社団法人 電子情報通信学会
THE INSTITUTE OF ELECTRONICS,
INFORMATION AND COMMUNICATION ENGINEERS

信学技報
IEICE Technical Report

The Combined Internet and Satellite Communications Networks

- IP based satellite networks can bring a fully multicasting Internet -

Osamu Ichiyoshi
Human Network for Better 21 Century, 230-7 Kamikuzawa, Sagamihara city, 229-1136 Japan
eMail; osamu-ichiyoshi@muf.biglobe.ne.jp

Abstract

The general trend in recent satellite communications is IP based network structure for varieties of different application areas. The IP based structure is going to be the dominant trend in terrestrial communication networks, too. The all-IP networks integrating broadcasting and communication are called Next Generation Networks (NGN). Thus the satellite communication networks will form a part of the NGN.

The application areas in which the satellite communications can play key roles are broadcasting, multicasting and teleconferences. The broadcasting and multicasting by satellite communications are quite easy because of its one dimensional structure. On the other hand broadcasting is inhibited and multicasting is difficult in the Internet because of its two dimensional structure which can form numerous loops. Tele-conferences of a large scale with a large number of participants existing over wide geographical areas are very difficult as real time multicasting for speakers taking turns almost randomly can be inefficient and cause delays of various values. Those group communications are not quite fit for the Internet which is essentially a point to point uni-casting network.

All those difficulties can be solved by including the satellite communication networks, which are essentially Local Area Networks (LAN) in its structure. Direct satellite broadcasting, multicasting and teleconferences can be easily made by the Satellite LAN. The Satellite LAN can be further extended by routers into the Local Internet so the features of the satellite communications can be offered to the users without satellite communication facilities. Thus the proposed combined Internet and satellite communications networks can bring about the Internet capable of broadcasting, multicasting and teleconferences of very large scales which is more than a mere integration of communication and broadcasting.

Keyword Internet, Satellite LAN, Multicast, Broadcast, Simulcast, IP, TCP/IP, UDP/IP, Digital islands, VSAT, MSAT, DSB

1. Introduction

The growth of satellite communications has been slow for the past 10 years as the growth of the broadband Internet and mobile communications on the ground have been so rapid and extensive. Those immense extensions of the terrestrial systems have brought the intensive information society in every aspect of our lives. The development has made the “digital divide” ever deeper for those residents in such remote areas as isolated islands and mountainous regions. It is quite difficult to provide the broadband Internet to those areas by terrestrial means. Those areas can be most easily covered by satellite communications networks.

Other new areas of satellite communications are the Internet broadcasting, multicasting and teleconferences. Those applications are quite difficult for the Internet to provide for a great many participants distributed over wide geographical areas. Such applications can be easily realized if the satellite communications networks are included in the Internet.

2. A review of Development of the Internet and the Satellite Communications

2.1 A historical review

In Japan the Internet began a remarkable growth around 1995. Initially the communication links were dial-up telephone access. The major problems were mismatching of the bursty packet switched Internet signals and the circuit switched telephony networks and also the high transmission cost of the telephony lines. Great efforts were made to increase the data rates from the initial 2400bps to 56kbps by ITU-V series modems development based on adaptive equalizer technologies but could not meet the ever increasing demands for more bandwidth.

The satellite communications were widely used to meet the demands for the bandwidth in the 1980’s. Very Small Aperture Terminals (VSAT) with the antenna diameters around 1.2m were used to avoid the congestion of the terrestrial networks and also for greater bandwidths. The wide area coverage, broadcasting nature and the greater bandwidth of the satellite communications were widely applied for business communications. Packet distributions technologies via satellites in pure ALOHA, Slotted ALOHA and TDMA channels were established [1]. The satellite internet systems were also provided for individual users built on Direct Satellite Broadcasting (DSB) networks based on IP/DVB and uni-directional routing protocols [2].

Around the turn of the century, began accelerated growth of ADSL, FTTH and digital mobile communication networks on the ground. The switching networks also evolved from the circuit switched to IP based packet switched networks. The broad band, packet switched and always-ON nature of those networks have greatly improved and broadened the applications of the Internet. The recent applications of the Internet have spread to streaming, multicasting and teleconferences.

