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ASYMMETRICAL SATELLITE COMMUNICATIONS SYSTEM FOR ASIAN MULTIMEDIA FORUM SATELLITE INTERNET TRIAL

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Abstract.

Asian Multimedia Forum (AMF) was established in June 1997 by 19 organizations to promote the collaborative development of multimedia business in the Asia-Pacific region. In March 1998, we started offering the AMF satellite Internet trial, using an asymmetrical satellite communications system that included a newly developed piece of equipment called the ATM satellite adapter. This paper describes the system configurations, examples of multimedia services, and the system performance evaluation results.

I. INTRODUCTION

The rapid growth of the Internet techniques has resulted in a corresponding growth in multimedia information distribution services around the world. This is also seen in both developed and developing Asian countries. Multinational corporations that require broadband and cost-efficient networks over the Internet between the head office and branches are driving the development of multimedia information distribution services in particular. Also adding to this demand is the rising number of educational exchanges between universities. High-speed circuits that allow access to multimedia information such as audio, photographs, and video signals are required, but laying the optical fibers that form the backbone to these circuits between Asia and the West quickly and at a reasonable price is proving to be a large obstacle.

Against this, Asian Multimedia Forum (AMF) [1] was established in June 1997 by 19 organizations to promote the collaborative development of multimedia applications and services in the Asia-Pacific region.

NTT has developed an asymmetrical multimedia network [2], combining satellite and terrestrial circuits. The forward signals (from servers to customers) in this system are transmitted through the satellite circuits, the transmission rate is approximately 30 M bit/s in each transponder, and the return signals (from customers to servers) are transmitted via the low-speed terrestrial circuits. This system allows interactive communications between many customer's PCs and some servers, and is already providing services in the Japanese market. The AMF Satellite Internet Trial applied this system to the international satellite communication infrastructure and has used it as a platform for developing multimedia applications and services[3]. Although the satellite receiving station interface of this system was 10Base-T, in order to perform service experiments with ATM applications, we have newly developed equipment that has an ATM interface.

This paper describes the system configurations, examples of multimedia services, and the system performance evaluation results.

II. SYSTEM CONFIGURATION

Figure 1 shows the configuration of the AMF satellite communications system. The system allows service providers to quickly implement networks using a high-speed forward link from Japan to Asia, and allows interactive communications between many PCs and some servers. It is comprised of four parts: information centers (ICs), a network control center (NCC), a transmitting earth station (TES), and user stations. At the ICs, servers providing information are established by the AMF users themselves. The NCC assigns network resources to each server, and transfers information using ATM cells to the TES. The NCC also has the function of asymmetrical routing; it sends traffic to servers from user stations and returns traffic to the TES from servers. The TES consists of a 4.5-m-diameter antenna, a 600-W high-power converter, a digital modulator, and ATM Satellite Adapter. The up-link frequency of this system is the Ku-band, which is the same as that for the trials in Japan. The down-link frequency of this system is the C-band because of the larger Ku-band rain attenuation in tropical areas like Southeast Asia compared to that in Japan. The user station consists of a C-band receiving antenna, a tuner that demodulates received signals, and an SRA (Satellite circuit Receiving Adapter) that picks out ATM cells and IP packets.

III. ATM SATELLITE ADAPTER

The current operational SRAs, which are called IP SRAs, only have a PC interface such as 10Base-T, and cannot be connected to other types of terminal equipment like video decoders, digital TVs, and digital VCRs. Therefore, for the service experiments with ATM applications, we have developed a new SRA (the ATM Satellite Adapter (ATM SA)) which has an ATM interface. It can be connected with most types of ATM network equipment and existing tuners and digital modulators. It also complies with two major transmission frames; RFC1483 and ISO/IEC13818. Here RFC1483 is the transmission frame for terrestrial ATM circuits, and ISO/IEC13818 is used in DVB (Digital Video Broadcasting).

Figure 2 shows the transmission frame of RFC1483 and ISO/IEC13818 and Figure 3 shows the protocol configuration. In the AMF satellite communications system, we adopted the RFC1483 (ATM transport stream) frame structure [4,5]. Its frame length is 188 bytes, which means that it is made up 1 synchronous byte and 187 data bytes.

