Hyper Hospital From the Sky

VR interfaced Medical Care System on the Satellite Multi-Media Network

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Abstract

We have been developing the Hyper Hospital, a network based VR mediated medical care system. The Hyper Hospital is composed of two seamlessly integrated environments, that is, the virtual and the real worlds. Of them, its virtual environment expands the conventional medical care system using the virtual reality technology as a principal human interface and a collaboration tool. In the present study, an attempt to extend the Hyper Hospital system to various modalities of communication network is reported. A satellite communication based multi-media network using Internet protocols with the WWW interface is used. Data transmission rate and other performances were measured under various conditions and the satellite network was shown to be suitable to the Hyper Hospital network.

Key Words: Hyper Hospital, Virtual Reality, Satellite Communication, IP over ATM, World Wide Web, Tele-Medicine

I.Introduction

In the present study, we present an attempt to extend the Hyper Hospital system to a satellite communication based multi-media network using Internet protocols with the WWW interface. Innovation of the present system lies in the following two points. Firstly, the satellite based communication network used in the present study is a hybrid system consisting of the satellite channel (down-link) and the ground channel (up-link). Secondly, the whole system looks as if a combination of the WWW servers and browsers so that no difficulties will be there to implement existing Internet based systems. We will discuss several aspects of our past and current development of the whole Hyper Hospital system, its implementation to the satellite based system, and the results of the feasibility study and usability tests of the new system in the current presentation.

A.What is the "Hyper Hospital"

We have been developing the Hyper Hospital, a network based VR mediated medical care system [1-2]. The Hyper Hospital is constructed over the virtual and the real environments. Of them, its virtual environment is used to reform the conventional medical care system to a truly collaborative one for not only medical personnel but also patients. Its key technology is the virtual reality used as a principal human interface and a human-to-human collaboration tool. The latter component of the

Hyper Hospital is the system which interacts with real patients including therapeutic measures. We therefore call the system as the "Hyper" hospital not merely "Virtual" hospital. We have developed various hardware and software for the Hyper Hospital. Fundamental studies on the safety features of the usage of the virtual reality in the medical environment were also conducted to show that virtual reality can be safely used for the medical purpose[3].

B.User-reconfigurable Virtual World

Of particular importance in our development is a virtual environment in which an end-user can dynamically reconfigure the virtual world construction, i.e., without recompilation of the system [4]. This was meant to allow patients with various physical and mental difficulties to experience comfortable medical care in an environment of their own taste. The original user-reconfigurable world was built on our in-house local area network.

C.Hyper Hospital on the WWW

We later extended the Hyper Hospital system to the Internet using World Wide Web interfaces and successfully showed its usefulness in the MMVR:4 in 1996 by a transpacific live demonstration [5]. This is the system which we transplanted to the satellite based multi-media network to be presented.