2.2 Recent development of satellite communications

In addition to Digital Satellite Broadcasting (DSB) and GPS which have already established as a social infrastructure, such mobile satellite communications networks as Inmarsat, Thuraya, ACeS and others have grown to cover the world many times. Those networks

have adopted multiple spot-beams that have enabled up to about 500kbps data communication with portable user terminals (UT).

Another trend is growth of such new VSAT systems as IPSTAR, Wildblue, BBSAT, etc. As the terrestrial networks have quite grown the bandwidth, coverage and applications areas, the so-called digital divide of the people living in remote islands or mountain areas has become ever more serious. The new VSAT systems can provide the universal broadband services to the residents in those remote areas for very competitive cost. IPSTAR (84 spot beams, Ka/Ku bands, Asia Pacific regions) and Wildblue (66 spot beams, Ka bands, North America) have achieved the low cost by multi-beams structure of the satellites. So does BBSAT by reuse of the existing Ka bands satellites.

What is common to those recent satellite communications systems is the IP based network structure. The common structure is quite effective to integrate those different satellite communications networks and the terrestrial networks into a combined communication network. Fig.1 shows the networks integration schematically.

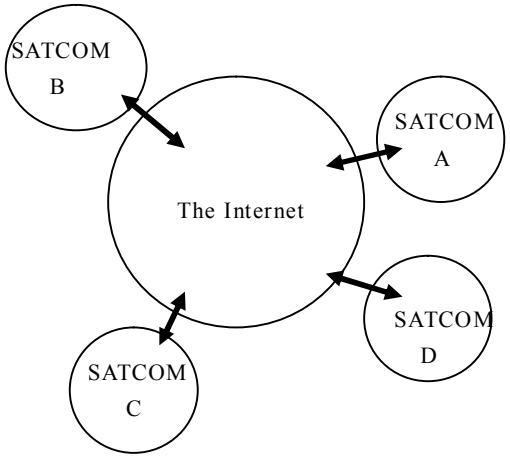

Fig.1
The Combined Internet and Satellite Communications

3. A review of Multicasting technology

The concept of multicasting grew from very early stages of the Internet development [3]. However, its development has been slow because of technological difficulties. Multicasting is a group communication overlaid on the Internet which is essentially a point to point communication or unicasting network. The different nature of the communications methods makes it difficult to integrate broadcasting and communications.

3.1 Multicasting protocols

Multicasting has two aspects. One is forming the multicast group and the other is delivering the multicast packets to the multicast group members in most effective ways. The group forming is done by IGMP functions between the end hosts and the routers connected to the LAN (Local Area Network). Then the task of the multicast routers is to form the multicast networks that can carry the multicast packets in most effective manners.

3.2 Technical difficulties in multicasting through the Internet

Forming an effective multicast network in the Internet poses the following difficulties [3]. The class D address for a multicast group has no relation with the structure of the networks where its group members exist. Thus the sequential localization procedures of the networks in terms of AS (autonomous systems) and geographical areas by analysis of the corresponding IP addresses can not be applied to multicast routing.

As the multicast address conveys no network information hence the multicast routers must form routing trees directly among themselves in the network of non-multicast routers, which are generally greater in numbers. Those non-multicast routers need to be tunneled through to form the spanning tree for the multicasting. Fig.2 shows the concept of a spanning tree for multicasting. The bold-face circles show the local networks served by multicast routers which receive the multicast packet from upstream (closer to the sending server), make copies to deliver the contents to the group member existing in their local networks and also transfer other copies to the next multicast router in the spanning tree.