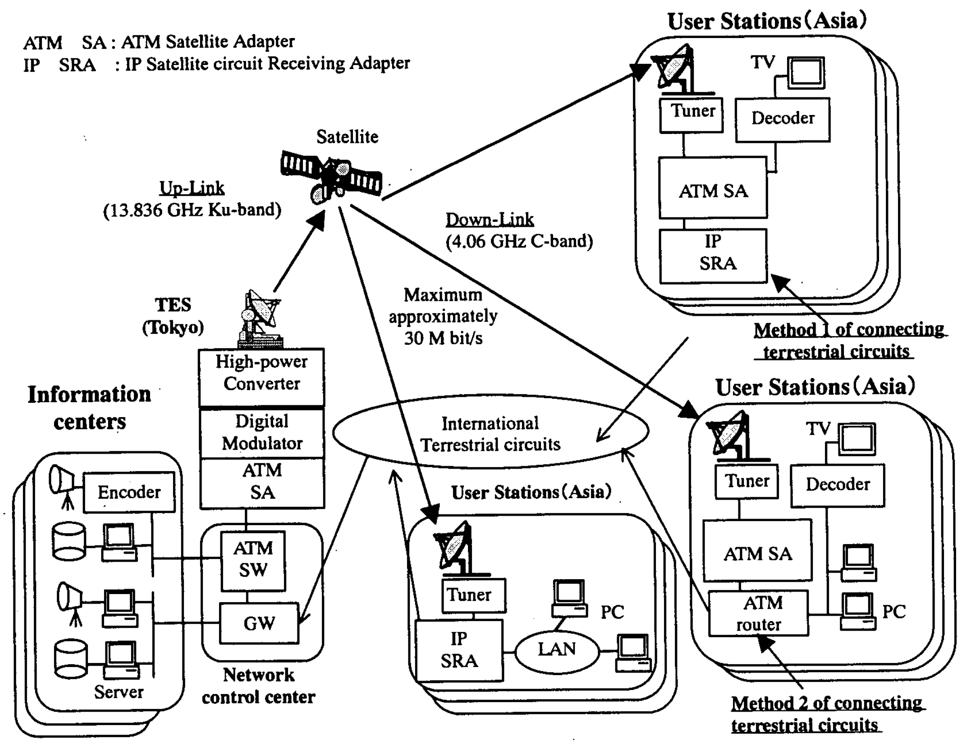


Figure 1. Configuration of AMF Satellite Communications System.

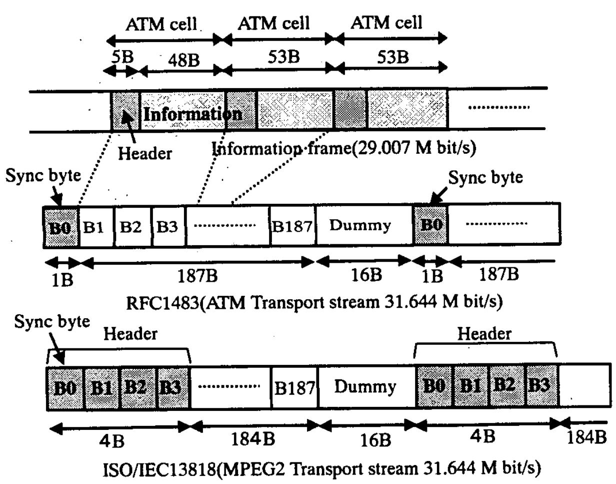
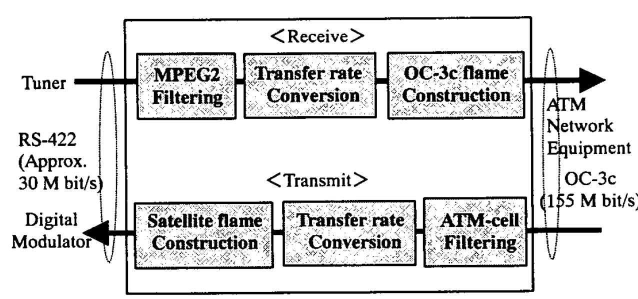


Figure 2. Frame Structure.

Table 1. Specifications of ATM Satellite Adapter.

Item	Description
Input Interface	D-sub 25-pin connector RS-422 8-bit parallel interface
Output Interface	SC-type connector Multi-mode optical fiber OC-3c (155 M bit/s)
Operating Voltage	AC 90 ~ 110 V (50/60 Hz)
Dimensions	99 mm(H) × 480 mm(W) × 250 mm(D)

Figure 4. Block Diagram of ATM Satellite Adapter.



