

A Multiuser Communication Environment with High Sense of Presence in the Next Generation Home Network

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Abstract—This paper proposes a highly effective communication environment for the next generation home network (NGHN). The proposed environment can be formed using commercially available peripheral devices. Users can perform real-time interaction with a high sense of presence via the network based on the use of man-size displays. In order to realize this environment, several system requirements are studied. Finally, we show the necessity of high speed infrastructures such as the Fiber To The Home (FTTH) from the viewpoints of presence and real-time interactivity.

I. INTRODUCTION

In recent years, broadband access networks have spread across the world. Broadband access networks allow users to transmit/receive large volumes of multimedia data, including videos, images and sounds, regardless of geographical location. A Gigabit-class or higher network will realize real-time communication since service quality can be kept high during transmission. Moreover, multimedia devices, including signal capturing devices (video cameras and microphones) and display devices (TV monitors, liquid crystal projectors and speakers), have been much improved. The improvement in the size of display or projection screen has been particularly remarkable. The costs of such devices have fallen so rapidly that we will be able to realize communication environments based on these devices in the next generation home network (NGHN)[1].

The goal of this research is to construct a communication environment for NGHN that offers high sense of presence through the use of high quality video, sounds and additional information.

This paper describes the framework of the environment, shows how to create a high sense of presence in NGHN and system requirements.

A number of studies have described networked communication systems that have a high sense of presence[2], [3], [4]. In particular, communication systems with man-size displays were found to be attractive because they can present large-scale images with high spatial resolution to users[3], [5]. We aim to construct a communication environment offering man-size video images by using popular peripheral devices and PC-connected broadband networks.

II. RELATED WORKS

Television conference systems have been developed in several laboratories and companies(for example [6], [7], [8]). However, most of their systems are not suitable for home since the devices are specified for conference. Several studies have examined mixed reality systems over networks[9], [10], [11] and tele-presence systems[4], [5]. However, most such systems assume the use of head mounted displays (HMD), immersive displays, or large size screens of special form. Therefore, they are not suitable for the rooms in most homes. Although HMD is quite small, use of HMD causes physical tiredness of a user.

Video chat systems, which use web cameras and microphones, are often used in regular homes (for example [12], [13]). However, such systems fail to offer a high sense of presence since the video images transmitted from the remote home have insufficient spatial resolution.

Research studies on video-oriented network systems, for example, the live broadcasting of sports have been reported[14]. Also software real-time encoder for high resolution video image has been developed by NTT Electronics[15]. These studies assumed that the service was basically one-way communication. This paper targets interactive communication.

A networked system using mixed reality techniques for home use was proposed by Cheok et al[16]. However, the main target of this system is multimedia communication using motion or touch sense which means that the direction of their work differs from ours.

To summarize we consider that construction of a communication environment specified for NGHN, which combines man-size video images, popular multimedia devices, and many sensors, is a novel and useful challenge.

III. AN OVERVIEW OF THE PROPOSED SYSTEM

To realize communication with a high sense of presence, we introduce image of remote interaction between two rooms. Figure.1 shows the basic structure of the proposed system. Input devices of the proposed system are a video camera, microphones, many sensors, and input devices attached to PC. The output devices are speakers and a liquid crystal projector. Screens for liquid crystal projector have an advantage over

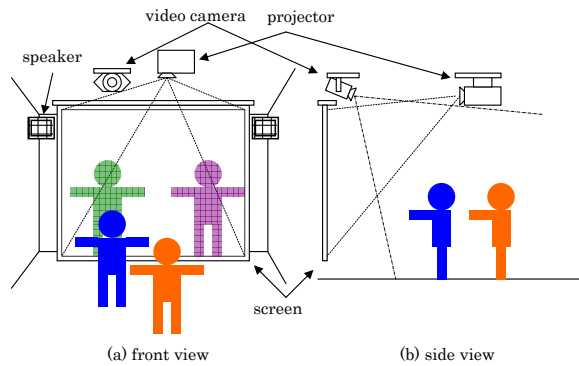


Fig. 1. Structure of the system in the room of a home

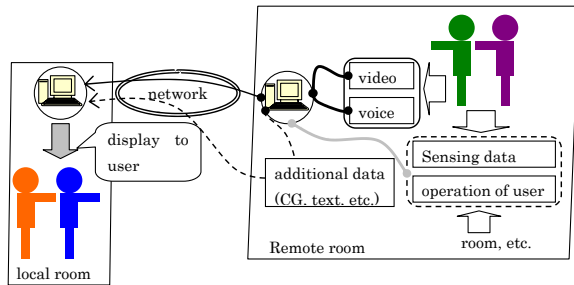


Fig. 2. Data flows between rooms in proposed environments

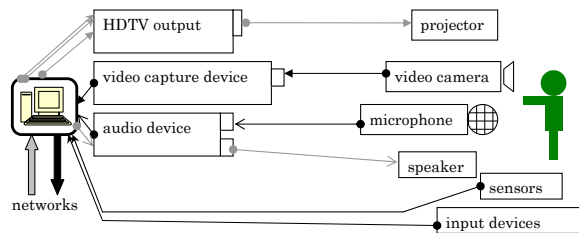


Fig. 3. Structure of devices in proposed environments

LCDs or PDPs, since they can be stored in the ceiling when not in use. Moreover, man-size PDPs are more expensive than liquid crystal projector.

