8 & 0 \end{bmatrix}; \quad \mathbf{R}_3 = \begin{bmatrix} 0 & 0 \\ 32 & 0 \end{bmatrix}; \quad \mathbf{R}_4 = \begin{bmatrix} 0 & 0 \\ 4 & 0 \end{bmatrix}; \quad \mathbf{R}_5 = \begin{bmatrix} 0 & 0 \\ 2 & 0 \end{bmatrix}$$

Table 14. Resource Matrices of the EMMA Multimedia Library Service

The $\mathbf{Z}_i$ filter matrices in Table 15 are used to select the parties who are present in a media in case of the i^{th} state.

$$\mathbf{Z}_1 = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_2 = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_3 = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 1 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_4 = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 0 & 0 \\ 1 & 1 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_5 = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}$$

$$\mathbf{Z}_6 = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 0 & 0 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_7 = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 0 & 0 \\ 1 & 1 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_8 = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 0 & 0 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}; \quad \mathbf{Z}_9 = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 1 & 1 \\ 1 & 1 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_{10} = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 1 & 1 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}$$

$$\mathbf{Z}_{11} = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 0 & 0 \\ 1 & 1 \\ 1 & 1 \end{bmatrix}; \quad \mathbf{Z}_{12} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 0 & 0 \end{bmatrix}; \quad \mathbf{Z}_{13} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 0 & 0 \\ 1 & 1 \end{bmatrix}; \quad \mathbf{Z}_{14} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 0 & 0 \\ 1 & 1 \\ 1 & 1 \end{bmatrix}; \quad \mathbf{Z}_{15} = \begin{bmatrix} 1 & 1 \\ 0 & 0 \\ 1 & 1 \\ 1 & 1 \\ 1 & 1 \end{bmatrix}; \quad \mathbf{Z}_{16} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 1 & 1 \\ 1 & 1 \end{bmatrix}$$

Table 15. Filter Matrices of the EMMA Multimedia Library Service

The **Q** matrix is given in Table 16. It contains the *V* and *D* values for each state. Almost every state has different resource requirement so the most suitable state can be chosen easily.

$$\mathbf{Q} = \begin{bmatrix} 7 & 12 & 12 & 12 & 12 & 17 & 17 & 17 & 17 & 17 & 17 & 22 & 22 & 22 & 22 & 27 \\ 2 & 10 & 34 & 6 & 4 & 42 & 14 & 12 & 38 & 36 & 8 & 46 & 44 & 16 & 40 & 48 \end{bmatrix}$$

Table 16. Configuration Complexity and Resource Requirement Matrix of the EMMA Multimedia Library Service

4. Epilogue

In this chapter I give some procedures to test my algorithm and the future perspectives of my work is presented. And finally, I summarise my work.

4.1 Testing

The Rule-Base Subsystem described in this work can be tested with the SIGNE prototype available this summer. There are several aspects that have to evaluated during this test:

- The general validity and applicability of the Rule-Base Subsystem should be verified by running the Multimedia Conference, Tele-University and Multimedia Library services on the EMMA/SIGNE experimental platform. If there are no invalid configuration accepted by SIGNE during the session management, the graphs described in section 3.2.4, 3.3.4, 3.4.4 are corrected.

- The performance of resource reservation should be checked by comparing the amount of resources consumed by SIGNE using the Rule-Base Subsystem and another system which has no Rule-Base Subsystem. Simulation is another way for this comparison.

- The proposed Methodology and Reservation Framework should be applied on other, more complex services in order to check if it is a feasible solution.

These tests could be part of my future research activities as a Ph.D. student.

4.2 Future Outlook

The proposed scheme could be extended by defining more priority levels for media types and more categories for the parties and media objects, introducing the notion of connections priority and inter-connection dependence. Moreover, the service description framework can be further developed in terms of applying different priority levels for the directions of bi-directional connections, involving point-to-multipoint connections, describing inter-media relations and defining more complex rules. This would have the following impacts on the framework presented in this document:

- the size of **L, C, M, R, Z** matrices would be larger
- new vectors, matrices have to be introduced for describing dependence of the objects
- new procedures and steps would be required for satisfying these complex rules

4.3 Summary

The primary goal of this diploma thesis was to present an abstract service description framework for multiparty, multimedia teleservices and an intelligent resource reservation scheme for networks providing resource reservation mechanisms. Distributed multimedia teleservices require numerous resources in the terminals and the network. However, if the network is overloaded or the capabilities of the terminals are not adequate then all of these resources can not be reserved for the service. In such a case a universal *resource reservation scheme* that maximises the completeness of the configuration fulfilling certain rules can be very useful for several multimedia systems. My resource reservation scheme is satisfying this effort. Adopting the algorithm into SIGNE gives an opportunity to manage uniformly the different multimedia services. This scheme can be further developed to prepare it for managing more complex services.