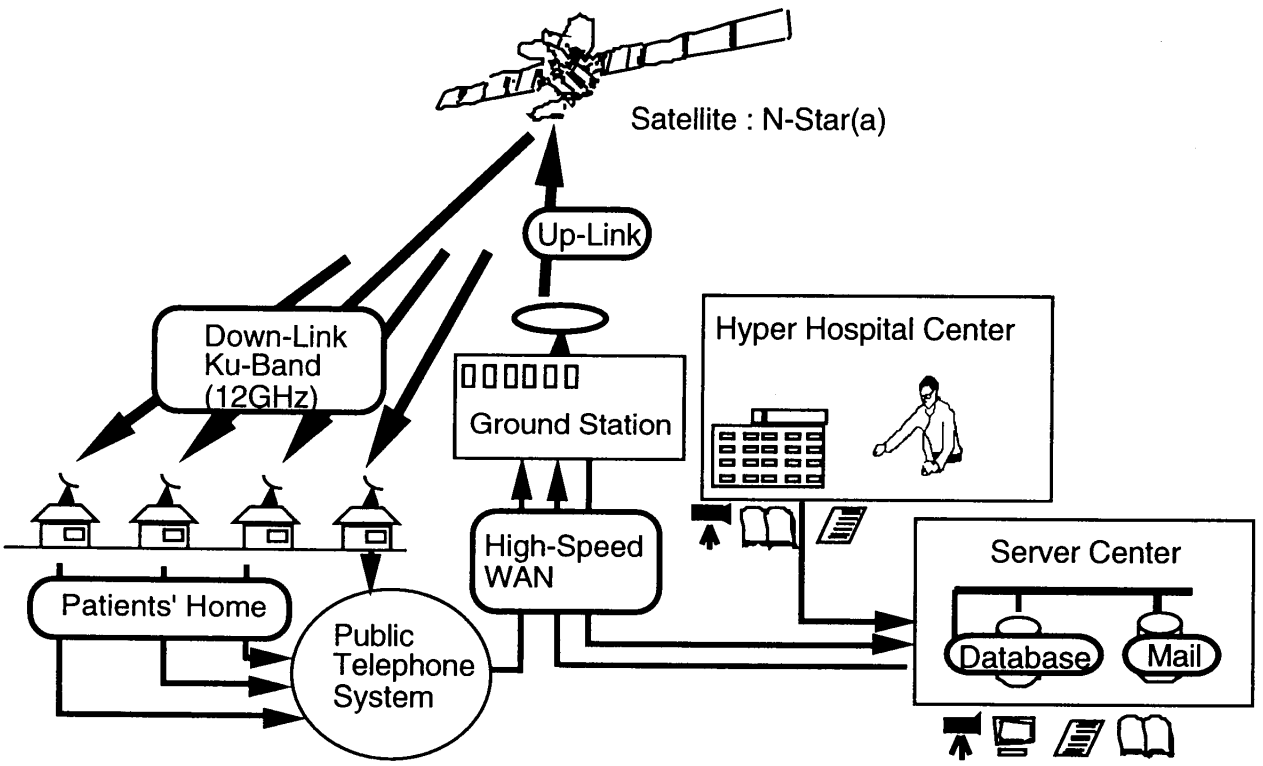

Fig. 1 The Hyper Hospital on the satellite: Scheme of the communication.

II.Method

A.Satellite Communication System

We used a specially designed satellite network provided by NTT (Nippon Telegraph and Telephone Co.) which utilizes the IP protocol to deal with multi-media data (Fig. 1) Each distributed user on the ground is equipped with a receiver set for the satellite communication and a modem based telephone line communication channel. Requests from the users are sent via the ground communication channel and responses from the WWW server return via the satellite communication channel. Each receiver set connected to the users' PC has a unique address and can decipher packets sent to the particular user. Thus two-way communication channel become available using the Internet protocol.

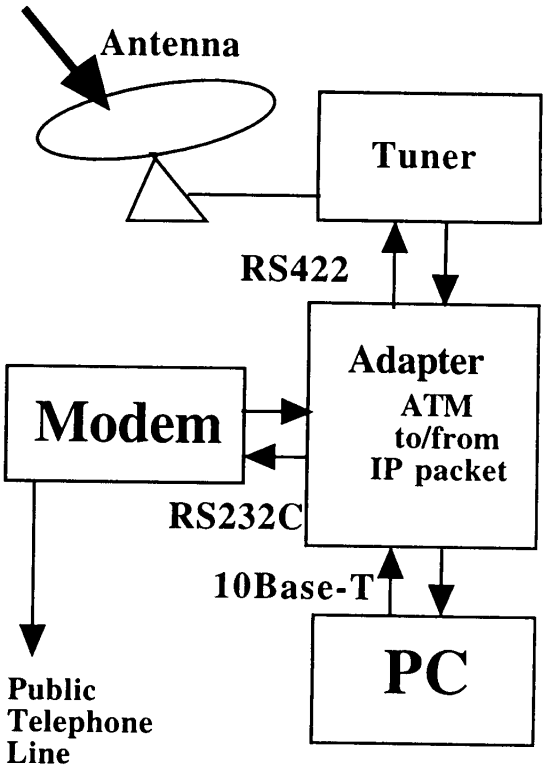

Fig. 2 The Ground System

1.Satellite

Used satellite was the N-Star(a) of NTT. This is a newly launched (August, 1995) satellite with a variety of communication ability for the domestic use. It can simultaneously operate in 4 bands of frequencies, including C(6/4 GHz), Ka(30/20 GHz), S(2.6/2.5 GHz), and Ku(14/12 GHz). Our experiments used Ku band(12 GHz) which allows 30 Mbits/s communication speed by using IP over ATM protocol.

2.Communication Protocol

The satellite up-link operated by the NTT uses ATM(Asynchronous Transfer Mode) technology. The up-link information sent to the NTT ground station is transmitted as ATM cells to the satellite which sends down the cells towards each user receiver. The receiver decodes unique address allotted to each user and transform the ATM cell to the IP packet which is transferred to the WWW browser running on a PC (Fig. 2). The request from the user through the WWW browser is sent to the server computer via ground communication channel like as usual Internet packets.