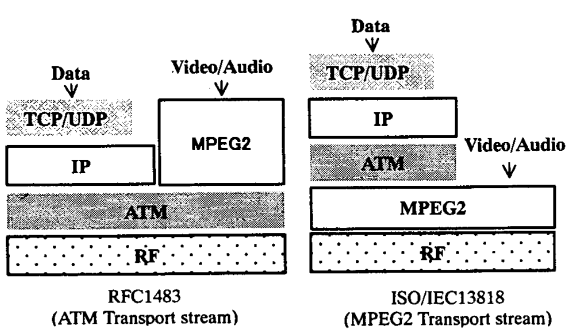


Figure 3. Protocol Configuration.

Table 1 shows the specifications of the ATM SA and Figure 4 shows its block diagram. The ATM SA is able to deliver information to equipment other than PCs. This adapter can also implement the following services at ATM end-end points: delivery of a real-time MPEG2 image service and a high-capacity delivery service.

In addition, communication equipment is not always connected with LANs. For example, video conference equipment is sometimes directly connected with external communication networks. Routers with an ATM interface will most likely be very expensive. Even in this case, the combined use of the ATM SA and the IP SRA, instead of an expensive ATM router, can offer an economical solution because the ATM SA can handle the forward link and the return link simultaneously.

IV. SATELLITE INTERNET TRIAL

This trial focuses on verifying technical aspects of the multimedia infrastructure for international telecommunications and specifying the performances to be offered. Therefore, we constructed the AMF satellite communications system that uses the JCSAT-3 satellite produced by JSAT Corporation, and put it into operation in March 1998. We have already constructed eight user stations on this system and conducted a number of experiments. In this trial, we are conducting experiments on the following services [6].

(1) Satellite information delivery services
(2) Satellite Internet services
(3) Satellite Intranet services
(4) Evaluation of the performance of the AMF satellite communications system

By using applications provided by participating members, we can experiment with item (1) through item (3) to develop multimedia applications and services.

The performance of satellite links is affected by rain attenuation(Ku band link) and the large propagation delay of the links. We therefore evaluated the quality and the characteristics of the satellite links in an effort to optimize the parameters for the satellite link design by testing the performance of the AMF satellite communications system.

We established a user station at NTT Yokosuka Research and Development Center, and used a terrestrial ATM circuit between the servers at Yokosuka and the TES at Tokyo.

We measured the following characteristics.

(a) C/N-BER(Bit Error Ration)
(b) BER-cell loss/error rate
(c) TCP/IP throughput
(d) Throughput using Netwarp[7]

To evaluate the quality of the satellite link, we looked at item (a) and (b) between the TES and the user station. To evaluate the throughput of satellite links where a long delay exists, we looked at item (c) and (d) between a server and a client PC.

V. RESULTS

In our work on satellite information delivery services, we are evaluating the efficiency of IP and ATM applications. In IP applications, VOD (Video On Demand) and the delivery of real-time images are conducted using with MPEG1 over IP. Experiments of the delivery of early news as the pushing services [8] and the delivery of large size files using Megacast [9] are conducted using RMTP (Reliable Multicast Transport Protocol)[10], which was developed by NTT and is based on UDP. For the ATM application trials, we have developed new equipment that can apply an ATM interface to end-end points. With this adapter, we have delivered MPEG2 video images and high-throughput video files by using Netwarp, a system developed by NTT.

In the experiments on the satellite Internet services, we are running Internet access trials in the following way. User stations in Asia are connected to proxy servers in Japan via terrestrial circuits and the servers deliver the required information over the Internet to the user station via the high-speed satellite link.

The experiments on the satellite Intranet services involve file transfer trials between head offices of companies in Japan and their branches in Asia. Those IP applications in the service delivering remote lectures with real-time images have accelerated the educational exchanges between Asian and Japanese universities. The video image transfer services obtained that no block noise of video transmission has been observed up to 360 consecutive days.

Figure 5 shows an example of the C/N-BER characteristics. The BER is less than 5.0×10^{-9} at C/N=6 dB. This system therefore has the performance required of a satellite link (a bit error ratio of less than 2.0×10^{-8} at C/N=6 dB). It should be noted that bit errors hardly occur under clear-sky condition of which performance is much better than the above performance.

