2004－ＤＰＳ－117　(29)
2004－CSEC－　24　(29)
2004／3／5

Realization of the 3-Dimensional Virtual Communication Environment Using User Information

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Abstract

Recently many communication systems based on three dimensional spaces are proposed. In those systems, in order to support many users in the same space, QoS control function based on the distance among the avatars is mainly applied. For this reason, the computing and network resources in the communication systems are wasted as the number of the users increases. In this paper, we propose a new QOS control to take account of user's interest and status information in addition to the distance among the avatars. Using this method, un-necessary communication and resources can be reduced and more interested communication can be attained with higher priority in the large communication space.

ユーザ情報を用いた３次元仮想コミュニケーション環境の実現

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近年、コンピュータ性能の向上やマルチメディア技術、ネットワーク技術の発展に伴い、３次元上の仮想空間(VEs)を利用した、バーチャル教室や美術館等のシステムが多数提案され、システムの大規模化やビデオの利用などによる高機能化により、サービス品質(QoS)を考慮することが求められている。従来は、仮想空間内のアバター間の向きや距離情報を用いて、ビデオなどのコミュニケーションの範囲を制御する手法が提案されている。しかし利用者が大規模化するにつれ、ユーザにとって興味がなく会話をする必要のない利用者に対しても資源が割り当てられ、必要のないコミュニケーショントラフィックが発生し、ユーザビリティの低下も引き起こしていた。本稿では新しい空間やビデオの制御手法として、従来の距離を用いた制御のほか、ユーザの興味や知識、立場情報などを用いた制御を行い、利用者にとって必要性のないコミュニケーションを削減し、ネットワーク資源の有効な利用とユーザビリティの向上を行うためのシステム環境を提案する。

1. Introduction

Recently, the growth of multimedia technology and network performance has brought 3D computer graphics and broadband networks. Then many systems are proposed such as virtual class or virtual museum which uses 3D computer graphics on the Virtual Environments (VEs). Some systems support collaborations between users. In those systems, it is necessary to support QoS control system to provide efficient communication and large scale environments.

In most of the current VE systems, the information of the position and direction of the avatars or the distances between the avatars are used to control QOS parameter[5][6][10][11].

In the actual art museum, a curator explains a work of art to the spectators. When the spectators are interested in and pay attention to the specific arts, both curator and the spectators will tightly communicate each other. In the conventional VE system, the situational difference between the curator and the spectators was not considered as QoS mechanism. Therefore, as the number of the spectators as users increase and the sharing space by the users expands, the computing and network resources are assigned to all of users even though they do not require to talk to each other. Consequently, unnecessary communication traffic will be generated and the total resource utilization will be decreased.

In this paper, we newly propose a QoS control method which takes a user's interest and situational information on large scale of 3D VE. By using those information, a user can exclude the communication which does not require. Therefore he not only can concentrate to the communication with the person who is commonly

interested in the topic or whom he want to talk, but also he can use a network resource effectively.

2. Related Works

As the conventional systems, Massive[1][2] and FreeWalk[3] treat video communication on distributed virtual environment (DVE). Their QoS control methods for the video are performed by changing the video frame size and rate based on only the relative distance one another between avatars. Moreover, VAE2000[4] uses multiple servers and network bridges to reduce the amount of messages in order to realize large scale of user environment. However, as for these systems, all of the users video communication QoS are the same even if some users are not interested in other users. Therefore, as the number of the users in the virtual environment increases, the users demand for QoS cannot reflected, eventually unnecessary traffic are generated and unnecessary computing resources are wasted.

3. System Configuration

In this paper, we define virtual environment (VE) as a domain where a certain amount of users co-exist, such as a virtual university, companies, buildings and assume that users cooperatively behave each other in the VE through multiple domains as shown in Fig. 1. A user participates as an avatar, views 3D objects arranged in VE, and performs the collaborative activities. And video communication can be performed when the user is more interested in the others among them by using CCD camera.