B.Transplantation of the Hyper Hospital System

Since the used satellite communication system forms a closed network using the TCP/IP protocol, a gateway computer was set up to transfer the Hyper Hospital home pages from our local system to the satellite system. This was also necessary to interactively update the contents of the Hyper Hospital

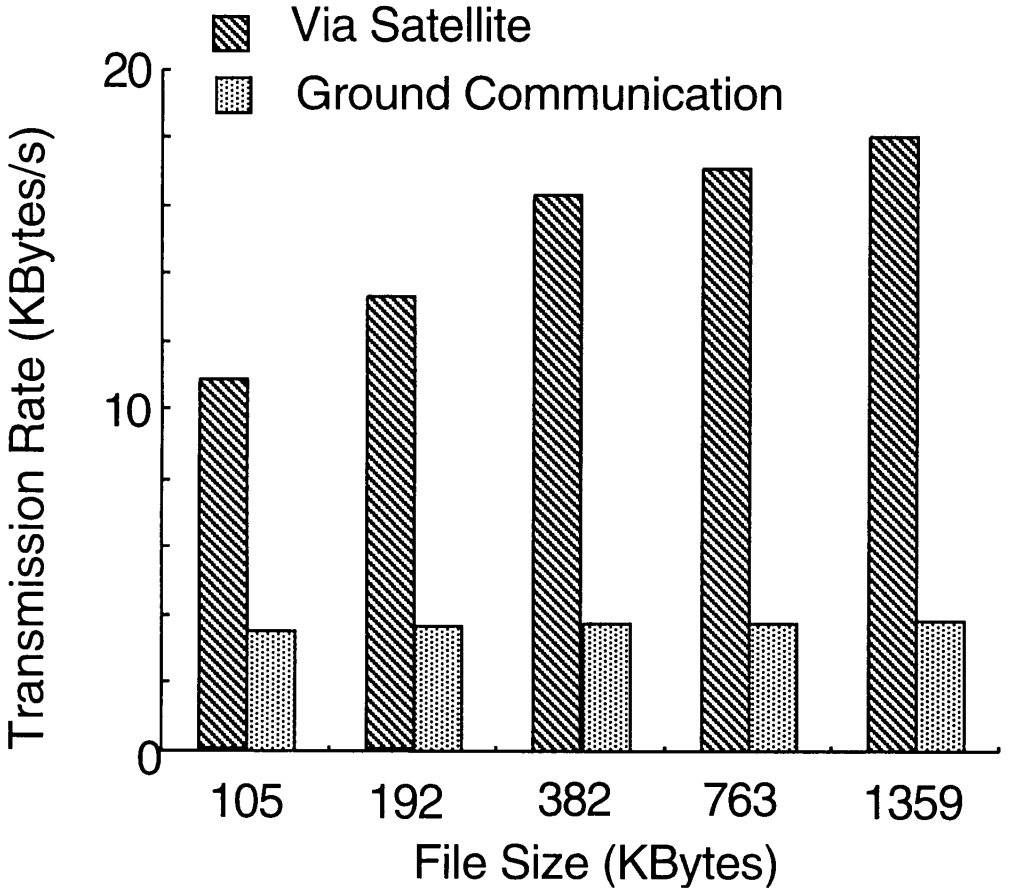

Fig. 3 Comparison of the data transmission rate for the standardized plain text data using the standard ground system between the satellite mediated and the normal telephone line communications. Satellite mediated communication was 3.1-4.8 times faster than the normal telephone line communication.

system during the experiments. Necessary pages from the Hyper Hospital on the WWW system including texts, sounds, graphics, and animations were transferred to the new system through this gateway computer by using the FTP protocol.

C.Experimental Procedure

Ten volunteers and one controller were equipped with identical satellite communication receiver sets. Of them, 9 used PCs with 486DX2(66MHz) CPU, 2 with Pentium(from 75MHz to 120MHz). Operating system was the Windows 95 (TM) and the browser was the Netscape Navigator (TM).

Using mailing capability of the system, the experiment controller synchronized all the computer sets and directed the experiments according to the pre-distributed protocol. The experiment consisted of two different parts; firstly, the response time was measured under various circumstances with different number of simultaneously accessing users. The usability of the system was measured by

using on-line questionnaire method through the mailing capability of the system at the same time of the response time measurements. A control trial was also carried out without using the satellite communication system and the data from the same set of measurements with the same protocol were compared with those obtained using the satellite communication system.