In this document firstly I gave a brief overview about the latest results of the related research area and briefly presented the main goals and structure of the Telia's EMMA/SIGNE project. Then my resource reservation scheme was introduced and the approach was illustrated on three different EMMA multimedia services such as Multimedia Conference, Tele-University and Multimedia Library.

References

[1] Y.I. Manolessos, M.E. Theologou, Dynamic application scaling as a means for QoS management, Computer Communications Vol. 20, 1997, pp. 393-405

[2] C. Diot, Adaptive Applications and QoS Guarantees, in Proc. of IEEE Multimedia Networking, Aizu Japan, September 1995

[3] T. Plagemann, V. Goebel, Towards User-Centred Multimedia Systems for Distance Education, Broadband and Multimedia Workshop, Zagreb, Croatia, November 1996, pp. 31-46.

[4] M. Jones, Adaptive Real Time Resource Management Supporting Modular Composition of Digital Multimedia Services, 4th International Workshop on Network and Operating Systems Support for Digital Audio and Video, University of Lancester, Nov. 1993

[5] ITU-T Recommendation I.371: Traffic control and congestion control in B-ISDN

[6] ATM Forum: ATM User Network Interface Specification 3.1, September 1994

[7] K. Farkas, I. Cselényi, G. Fehér: Rule Based Reservation Scheme for Multiparty, Multimedia Teleservices, submitted to ICSC'98, Singapore

[8] I. Cselényi, R. Szabó, I. Szabó, N. Björkman, A. Latour-Henner: An Experimental Resource Management Platform, submitted to the Computer Communications Journal

[9] J. Heinanen, K. Kilkki: A fair buffer allocation scheme, Computer Communications Vol. 21, 1998, pp. 220-226

[10] C. Parris, H. Zhang, D. Ferrari: Dynamic management of guaranteed performance multimedia connections, SCM Multimedia Systems Journal, Vol. 1 No. 6, 1993, pp. 267-283

[11] C. Parris: The Dynamic Management of Guaranteed-Performance Connections in Packet Switched Integrated-Services Networks, Ph.D. dissertation, University of California at Berkeley, September 1994

[12] D. P. Anderson, R. G. Herrtwich, C. Schaefer: SRP - A Resource Reservation Protocol for Guaranteed-Performance Communication in The Internet, available from http://sunsite.berkeley.edu/Dienst/Repository/2.0/Body/ncstrl.ucb

[13] M. Andersson, A. Latour-Henner, N. Björkman, K. Svartsjö, C. Gisgård: *CARAT's Experimental Approach to Service & Network Control,* Teknisk Rapport, Telia Research AB, Sweden, 1995.

[14] C. Gisgård: *SIGNE - Signaling Emulator,* Fasrapport, Telia Research AB, Sweden, 1995.

[15] I. Cselényi: *EMMA - Experimental Multimedia Middleware for ATM,* Specification of Requirements, HSNLab, TUB, Budapest, 1995.

[16] I. Cselényi, I. Szabó, N. Björkman, P. Haraszti, C. Gisgård, A Versatile Multimedia Platform, 15th IASTED International Conference on Applied Informatics, Innsbruck, Austria, February 17-20, 1997, pp. 276-279

[17] RACE Project R2044: MAGIC- Multiservice Applications Governing Integrated Control, Service Description Framework and B-ISDN Service Descriptions, 3rd Deliverable, EC, 1992.