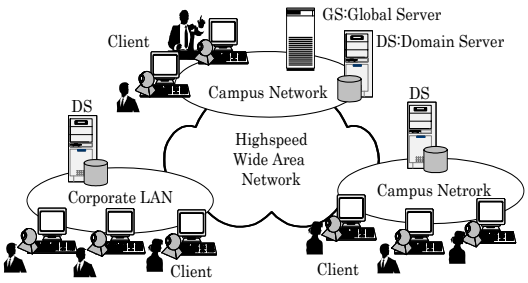


Figure1. System Configuration

In this system, computing and network resources are assigned with the higher priority to more important communication for a user. As a result, user can not only concentrate to the communication, but also can reduce unnecessary resources for video communications, eventually network resource utilization and efficiency of whole VE can be maintained.

In order to realize such effective VE, the following functions as QoS control are introduced as:

- The information retrieving function based on the user's interest information.
- The media selection function based user's interest, a situation, and spatial information in VE.
- The QoS control function using interest, a situation, and spatial information

4. System Architecture

Our suggested system is consisted of two layers on top of the transport layer in OSI model, including an application layer which is furthermore organized by two sub-layers and two planes, including Interface layer and QoS Control Layer and Presentation Plane and Interest Management Plane, respectively. The interest information from a user is input from Interest Management Plane in Interface Layer(Fig.2). Based on this interest information, the QoS Control Layer searches the suitable user to communicate each other. The media selection and decision of QoS parameters also carried out based on user's interest, situation, and position information. The media selection request for audio and video based on those QoS parameters is issued to the lower layer, so called MidField System[7][8], whereas the selected media for audio and video offered to the user is performed through Presentation Plane of Interface Layer.

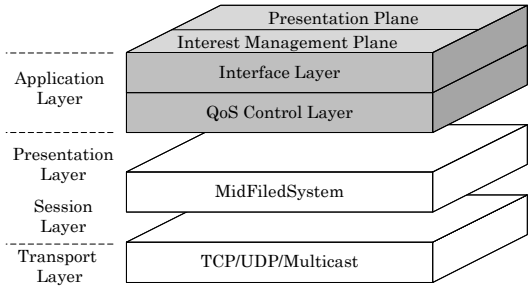


Figure2. System Architecture

4.1 System configuration

Our suggested system is consisted of a Global Server (GS), domain servers (DS) and clients.

GS performs control of DSs, management of thread dimensions, user status, and QoS control policy. DS controls the search service of the user according to interest, and multimedia data transfer in a domain. A client offers user the 3D interface and the video communication function accompanied by QoS control. By using DSs, even when users increase, search of the user and the load of video communication can be distributed.

4.1.1. Global server (GS)

Domain Controller of GS manages the status of all of the links in DS, and the session status of the user who belongs

to DS. Scene Manager manages object information related with the space and QoS control policy.

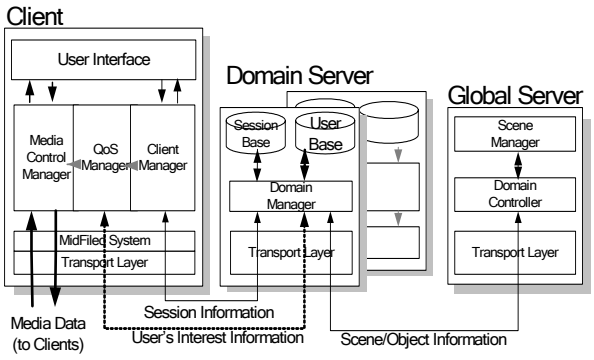


Figure3. System Module Configuration.

4.1.2. Domain server (DS)

A domain server performs inquery and acquisition with a user's interest information, management of the session, and transcoding of media. Domain Manager performs connection management of clients, and management and the inquery service of interest information. A user registers user's background information into DS when he initially takes service at the time of the first use. The registered interest information is accumulated in User Base of DS. Moreover, the user is also notified the number of references and period of stay of an object in space, and DS accumulates the interest information about the object. When other users issue a search request of interest information, DS searches the similarity of interest and notifies a similarity with client ID. And, when a client requires media, Domain Manager assigns the session information containing a multicast address to a client, and records on Session Base. MidField System offers the transcoding function of the media between clients. If the gap of a request of media occurs among users, MidField System translates media, and it can offer the media which he wishes mutually, without giving load to a client.

