

Design and Implementation of Agent-Based Flexible Multimedia System

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Abstract

Distributed multimedia communication system which not only integrates various multimedia information distributed over computer networks and but also provides it to users in accordance with the requirements of users during realtime communication must guarantee the user requested quality of services (QoS) even though the computer and network resources change statically or dynamically. We have proposed a flexible multimedia system (FMS) which is based on agent-oriented architecture and is able to organize required functions itself, guarantee end-to-end QoS. This paper describes the FMS architecture and the design for multimedia teleconference service. FMS is able to realize various multimedia communication services flexibly for service requests and QoS requests from users.

1. Introduction

Recently, high performance computers which can process and integrated audio, video, graphics and text have been used on high speed network for various applications such as Web browser, VOD systems and teleconferencing systems.

However, since generally multimedia communication services are provided on different computers and network environments for different users, it is difficult to offer required services from users and guarantee end-to-end QoS in accordance with individual user's environment and required media processing. Therefore, multimedia system must be carefully designed in terms of system architecture and operating systems with network protocols.

There are a number of researches concerned with QoS guarantee for media data flow on the transport and network levels[1] using QoS oriented protocols and networks such

as RTP[2], RSVP over ATM. However there are few researches which have paid attention to the end-to-end QoS control functions and mechanisms accordance with different user's environments, although it is very significant for multimedia services.

For example, in case of multimedia teleconferencing service, users not only use realtime media services but also stored media services for their communication and media presentation simultaneously. Therefore the system must process stored media and realtime media at the same time. In order to provide the stored multimedia information to users, the system must not only integrate both continuous media such as audio, video and discrete media such as still image, graphics and text, but also perform end-to-end QoS functions and different media processing functions inherit to each media data.

On the other hand, all multimedia communication services are not always required from users. For example, if a user doesn't require shared window function, it's functional modules are not required in the system. It is an effective means that the system organizes[3] required functions for user's multimedia service requirements dynamically according to the status of computing and resource utilization.

In order to realize multimedia communication service in accordance with user's requirements in the different user environments, an agent-oriented Flexible Multimedia System (FMS) based on the concepts of Flexible Network[4] has been investigated.

2. Flexible multimedia system

Figure 1 shows the system configuration of multimedia teleconferencing system as an example of FMS.

Using the system, users can hold conference on the computer networks interconnected by LANs and WANs. The

user stations are able to process and display multimedia data using keyboard, mouse, video camera and microphone. The repositories store functional modules (agents and components) for different user stations, and manage knowledges how to control media processing, and offer required modules to user stations as when these were required.

In order to effectively and dynamically perform these QoS functions, we introduce an agent-oriented architecture for multimedia teleconferencing system architecture shown in Figure 2.

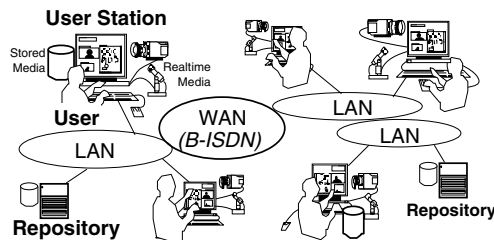


Figure 1. An example of FMS:Multimedia Teleconferencing System

User Interface Layer performs user interface function for service requirements and QoS requirements from user and offers multimedia data to user. *Resource Management Plane* manages user station's resources such as OS type, devices, network configurations, CPU and memories, and allocate and releases the required resources. *Service Management Plane* manages multimedia communication service such as Video-on-Demand, TV-Phone and multimedia teleconference services. In this plane, the required modules for multimedia conferencing are organized dynamically. *Media Management Plane* manages media processing for user required multimedia communication services. *Media Data Plane* processes media data. In this plane, *Synchronization Layer* processes inter and intra media synchronization, *Data Transform Layer* transform data format and *Media Flow Control Layer* controls various media data flow.

In Media Management and Media Data Plane, the functional modules are also organized dynamically. For example, when a user station can use QoS functions of ATM, the FMS organizes functional modules for using the functions into Media Management and Media Data Plane.