[18] I. Szabó, User Interface based on World Wide Web for Multimedia Applications, Diploma Thesis, TU Budapest, HSNLab, Budapest, 1996

[19] Nils Björkman, István Cselényi, Alexander Latour-Henner, Gergely Záruba, The EMMA Multimedia Conference Service, accepted for the First International Conference on Information, Communications & Signal Processing , Singapore, September 1997

[20] P. Haraszti, User Applications in the SIGNE-EMMA Project, Diploma Thesis, TU Budapest, HSNLab, Budapest, 1996

[21] G. Záruba, Video Conference Application for the EMMA Teleconference Service, Diploma Thesis, TU Budapest, HSNLab, Budapest, 1997

[22] ATM Forum Technical Committee: Native ATM Services: Semantic Description, 1995

Appendix A: Acronyms

AAL	*ATM Adaptation Layer*
ABR	*Available Bit Rate*
ABB	*Application Building Block*
ACE	*Access Control Element*
API	*Application Programming Interface*
AppLD	*Application Launcher Daemon*
ASM	*Abstract Service Module*
ATM	*Asynchronous Transfer Mode*
B-ISDN	*Broadband Integrated Service Digital Network*
CPU	*Central Processing Unit*
DCM	*Dynamic Connection Management*
EMMA	*Experimental Multimedia Middleware for ATM*
EMVC	*EMMA Video Conference*
FIFO	*First In First Out*
GPC	*Guaranteed Performance Connection*
HSNLab	*High Speed Networks Laboratory (at TUB)*
HTTP	*Hyper Text Transfer Protocol*
IP	*Internet Protocol*
LVSI	*Local View of Service Instance*

MAGIC	*Multiservice Applications Governing Integrated Control*
MMON	*Minimal Medium Object Number*
NAAPI	*Native ATM Application Programming Interface*
NAP	*Network Access Program*
PAE	*Party Abstract Edge*
PE	*Party Edge*
PT	*Party Type*
QoS	*Quality of Service*
RACE	*Research and Development in Advanced Communication Technologies in Europe*
SC	*Service Control*
SI	*Service Instance*
SIGNE	*Signaling Emulator*
SM	*Service Module*
SRP	*Session Reservation Protocol*
TCS	*Telecommunication Service*
TCP	*Transmission Control Protocol*
TCSD	*Telecommunication Service Description*
TP	*Terminal Profile*
TSP	*Telecommunication Service Protocol*
TUB	*Technical University of Budapest*

UA	*User Application*
UBR	*Unspecified Bit Rate*
USM	*User Service Module*
VAS	*Value Added Service*
WWW	*World Wide Web*

Appendix B: Configuration Files for SIGNE

The configuration files of 3-Party EMMA Videoconference Service are listed below. The first file contains the definitions of the objects and the second one describes the Resource Reservation Graph.

; EMMA Multimedia Conference for the Three-Party (EMVC3)
; USM names
[USM]
VideoPhone = 1
WhiteBoard = 2

; ASM names
[ASM]
Audio = 1
Video = 2
Transfer = 3

; Party type names
[PartyType]
Chairman = 1
Member = 2

; EMMA Multimedia Conference for 3 Parties (EMVC3)
[Bandwidth]
; The values show how many kilobytes has to be reserved at a quality rate. First is the best
; quality.
Audio = 256, 128, 64
Video = 2048, 1024, 512
Transfer = 64

[States]
; The values show the connections in the state. They are stored in format
; <PartyType1>–<PartyType2>–<Media> separated with comma. If a state contain some
; previously defined states that the format <+><State Name> is allowed to notify it.
; The 'top' is a reserved state, it contains no connections and it will be the top of the graph.
q1 = Chairman-Member1-Audio
q2 = Chairman-Member2-Audio
q3 = +q1, Chairman-Member2-Audio, Member1-Member2-Audio
q4 = +q1, Chairman-Member1-Video
q5 = +q2, Chairman-Member2-Video
q6 = +q3, Chairman-Member1-Video
q7 = +q3, Chairman-Member2-Video

q8 = +q6, Chairman-Member2-Video, Member1-Member2-Video
q9 = +q8, Chairman-Member1-Transfer
q10 = +q8, Chairman-Member2-Transfer
q11 = +q9, Chairman-Member2-Transfer, Member1-Member2-Transfer

[Graph]
; It shows the hierarchy among the states. The graph is built with the same state order as it
; defined below. The states are separated with commas.
top = q1, q2
q1 = q3, q4
q2 = q3, q5
q3 = q6, q7
q4 = q6
q5 = q7
q6 = q8
q7 = q8
q8 = q9,q10
q10 = q11

The configuration files of the Three-Student EMMA TeleUniversity Service are listed below. The first file contains the definitions of the objects and the second one describes the Resource Reservation Graph.