4.1.3. Client

A client can use video communication in 3-dimensional space. User Interface offers the virtual environment by 3D interface and the display of video to a user. Client Manager collects management of a session with DS, and the avatar information at the time of interaction. Client Manager holds the position information, interest information, and situation information on other clients. And, this receives the interest information from a user and searches the interest information on DS. QoS Manager makes the selection of media and the determination of a QoS parameter based on other client information. Media Control Manager manages the session request to DS, and the media communication request to MidField System.

4.2. MidField System

MidField system is a middleware as presentation and session layers between application and network transport layer and offers intelligent multimedia communication functions; including capturing, transcoding, media synchronization functions for audio and video using RTP based streaming. The media stream generated by MidField System can be distributed to all of the clients by a request by multicasting function.

Moreover, using transcoding function on MidField System, multiple streams with different quality can be generated from a single video sauce and the most suitable video streams individually according to a client's performance request can be offered.

5. Media Selection and QoS determination

In this System, QoS control function is used to consider the user's interest and purpose to use space. In this control, the quality of the media which uses and offers a QoS control policy table based on position information, the user's interest information, and the situation information among users, and media is determined in as show in Fig.4.

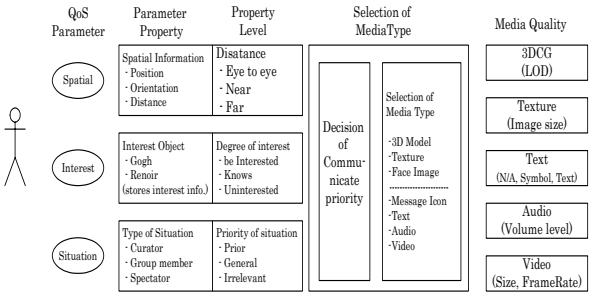


Figure 4. QoS parameter and Media Selection

5.1. Determination of Control Parameter

5.1.1. Spatial information

Position information is determined based on the distance information and the rotate information between the avatars in 3-dimensional space. The position information and the rotate information generated at the time of movement of an avatar are classified into several position levels according to the threshold value defined beforehand, and are used as a parameter of QoS control.

5.1.2. Interest information

When a user chooses his interested object and notifies to the client, the client will issue a search request to the Domain Server. A domain server searches the user who gets interested in the object which the user chose (Fig.5). Moreover, the interested user also searches from the registration information.

And, the user can specify with the present interest user with past interest as a user parameter at the time of search.

By this function, a user can have supported discovery of a user with the same interest and the user conjectured to have many knowledge.

Based on the user's interest information acquired, the degree of interest is classified into several levels, and it uses as a QoS parameters

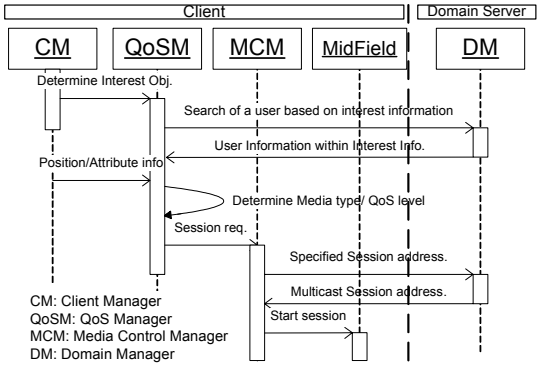


Figure5. QoS Control Flow

5.1.3. Situation

A user can assign user attributes, such as a presenter, a group student, and an audience, by GS at the time of login. The QoS control using a situation uses a user's attribute.

For example, when a user wants to communicate to the other person, he will pay attention to explanation of a work of art, and appreciate a presenter's high-performance video and can raise the degree of satisfaction.