3. Functional modules

Figure 3 shows system configuration by stationary and mobile agents for multimedia teleconference service. In this figure, the mobile agents have been organized at the beginning of the service. The agents of User Interface Layer and Resource Management Plane are realized as stationary agents on each user station. On the other hand, the agents of Service Management Plane, Media Management Plane and

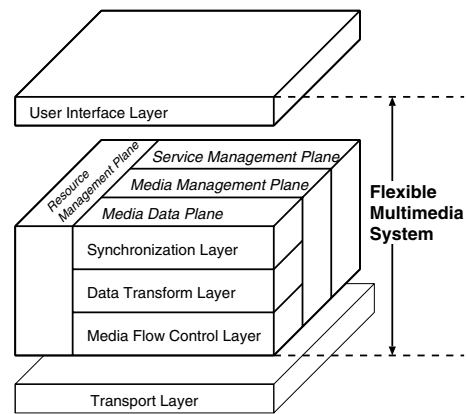


Figure 2. Flexible Multimedia System

Media Data Plane are realized as mobile agents and media components.

Here, Multimedia Service Management Agent (MSMA), Media Agent (MA) and Media Component (MC) are the general term for dynamically organized agents and components in these three planes.

3.1. Agents on a user station

A user station consists of the following agents and components.

(1) Stationary agents and components :

UPA and *RMA* are stationary agent and realize the functions of the User Interface Layer and Resource Management Plane.

(2) Mobile agents and components :

MSMAs coordinate multimedia communication services. *MSMAs* also organize and operate *MAs* and *MCs*. In order to realize multimedia teleconference service, the four *MSMAs* are organized by *UPA*. *MTMA* is organized at the conference manager's user station, manages joining to and leaving from the conference by participants, decides consensus policy, and performs negotiation and decision functions of service class and QoS requirements from participants. *MTPA* is organized at the conference participant's user station and processes conference service requests from user. *RSMA* and *SSMA* organize *MAs* to provide realtime/stored media services to users. *RSMA* and *SSMA* also control and manage the *MAs* which monitor and controls each media processing.

MCs is a functional module to process media data [5]. The following three functions are performed by *MC*.

1. **MSC**: intra and intermedia synchronization.
2. **MDTC**: compression/decompression and data format conversion of media (ex. JPEG, MPEG1/2 and H.261 for video).
3. **MFCC**: variable packet flow control and packet loss rate control.

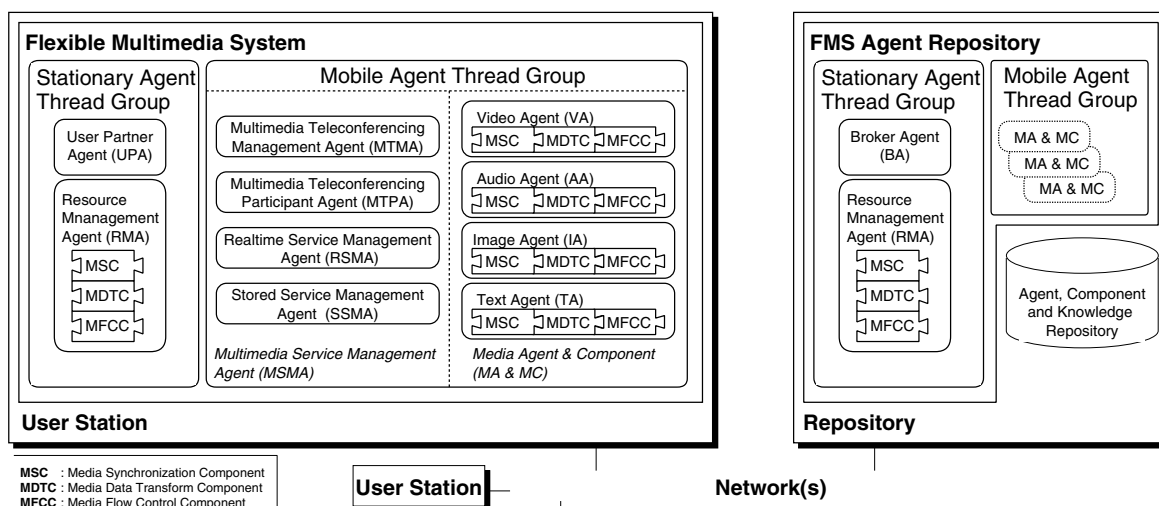


Figure 3. Agent Configuration for Multimedia Teleconference Service

3.2. Agents on a FMS agent repository

A FMS Agent Repository consists of User Interface Layer and Resource Management Plane.