; EMMA TeleUniversity for 3 Students (EMTU3)
; USM names
[USM]
Talk = 3
Edu = 4

; ASM names
[ASM]
Audio = 1
Video = 2
Control = 4

; Party type names
[PartyType]

Teacher = 3
Student = 4
Edu_Server = 5

; EMMA TeleUniversity for 3 Students (EMTU3)
[Bandwidth]
; The values show how many kilobytes has to be reserved at a quality rate. First is the best
; quality.
Audio1 = 256, 128, 64
Audio2 = 256, 128, 64
Audio3 = 256, 128, 64
Video1 = 2048, 1024, 512
Video2 = 2048, 1024, 512
Video3 = 2048, 1024, 512
Control1 = 64
Control2 = 64
Control3 = 64

[States]
; The values show the connections in the state. They are stored in format
; <PartyType1>–<PartyType2>–<Media> separated with comma. If a state contain some
; previously defined states that the format <+><State Name> is allowed to notify it.
; The 'top' is a reserved state, it contains no connections and it will be the top of the graph.
q1 = Teacher-Student1-Audio1, Teacher-Student2-Audio2
q2 = Teacher-Student1-Audio1, Teacher-Student3-Audio3
q3 = Teacher-Student2-Audio2, Teacher-Student3-Audio3
q4 = +q1, Teacher-Student3-Audio3
q5 = +q4, Student1-Edu_Server-Video1, Student1-Edu_Server-Control1
q6 = +q4, Student2-Edu_Server-Video2, Student2-Edu_Server-Control2
q7 = +q4, Student3-Edu_Server-Video3, Student3-Edu_Server-Control3
q8 = +q5, Student2-Edu_Server-Video2, Student2-Edu_Server-Control2
q9 = +q5, Student3-Edu_Server-Video3, Student3-Edu_Server-Control3
q10 = +q6, Student3-Edu_Server-Video3, Student3-Edu_Server-Control3
q11 = +q8, Student3-Edu_Server-Video3, Student3-Edu_Server-Control3

[Graph]
; It shows the hierarchy among the states. The graph is built with the same state order as it
; defined below. The states are separated with commas.
top = q1, q2, q3
q1 = q4
q2 = q4
q3 = q4
q4 = q5, q6, q7
q5 = q8, q9
q6 = q8, q10
q7 = q9, q10
q8 = q11
q9 = q11
q10 = q11

The configuration files of EMMA Multimedia Library Service are listed below. The first file contains the definitions of the objects and the second one describes the Resource Reservation Graph.

```
; EMMA Multimedia Library (EMML)
; USM names
[USM]
Browsing = 5
Download = 6

; ASM names
[ASM]
Data = 5
Picture = 6
Video = 2
Audio = 1
Text = 7

; Party type names
[PartyType]
Visitor = 6
Database = 7
```

```
; EMMA Multimedia Library (EMML)
[Bandwidth]
; The values show how many kilobytes has to be reserved at a quality rate. First is the best
; quality.
Data = 64
Picture = 512, 256, 128
Video = 2048, 1024, 512
Audio = 256, 128, 64
Text = 128, 64

[States]
; The values show the connections in the state. They are stored in format
; <PartyType1>–<PartyType2>–<Media> separated with comma. If a state contain some
; previously defined states that the format <+><State Name> is allowed to notify it.
; The 'top' is a reserved state, it contains no connections and it will be the top of the graph.
q1 = Visitor-Database-Data
q2 = +q1, Visitor-Database-Picture
q3 = +q1, Visitor-Database-Video
q4 = +q1, Visitor-Database-Audio
q5 = +q1, Visitor-Database-Text
q6 = +q2, Visitor-Database-Video
q7 = +q2, Visitor-Database-Audio
```

q8 = +q2, Visitor-Database-Text
q9 = +q3, Visitor-Database-Audio
q10 = +q3, Visitor-Database-Text
q11 = +q4, Visitor-Database-Text
q12 = +q6, Visitor-Database-Audio
q13 = +q6, Visitor-Database-Text
q14 = +q7, Visitor-Database-Text
q15 = +q9, Visitor-Database-Text
q16 = +q12, Visitor-Database-Text

[Graph]
; It shows the hierarchy among the states. The graph is built with the same state order as it
; defined below. The states are separated with commas.
top = q1
q1 = q2, q3, q4, q5
q2 = q6, q7, q8
q3 = q6, q9, q10
q4 = q7, q9, q11
q5 = q8, q10, q11
q6 = q12, q13
q7 = q12, q14
q8 = q13, q14
q9 = q12, q15
q10 = q13, q15
q11 = q14, q15
q12 = q16
q13 = q16
q14 = q16
q15 = q16