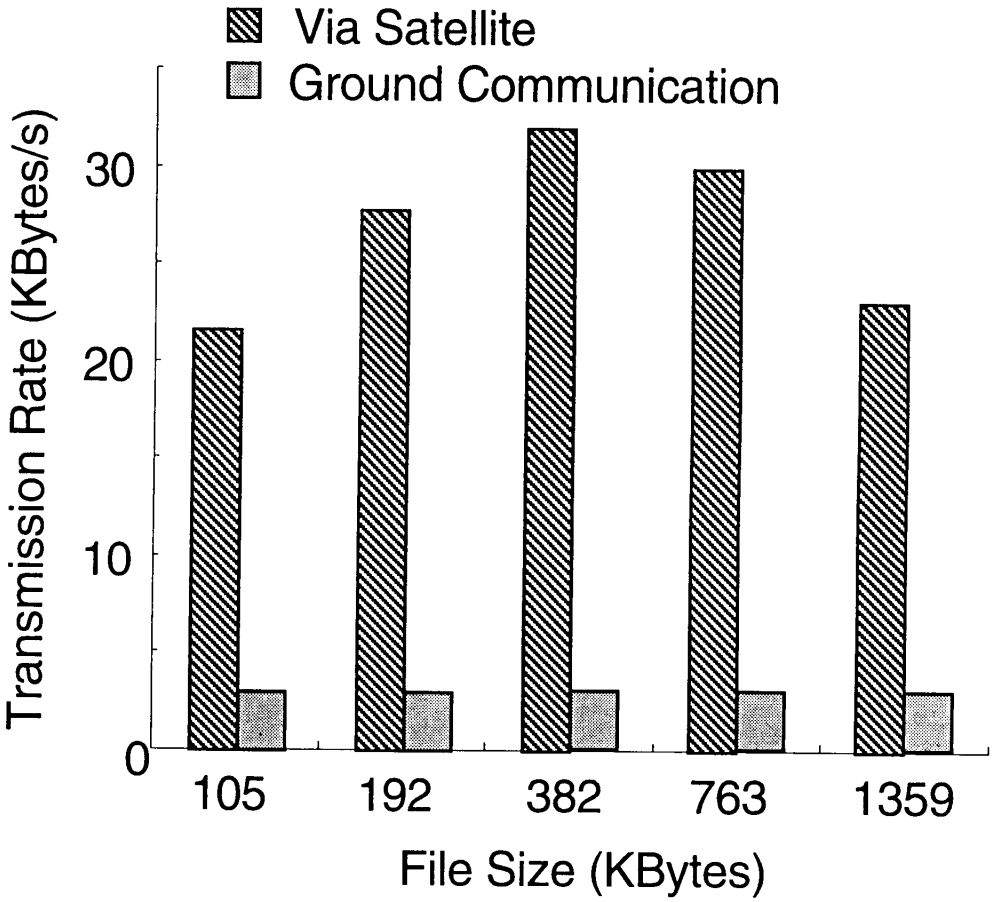

Fig. 4 Comparison of the data transmission rate for the standardized graphical (GIF format) data using the standarad ground system between the satellite mediated and the normal telephone line communications. Satellite mediated communication was 10.3 times faster than the normal telephone line communication at the peak with the size of the graphic data of 400 KBytes.

III.Results

The measured results of the data transmission rate is shown as Kbytes/s, dividing the file size of plain texts, static graphics (in GIF format) and animation (in Quick Time format). In Fig. 3, transmission rates for plain text files measured by using the satellite communication network and by using usual telephone line communication (via 28.8 kbps modem) are compared. Satellite communication network showed 3.1-4.8 times faster all over transmission performances than that of the usual telephone communication line. Of particular interest is that the transmission performance becomes improved for larger file sizes and does not saturate as long as this study concerned. In contrast, the ground telephone line communication showed almost a flat transmission rate of 3.7 kBytes/s, that is

approximately the upper limit of the modem (29 kbps). In other word, date transmission rate is saturated in much smaller file sizes.
Transmission rates for static graphics files in GIF format are compared in the same way in Fig. 4. Characteristic is that the transmission rate is much larger for the graphics files than that for plain text files. The transmission rate becomes the fastest at the file size of approximately 400 KBytes, at which it showed 10.3 times faster response than that of the ground telephone line communication. At this peak performance rate, graphics file transmission was approximately 2 times faster than that of text file of the same size.