Situation	Interest	Spatial	Type of Media				
			3DCG	IMG	Text	Audio	Video
Prior	Strongly	EtoE	O	Hi	Text	High	High
	Strongly	Near	O	Mid	Sym	Mid	Mid
	Strongly	Far	O	Low			
	Knows	EtoE	O	Hi	Text	High	Mid
	Knows	Near	O	Mid	Sym	Low	Low
	Knows	Far	O				
	UnInterested	EtoE	O	Hi	Sym		
	UnInterested	Near	O	Mid	Sym		
	UnInterested	Far	O				
General	Strongly	EtoE	O	Hi	Text	High	Mid
	Strongly	Near	O	Mid	Sym		
	Strongly	Far	O				
	Knows	EtoE	O	Hi	Sym	Sym	Low
	Knows	Near	O	Mid			
	Knows	Far	O				
	UnInterested	EtoE	O	Mid	Sym		
	UnInterested	Near	O				
	UnInterested	Far	—				
Irrelevant	Strongly	-	O				
	Knows	-	O				
	UnInterested	-	—				

Figure 6. Example of table of QoS policy

5.2 Media selection and QoS determination

The media type and quality level are determined by QoS Manager in a client based on the position information, interest information, and situation information between users. When the user logs in to space, QoS Manager controls by being getting a QoS control table (Fig.6) from GS. Therefore, an administrator can change a QoS control parameter according to the application purpose of space.

6. Prototype System

In order to verify the functionality of our approach, we implement a prototype system in which the various typed video formats are support according to the user's interest information on 3D VR space.

This prototype system consists of DS and clients which connected by 100Mbps Fast Ethernet (Fig.7). Each client obtains a QoS control policy from DS, searches interest information using DS, and performs selection of media, and QoS control. Java RMI is used to realize application layer for interest information session information, and a media control stream in order to guarantee reliability. Media data streams, such as audio and video, are multicasted to distribute multiple users. We implement this using Java (JDK1.4, Java3D) and MidField System.

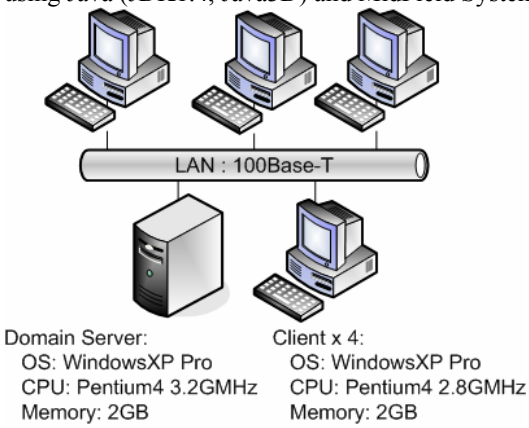


Figure7. Prototype system.

A user can view the impressionistic pictures arranged in 3-dimensional space. The user can move freely and can discuss with other users using a text, or an audio and video depending his interest level. When interested in specific pictures, the user can operate a Interest controller and can reconstruct space by specifying interested pictures and the author (Fig.8).

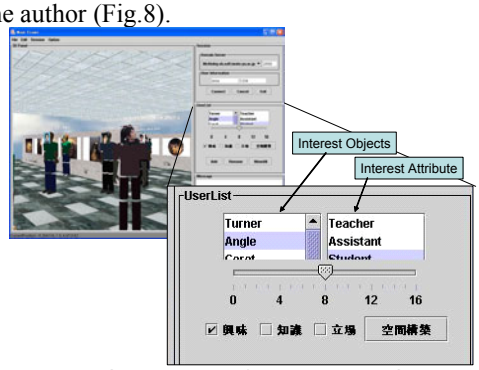


Figure8. Selection of Interested Objects.

Thereby, the user who has neither interest nor knowledge to a specific object is deleted from space(Fig.9). A system controls media to be able to communicate preferentially to the user whom the property of interest resembles, and the user with much knowledge.

Fig. 10 shows change of the media by change of the user's priority. The user is provided with video as a user's priority increases. The user with the highest priority is provided with high-performance video. On the contrary, as a priority becomes low, 3DCG changes from a detailed model to a simple model, and the user with the lowest priority is excluded from space.

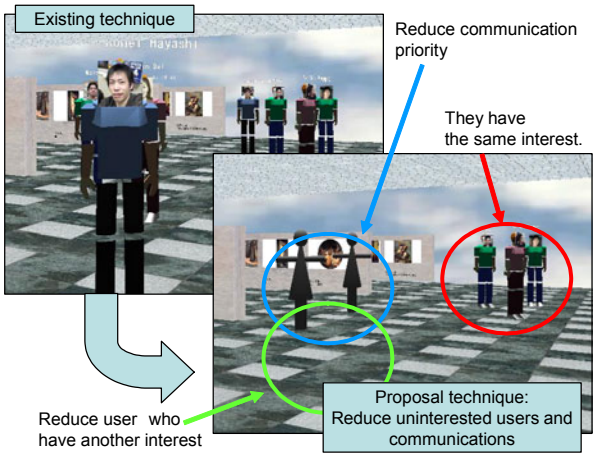


Figure9. Reduce uninterested users.