BA is an agent to select dynamically the required agents knowledge and components from *Agent, Component and Knowledge Repository* to user station. RMA manages available computing and network resources in the repository. Moreover, in order to communicate with each user station, RMA has MCs.

3.3. QoS guarantee functions

In order to use guaranteed QoS multimedia communication service, user issues a request with four items to FMS. These items are shown in figure 4(a). In the case where the service type is "multimedia teleconference", in order to arrange user's service and QoS requirements, the conference manager determines consensus policy. Finally user determines service class and QoS class for each application. We define "consensus policy" which is shown in figure 4(a). For an example, the conference such as the explanation meeting of products in a company, the policy may selected higher priority to "Special User". A consensus policy is selected by the conference manager, and MTMA manages the policy during the multimedia conferencing service.

On the other hand, we define "Service Class" and "Application QoS Class" shown in figure 4(a). Users can select one of the service class and application QoS class which provide a multimedia teleconferencing service easily. Service class defines application type and its priority.

On the other hand, in order to guarantee the required QoS, FMS has following four QoS functions; QoS Mapping, Resource Management and QoS Adaptation func-

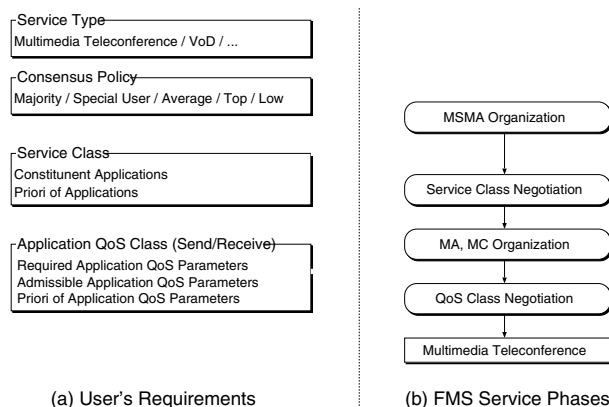


Figure 4. User's Requirements and Service Phases in FMS

tions. Each agent performs the required QoS functions shown in Figure 5.

QoS Mapping is explained as the relation between user's required QoS and processing media QoS in each MC. Each MSMA and MA maps the parameters from application QoS parameters such as video and audio quality to media QoS parameters such as media synchronization, coding schemes and throughput, and RMA maps media QoS parameters to resource parameters such as network traffic, cpu utilization and memory size by considering resource environment such as OS type, CPU type and characteristics of devices.

FMS has knowledge how to use and control the parameter's relation described above. Each user stations can get the knowledge from repository to process the required media data.

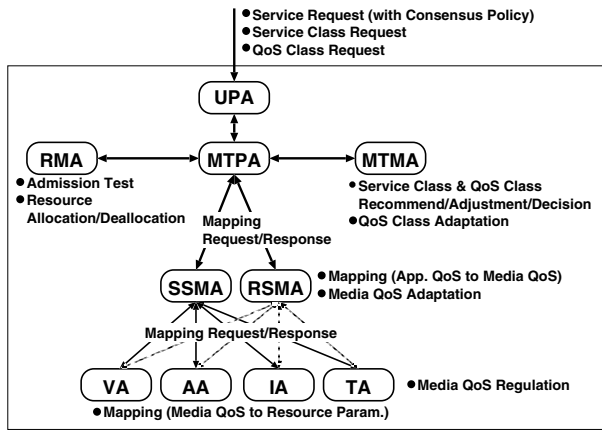


Figure 5. Adaptive QoS Functions and Agents

Resource Management performs admission test to decide whether computer and network resources are available. In addition, resource allocation and release function are required. In our FMS, RMA performs these functions.