All data including video images, voices, sensing data and user inputs through peripheral devices is periodically transmitted to the remote room via the control PCs which are connected via the public network. Figure 2 shows the data flows in the system between the local room and the remote room. In this figure, solid arrow means that live data in a local room are transmitted. Dashed arrow means that additional data generated from sensing data and operation of a user in a local room are transmitted to display computer graphics or texts in a remote room. Figure 3 shows the structure of devices in the proposed system. Upon receiving the data from the remote control PC, the local control PC displays video images on the screen, play sounds, and overlays text or computer graphics generated from some additional data on the video images to the user immediately while synchronizing the display/presentation timing of each data stream or event.

IV. REQUIREMENTS FOR REAL-TIME COMMUNICATION

We examine here the requirements for establishing real-time communication. For example, we assume communication between family members and remote lectures as collaboration. We also assume real-time networked games using physical motion control inputs as entertainment. In order to realize these types of application smoothly, the system must display such data as video images, sounds, computer graphics, text, etc. received from a remote room in real-time. Thus, propagation of each data should be done immediately. Moreover, information updating of a data should be done in short time period. Packet loss and jitter of transmission delay should be avoided for maintaining the quality of image and real-time interactivity. There are two main issues that affect the sense of presence and real-time interactivity: spatial concerns and timing attributes.

A. Spatial concerns

In order to display an image that has a high sense of presence, the display device must satisfy the following conditions:

- The display area must offer man-size images.
- Sufficient brightness to realize clear images under indoor lighting.
- Sufficient spatial resolution, i.e. even when standing close to the screen, user is unable to discern individual pixels.

The screen in a room must be at least 3 meters wide and 2 meters high to realize adequate presence. Therefore, it is desirable that the video images be High Definition Television (HDTV) class or higher. Also the video camera must match the resolution of the display. When a HDTV class video image is projected on the screen 3 meters width and 2 meters high, each pixel will become less than $2mm \times 2mm$.

B. Temporal attributes

There are two factors that prevent real-time interactivity. One is processing delay caused by media processing. Powerful graphics cards, powerful video capture cards, faster processors, and high-speed interface cards will overcome processing delay.

The other is network latency. Several researchers have found that the video frame rate should be at least 20-40 [fps], in make it impossible to discern the screen update operation[17], [18]. Moreover, data acquired from the many sensors will be transmitted to the remote room periodically for updating additional data.

In the case that mutual interaction is occurred frequently, time lag in transmitting data from remote terminal is serious problem. Permissible limitation in transmitting voice data is less than 400ms [19].

V. TECHNICAL ISSUES

We examine here the technical issues to satisfy the requirements raised in the previous section. Tables I and II show the average bit rates required for transmitting the video image stream and audio, respectively. Data is assumed to be non-compressed to avoid the delay imposed by encoding and decoding. To minimize the total bit rate of transmitting data, use of JPEG image in generating an image of frame, is

TABLE I

AN ESTIMATION OF NETWORK TRAFFIC IN TRANSMITTING VIDEO IMAGE

Average [Mib/s]	Size of image	Frame rate [fps]
1021	1280x1024 (32bit)	30
1901	1920x1024 (32bit)	30
2027	2048x1024 (32bit)	30

TABLE II

AN ESTIMATION OF NETWORK TRAFFIC OF SOUND

Average [Mib/s]	Bit rate [bit]	Sampling rate [kHz]	Channel
0.34	8	44.2	monoral
0.67	16	44.2	monoral
0.67	8	44.2	stereo
1.35	16	44.2	stereo

effective if the delay imposed by encoding and decoding is significantly short. Therefore, it is desirable that the network bandwidth be more than 1 [Giga-bit/s], since large volume data are constantly transmitted to the remote room[20], [21]. This indicates the need to use optical networks in the Internet and the Fiber To The Home (FTTH).

VI. CONCLUSION

In this paper, we proposed a communication framework to realize a high sense of presence. First, the structure of our man-size communication environment for home use was proposed. Next, the requirements placed on the infrastructure to realize this environment were studied from the viewpoints of presence and real-time interactivity. As a result, both media processing speed and network bandwidth were elucidated. The current main obstacles to introduce a proposed system in homes are network bandwidth and the cost of liquid crystal projector with high resolution. We believe these obstacles can be solved in the future by reduction of the cost of projectors and by spreading FTTH in much homes.

Future work includes confirming the applicability of our proposed framework. For example, we plan to implement several applications such as a remote lecture system, a remote observation system for families, and a real-time network game, and to evaluate the performance of these applications. Further details of this future work will be presented at the conference.

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