Figure10. Media selection and QoS determination

7. Evaluation

In the system evaluation, the effect of the system function of 3DCG virtual space and media selection functions ware compared between the suggested method and the conventional method how one user can easily identify the objective partner whose interest is close to him or how the user can easily communicate with this partner using video and audio by controlling the QOS parameters. In this experiment, a virtual art museum was implemented as a shared VR space where 4 participants are separated into 2 groups A and B which are consisted by one visitor and one attendant. as shown in Fig. 11.

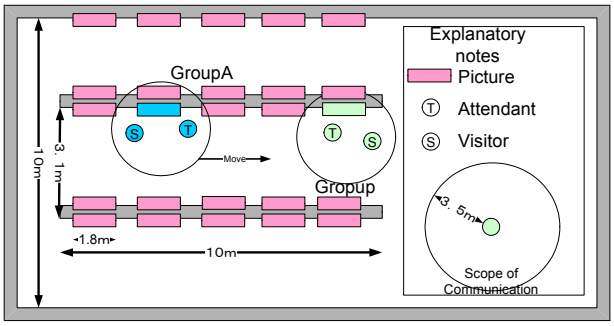
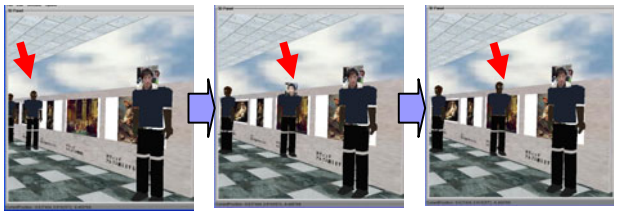


Figure11. Evaluation environment

After the group A and B members discusses among the same groups, the group. A members approach to the group B members. When the distance between both group And B is within 3m, then a new session starts using text, video MPEG-4, 320x240, 30fps) and audio(RAW PCM, 44.1KHz, 16bits) while the previous session among the same group is terminated as shown in Fig. 12. At this time, proper QOS parameters for audio and video are determined and the video session could smoothly starts. As result, The member of the group B concentrate to the communication with the member of the group A. Thus, more efficient communication based on the interest level regarding with the objective art picture could be attained in the prototyped virtual art museum. Fig. 13 shows the consumption bandwidth of the receiving video stream during an evaluation experiment. Although the consumption bandwidth of a video stream was temporarily expanded according as approaching to another group user, the receiving bands are decreasing in number by restriction by an interested video stream.



Scene(1) Scene(2) Scene(3)

Figure.12. Change of the media by priority control

In scene 1, a video session is performed only with a right end user since the distance between groups is away. In scene 2, since the user of another group approached, a new video session is started. However, that session is the obstacle of communication because it is talking about another picture. In scene 3, wasteful video was terminated by permitting a video session only to the user who has interested in same pictures.

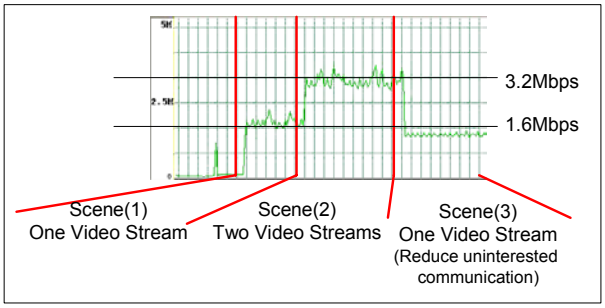


Figure13. Bandwidth of receiving video stream

8. Conclusion

In this paper, we proposed a QoS control method which takes a user's interest and situational information on large scale of 3D VE, and described prototype environment and process composition. We are performing evaluation of function now supposing the largescale virtual museum.

9. References

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