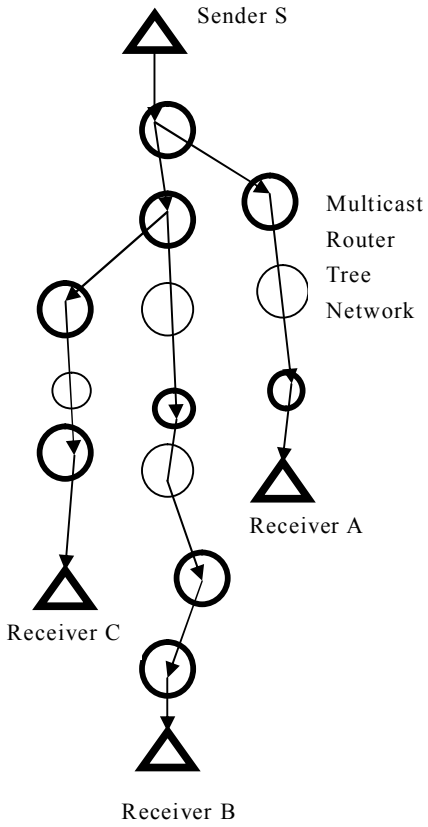

Fig.2 Spanning Tree for Multicast

3.3 Application Layer Multicasting

The above difficulty is quite difficult to solve in the network layer. On the other hand dedicated multicasting networks can be constructed in the application layers [4]. One such method is CDN, or Contents Delivery Network. The CDN constructs many cache servers on the network to minimize the distances between the servers and end users. Another method is Multicast Overlay Network (MON). The MON also constructs many servers on the network to distribute among themselves and deliver to the end users the requested multicast contents.

3.4 Teleconferences

In teleconferences the location of the speakers change frequently among the participants. Forming multicast spanning trees for each speaker in real time is extremely difficult if not impossible. A possible method will be to reuse the spanning tree for the main speaker (lecturer, presenter or chair person) and making the signals flow in both directions. However, the spanning tree is optimized for a specific sender-receivers configuration, hence there can be long branches among some participants causing large delays for some receivers. For example the spanning tree in Fig.2 is optimized for participant S as a sender. When participant A speaks the paths for participants B and C can be very long despite of their geographically close locations.

Thus multicasting and teleconferences in the internet become all the more difficult as the more members participate into the groups from wide geographical areas.

4. Integration of satellite communications into the Internet

The direct satellite broadcasting (DSB) is a sort of multicasting. All the satellite receivers are directly connected with the transmitters in the satellite earth stations via satellites.

4.1. Structures of satellite communications networks

Generally there are STAR and MESH networks. In the star network all the communications via satellite is made between the user terminals (UT) and the gateway station (GW). In a mesh network all the user terminals (UT) can directly communicate among themselves. The connection with external networks is provided by the GW. Note those satellite communication networks structures are topologically equivalent to one dimensional space, or LAN (Local Area Network). For this reason the author calls the IP based satellite communications network Satellite LAN (SLAN).

4.2. Structure of the Internet

The Internet is a WAN (Wide Area Network) which is a network of sub-networks. Each sub-network is connected to the Internet through a router. Each router represents a sub-network such as LAN or WAN. The WAN structure of the Internet is two-dimensional. The two-dimensional networks contain numerous loops therefore broadcasting in the Internet is inhibited. There can be a great many paths that connect any two points (routers) in the Internet. The routers exchange link state information between adjacent routers to grasp the network configuration from which establish the shortest paths for other routers and generate the routing tables. The multicast routers generate spanning trees among the relevant multicast routers to transfer the multicast contents. For teleconferences the related routers need to generate bi-directional routing configurations.

4.3. Structures of the Internet including satellite communications networks

Fig.3 shows how the satellite communication can skip the long series of multicasting trees branches and drastically shorten the number of hops from the sender to the receivers. The receiver can receive the signals from the sender through the satellite links directly as Receiver A, or can receive the signals through the local Internet extended from the satellite network as Receiver B and C in Fig.3.

Thus the multicast network can be greatly simplified. Furthermore, using bidirectional satellite communications networks, the teleconferences networks can be configured easily as shown in Fig.4.

Fig.4 shows how the two-dimensional complexity of the Internet can be simplified by including the one-dimensional Satellite LAN.