QoS Adaptation arranges application QoS parameter in accordance with consensus policy and priority of the parameters. As result of admission test, when RMA can not allocate the required resources, FMS must coordinate application QoS parameter in accordance with consensus policy and priority of the parameters. In the multimedia teleconferencing service, MTMA performs QoS adaptation in accordance with service or QoS requirements of MTPA's

4. System organization and negotiation

FMS organizes the required agents and components dynamically in accordance with service requirements from users, and decides suitable QoS in accordance with consensus policy and QoS requirements from user. At the beginning of the service, first, FMS performs MSMA Organization, next, Service Class Negotiation and MA-MC Organization, finally QoS Class Negotiation. Figure 4(b) shows the organization and negotiation phases. FMS can guarantee suitable QoS using negotiation protocols which are related QoS functions among user stations.

At the beginning of the service, user requests multimedia communication service to FMS. FMS starts organization the required MSMA. Figure 6 shows organization of MSMA flow when the user requests multimedia teleconferencing service to FMS. UPA at each user station receives service requirement from the user, then UPA sends MsmaRequest message to BA in repository. This message includes the required service type and attributes. Figure 6 shows an example of conference manager requests to initiate multimedia teleconferencing service where the attribute is "Manager". Next, BA informs the required service type and attributes to RMA. Then BA receives the information

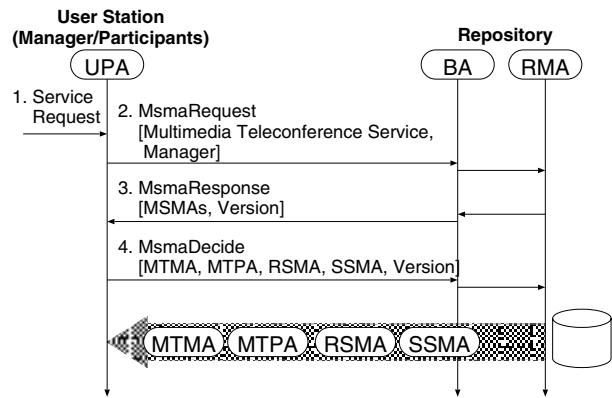


Figure 6. Organization of MSMA

with suitable MSMA from RMA. BA sends MsmaResponse message to UPA. This message includes information with MSMA to perform multimedia teleconferencing. UPA receives information with MSMA, then informs suitable name and version of MSMA to BA. Finally, suitable MSMA are organized in the user station.

Conference manager's user station organizes MTMA as one of MSMA. The conference manager selects consensus policy, then MTMA manages the policy which is used to negotiate service class and application QoS class.

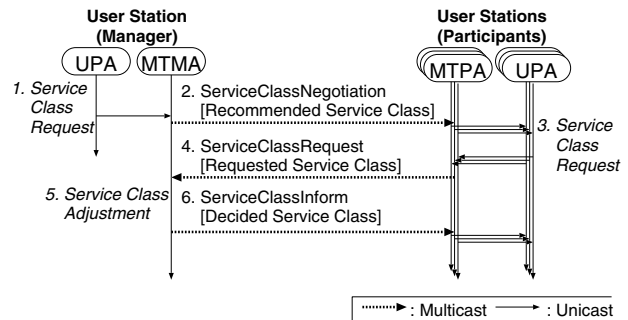


Figure 7. Negotiation of Service Class

In the same way, service class is negotiated as shown in figure 7, then MA and MC are organized in user stations. Finally, multimedia teleconferencing service with QoS is started.

5. Implementing of the prototype system

Now, we are implementing of the prototype system for the system evaluation on SUN Workstation/Solaris 7 and personal computer/Microsoft Windows 98/NT.

For realizing prototype system on each platform, we are using Java 1.2. In the figure 3, each agent and component is realized by Java thread. Dynamic organization for mobile agent is realized by Java RMI. Media data processing functions are realized by Java Media Framework(JMF)

2.0 which is an API for incorporating time-based media into Java applications. Using the JMF, we realize the required functions for media capturing, storing media data, controlling the type of processing that is performed during playback, and performing custom processing on media data streams using RTP.

Moreover, in the IRIX and Solaris, we are using "rstat" library for realizing of RMA. Using the library, RMA gets status of CPU, load average, etc.