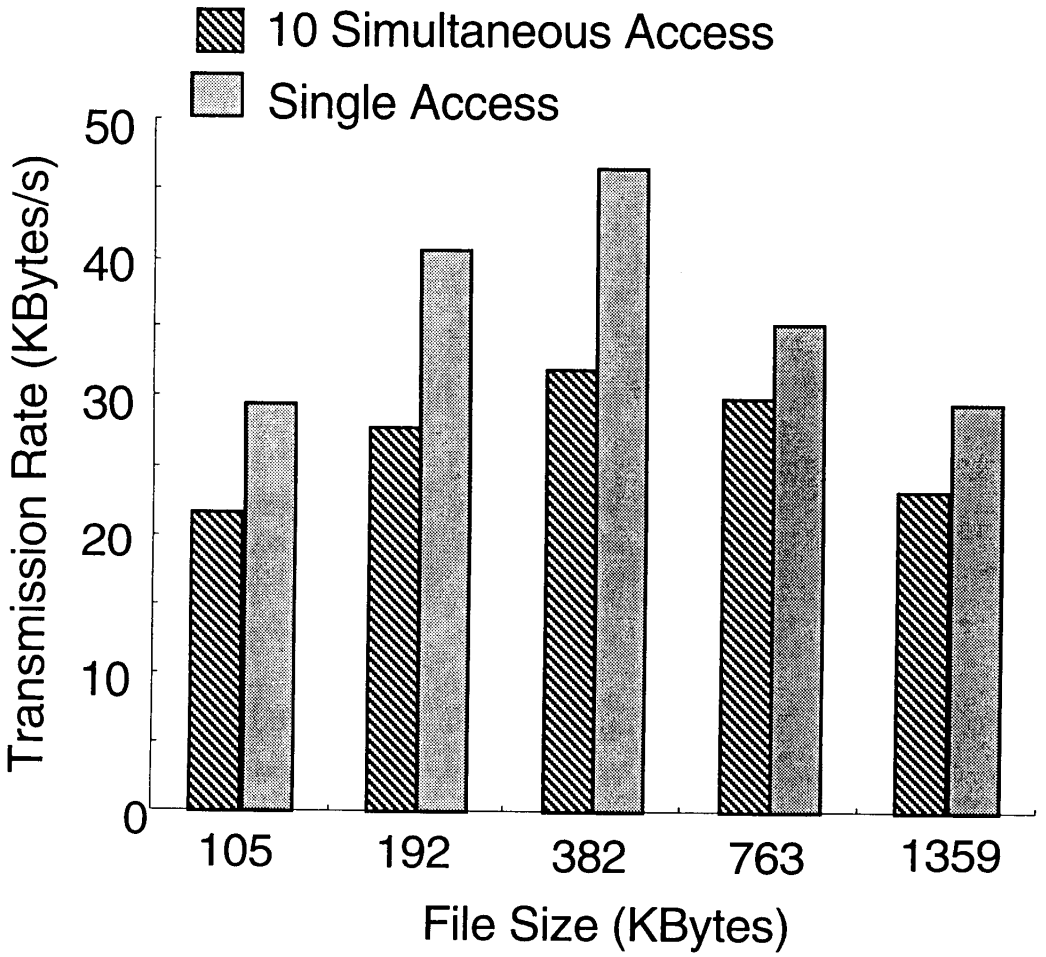

Fig. 5 Effect of number of simultaneous access to the identical data using the standard ground station system with sattellite communication. For the simultanesous access of 10 ground stations to a graphic file, 78% of the maximum transmission speed obtained by an access of one station was observed

In Fig.5, the results regarding the transmission rate due to multiple simultaneous access are shown. In this experiment, 10 ground system accessed at the same time (they were rigorously synchronized) to the identical static graphics files. Since we used two types of slightly different PC machines for this experiment, the results shown are for 6 perfectly identical setups under the condition that 10 ground systems simultaneously accessed the identical graphic file. Maximum reduction of the transmission rate was found at the file size of nearly 400 KBytes. The transmission rate decreased to 78% of that

of single access. In contrast, there was no reduction of the speed in the network using the ground telephone lines.

IV. Concluding Remarks

As a result, the satellite based system showed exceedingly high-speed communication capability particularly for the multi-media data, such as the graphics, sound, and animation presentations. We concluded that the satellite multi-media communication system is suitable to the Hyper Hospital because large amount of multi-media data is necessary to produce virtual reality based communication channel which is the key part of the Hyper Hospital.

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