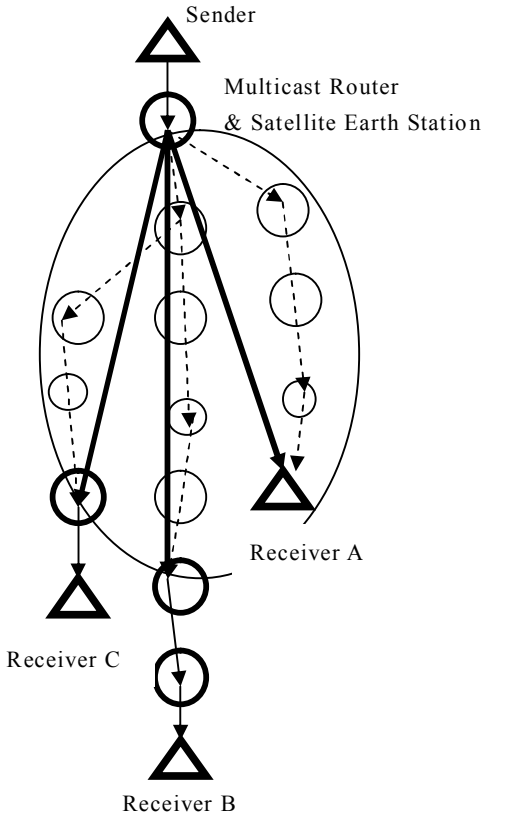

Fig.3 Skipping Multicast Spanning Tree by Satellite Network

4.4 Provision of the services to users without satellite communication facility

The figure also shows that the extended network beyond the satellite communication networks can provide the users without satellite communication facilities with the benefit of the satellite communications. The satellite

communication VSAT can function as a multicast router which connects the end users through wired or wireless LAN or can further extend the network by connection into the local Internet through the routers. The VSAT can also provide an entrance links connected with such base stations (BS) as 3G mobile communication networks.

Those network extensions can offer the satellite LAN features for the end users without any satellite communication capabilities together with normal Internet services.

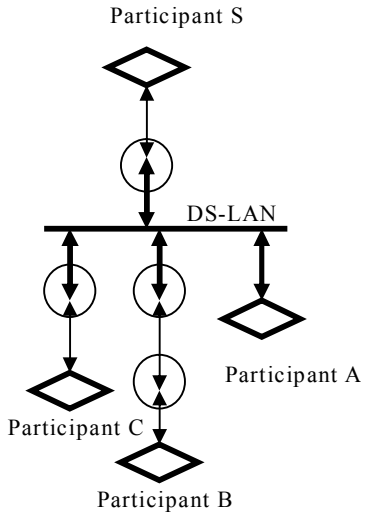

Fig. 4 Tele-Conferences by Satellite LAN and Extended Internet

5. Conclusion

The IP based satellite communication networks for mobile or fixed applications today can be easily integrated with the Internet to expand the realms of the whole information networks. The wide areas coverage and the broadcast nature of the satellite communication is topologically equivalent to LAN, which is proposed to be called Satellite LAN (SLAN). The one-dimensional SLAN can be included in the Internet and simplify the routing trees especially for multicasting and teleconferences. Varieties of users can take part in the teleconferences through the proposed combined Internet and satellite communications networks. For example, users in the general Internet, remote areas local internets or wireless networks extended from the SLAN or through MSAT can participate into the same group communications such as broadcasting, multicasting or teleconferences. Thus the common IP based networks of various applications can be easily integrated into an extended Internet and satellite communications networks.

The combined Internet and satellite communications networks can not only break the digital divide for the residents in remote islands or deep mountain areas but also provide a universal Internet service including broadcasting, multicasting and teleconferences to the general Internet users everywhere.

References

[1] Roy D. Rosner, Distributed Telecommunications Networks -via Satellite and Packet Switching- Wadsworth,Inc.

[2] Jun Takei, Hidetaka Izumiyama, “A Study of Resource Assign Method on the Internet Service with a Unidirectional Link” IEICE Vol.J85-B No.8, 2002 p.1199-1206 (in Japanese)

[3] Andrew S. Tannenbaum, Computer Networks Prentice Hall International Editions

[4] James F. Kurose, Keith W. Ross, Computer Networking, Pearson Education Japan, 2004 Tokyo

[5] Wildblue HP; http://www.wildblue.com/aboutWildblue/index.jsp

[6] IPSTAR HP; http://www.ipstar.com/index_country.html