5.1. Media data plane in the prototype system

It is considerable that more than two presentations may be provided concurrently in the same application. For example of the multimedia teleconference, the live presentations organized by participations face images and voices are exchanged between these participations and stored presentations may be also provided as the reference data of the conference concurrently.

Figure 8 shows the functional modules in the Media Data Plane to handle multiple presentations; one is stored multimedia play-out, another is transmitting realtime audio-video.

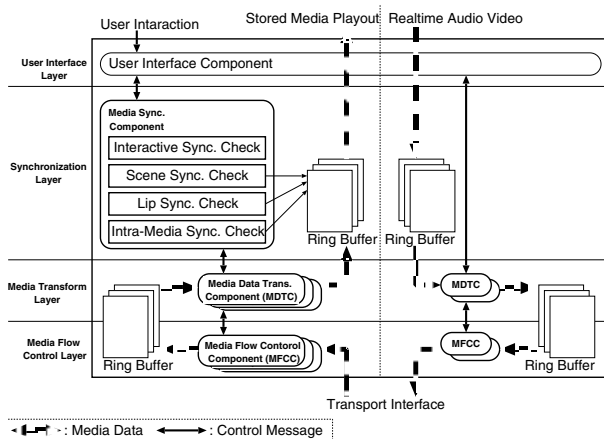


Figure 8. Functional Modules in the Media Data Plane

In this figure, *User Interface Component (UIC)* performs user interface. *Media Synchronization Component (MSC)* performs each synchronization sublayer's functions. *Media Data Transform Component (MDTC)* performs compression/decompression and data format conversion of media, such as JPEG, MPEG1/2 and H.261 for video. *Media Flow Control Component (MFCC)* performs variable packet flow control and packet loss rate control.

MSC has four functions for synchronization sublayers; Interactive Synchronization, Scene Synchronization, Lip Synchronization and Intra-Media Synchronization functions. When each media should be synchronized, each synchronization function check the ring buffer which has been filled with media data by MDTC. Then, checked media data are played.

These components are dynamically organized in the user station from repository. For example, in this figure, user has been requiring stored multimedia and realtime audio-video service. In the case of realtime audio-video, the system not organizes MSC, because realtime audio-video not requires strict synchronization in source side.

6. Conclusion

In this paper, we proposed Flexible Multimedia System to realize multimedia communication services in the various user environments, and showed system organization by agents and components for multimedia teleconferencing service. Moreover, in order to realize suitable QoS guaranteed service, we introduced organization and negotiation protocols.

Currently, we are implementing prototype system. In the near future, we will evaluate and analyze the prototype system and obtain knowledge that shows relation among media QoS, resource and environment parameters.

However, the required knowledge for organization are still under consideration, and it requires a lot of experiments of media data processing, transmission on various environmental conditions. This problem will be cleared through the functional and performance evaluation of the prototype. The analytical results from those experimentation can derive valuable knowledge.

References

- [1] A. Campbell, G. Coulson and D. Hutchison.: *A QUALITY OF SERVICE ARCHITECTURE*, ACM sigcomm Computer Communication Review, Vol.24, Number.2, pp.1-27, Apr 1994.
- [2] H. Schulzrinne, S. Casner, R. Frederick and V. Jacobson : *RTP: A Transport Protocol for Real-Time Applications*, RFC 1889, January 1996.
- [3] K. Hashimoto, Y. Shibata and N. Shiratori : *The System Organization and QoS Functions for Flexible Multimedia System*, Proc. of the 6th International Conference on Distributed Multimedia Systems (DMS'99), pp.209-216, 1999
- [4] N. Shiratori, K. Sugawara, T. Kinoshita and G. Chakraborty : *Flexible Network: Basic Concepts and Architecture*, IEICE Trans. Communication, Vol.E77-B, No.11, pp.1287-1294, 1994.
- [5] J. Sato, K. Hashimoto, M. Katsumoto and Y. Shibata : *Performance Evaluation of Media Synchronization for Multimedia Presentation*, Proc. of the ICPP Workshops on Multimedia Network Systems (MMNS), pp.614-619, 1999.