Figure 6 shows an example of the BER-cell loss rate and the BER-cell error rate characteristics. It was confirmed that cell losses in the satellite links occur in burst at an average of 40~50 bit/sec[11]. The C/N-BER characteristics are generally used as the indicator of quality in a satellite link, and the cell error rate characteristics are generally used as the indicator of quality in an ATM link. From this experiment, we clarified the relationship between the BER and the cell loss/error ratio of the satellite link. We confirmed that it can achieve to design the satellite link (the diameter of the receiving antenna, the unavailable ratio, etc) taking into consideration our findings on the ATM link quality.

As the results of item (c), we have obtained the IP packets transmission performances over ATM cells. The TCP/IP throughput is about 1.3 M bit/s and the FTP is about 800 k bit/s.

Figure 7 shows an example of the throughput characteristic using Netwarp [12]. We used the region size as the parameter of the transmitting block unit, which corresponds to the window size in TCP/IP. At each transmission rate the throughput improved as the region size became bigger. Furthermore, by adjusting the region size to the optimum size, Netwarp achieved a throughput efficiency of more than 85%. These results indicate that Netwarp can more effectively use satellite links that have a longer propagation delay than terrestrial circuits.

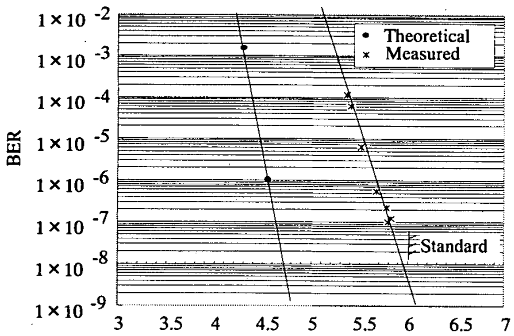


Figure 5. C/N-BER Characteristics.

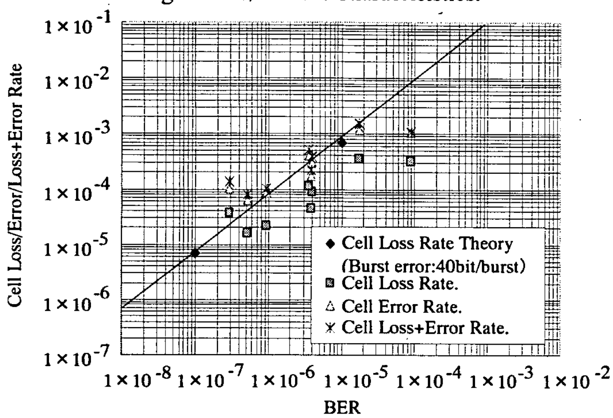


Figure 6. BER-cell Loss/cell Error Characteristics.

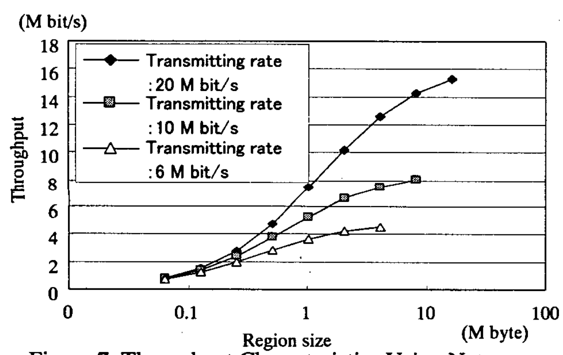


Figure 7. Throughput Characteristics Using Netwarp.

VI. CONCLUSION

We have described the configuration of the AMF satellite communications system. This system allows service providers to quickly implement networks over high-speed forward links. We have also described the ATM satellite adapter, that has an OC-3c ATM interface. This adapter can multiplex both IP packets for PCs or LAN and MPEG2 video packets on the same satellite link and it can deliver information to users and provide ATM end-end services such as MPEG2 transport stream packets over ATM video transfer.

We confirmed that the system has a satellite link BER of less than 2×10^{-8} at C/N=6 dB, thus satisfying performance requirements. The relationship between the BER and the cell loss/error ratio of the satellite link was also explained.

We have obtained the IP packets transmission performances over ATM cells. The TCP/IP throughput is about 1.3 M bit/s and the FTP is about 800 k bit/s. Furthermore, it was confirmed that Netwarp, which has been developed by NTT for high-speed transmission services, has a throughput efficiency of more than 85%. These throughput rates depend on the performance of the user terminal.

This project will be continued. We plan to conduct experiments on QoS (Quality of Service) control and transmission rate control to offer more advanced services and achieve more efficient use of satellite links.

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