

Guest Editorial

Broadband IP Networks via Satellites—Part II

THE SATELLITE communications industry went through a very difficult period and this downturn has later accelerated because of the economic downturn in other areas in telecommunications industry. On the one hand, the long development cycle for a satellite system and the high cost involved in such development were incompatible with simplicity and lower cost associated with younger telecommunications technologies such as terrestrial cellular systems, and on the other hand, failure of some complex and expensive satellite systems proposed in 1990s has prompted thoughts of not to have any research and development for any other satellite systems. All these factors seem to have been changed much quicker than expected and the satellite shows its great position inside and above other telecommunications technologies. The wide coverage of a satellite footprint together with its broadcasting capability are again the strong advantageous points bringing the satellite back to the market as a global communications service provider.

Increasing Internet applications have specifically introduced new applications for satellite communications. It is generally understood that with just old satellite applications such as voice telephony the industry is not sustainable. Television broadcasting, though identified as an old business for satellite communications, started new applications such as video-on-demand and high-definition televisions (HDTVs) with a bright progress outlook.

The high-capacity satellite link is a promising medium for transporting high-speed Internet information, virtually to all parts of the world without additional cost of cabling and maintenance. With the introduction of wireless local area networks (LANs), it is also understood that the satellite can act as a hub or bridge for interconnecting remote cells of the network; making the wireless LAN much more scalable and reliable for high-speed and broadband Internet access. A recent report by Northern Sky Research shows that over a thousand satellite-based Wi-Fi hot spots have already been deployed in North America, with an increasing market of 95 000 more over the next five years. This shows the important role of satellites in the future global broadband data networks.

The satellite communications industry is apparently moving in a new direction from its traditional voice service to the emerging data communications. This can be seen from the recent growth in usage of *Ku*-band versus the *C*-band. According to a recent report from Futron Corporation, Bethesda, MD, during the period of 2000–2003, *C*-band capacity has grown at 9%, while at the same period the capacity of *Ku*-band had an increase of 20%. At the same time, capacity of *Ka*-band has

fallen as much as 29%. The reason is mainly due to the growth in data and video applications, while the voice telephony application was almost halved in 2003. The Internet service for home and corporate users, as well as the increasing demand for HDTV is the main factor in increase of data and video applications over satellites in recent years.

While in the last three years the telephony service was down at 45.1%, the data was up at 6.6%, and video was up at 9%, the report also shows that the available capacity in the market has risen 52.1%. That is, there are about 52% unutilized transponders in the sky, which is a result of huge increase in deployment of new transponders in recent years. New applications for satellites and new users in other locations on the globe than Europe and North America are the potential users of this available capacity.

As the new applications for satellite communications, home and small business users especially in remote areas are taking advantage of high-speed downlink Internet protocol (IP) access through satellite systems. Efficient integration of satellite broadcasting and Internet access to individual users is seen as a driver for more progress in satellite communication industry. The in-flight high-speed and cost-efficient Internet access to users is also in the stage of development, with large amount of investment by airline companies. All in all the satellite industry finds its marketing and growth way through service paths that no other communications system could provide. This new trend is completely different from that was considered in early 1990s, where mobile satellite phone was the main service target for the industry. That goal has been resulted in failure of several satellite projects and a slow down in the overall industry.

As the satellite industry comes back to the stage, so does the research in laboratories and academia around the world. A good and handy indication of the growth in satellite-based research is the overwhelming response to the open call-for-papers for this issue of the IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS (J-SAC). After receiving a large number of high-quality papers to this special issue, we have decided to divide it into two parts. Part I was published in February 2004, and it included 17 papers mainly discussing topics at higher layers of the network protocol stack. In the second part of this issue, we have tried to cover topics related to the lower layers of network, including link and physical layers, such as switching, multiple access techniques, traffic, and flow control. A total of 16 papers have been carefully selected for this part after a long peer review process.

As the Guest Editors of this special issue, we hope that the readers find it interesting and consider it as a useful guide in research and development activities toward realization of the global wireless Internet. We are confident that many of the papers included in this issue will become long-term references for future works in this emerging field of technology.

The special issue has included papers in six categories. In the following, a brief summary of the contents of each paper is provided with the hope that this assists readers for an easier search through their respective topics of interest.

I. TOPOLOGY AND SATELLITE CONSTELLATION

The first part of this issue covers the topic of switching and buffer management, as well as the network topology and satellite constellations. The first paper, "MPLS-Based Satellite Constellation Networks," by Donner *et al.* looks at the dynamic topology of nongeostationary satellite networks and outlines the multiprotocol label switching (MPLS) as a promising candidate for incorporating this dynamic topology into an efficient support of IP traffic flows in future satellite systems. This paper provides a good reference for calculation of link dynamics in a satellite system with intersatellite links, as well as routing and rerouting scenarios in such architectures. Despite a decreasing number of satellites in lower orbits for commercial purposes, the analytical model and discussion provided in this paper can be used for other satellite systems; those that have not been considered in the paper.

The second paper, "Multilayer Multicast Congestion Control in Satellite Environments," by Peng and Sikdar, proposes a new multilayer multicast congestion control scheme in order to combat the problem of long and variable delay observed in satellite links. The proposed scheme is said to provide fair sharing of capacity to the transmission control protocol (TCP) sessions too. In addition to comprehensive analytical model presentation, the paper provides quite a large number of simulation results for the throughput of TCP sessions at different numbers of layers.

The last paper in this section, "Switching for IP-Based Multimedia Satellite Communications," by Le-Ngoc, looks at multimedia services over satellite systems to support the IP differentiated services (DiffServ) traffic. Multibeam satellites are considered in this paper. The paper interconnects the topics of multiservice communications, buffer management, and on-board switching for satellite multimedia networks.

II. FLOW CONTROL

With a close relation to the previous section, the papers in this section address the topic of flow control in satellite networks. The first paper, "Improving Link Layer Performance on Satellite Channels With Shadowing via Delayed Two Copy Selective Repeat ARQ," by Zhu and Roy, proposes a scheme in which a second delayed packet is sent in every transmission and retransmission. It is revealed that the proposed scheme can achieve a shorter delay than interleaving when it is compared with the traditional selective repeat automatic repeat request (ARQ) scheme and this reduces the mean transmission time and achieves a higher throughput for TCP traffics.

The second paper in this section, "A Flow Control Scheme Using Broadcast Information for Internet Services in Multiple Beam Satellite Networks," by Kim and Jamalipour, proposes a new flow control scheme for Internet-based services in broadband satellite networks. The proposed scheme uses periodically broadcasted information from satellites, which assists regulation of satellite terminals and earth stations' data rate to avoid

congestion in satellite switch. The overall communication performance is said to be improved significantly through the utilization of this new protocol compared with traditional flow control schemes in multibeam satellite systems.

III. TRAFFIC ENGINEERING

In addition to the traffic-related papers listed in the first section of the special issue, this section includes two papers specifically devoted to the important topic of traffic control and traffic engineering in satellite communications. The first paper in this section, "Optimum Traffic Distribution Algorithm for Multiple Satellite Systems Under Power Constraints," by Nanba *et al.*, proposes an algorithm applicable in all satellites systems at different orbits. The proposed traffic distribution algorithm uses linear programming to maximize the accommodating traffic level in satellite systems. The paper takes into account the satellite power constraints in increasing its total capacity.

The second paper, "A Multiservice Traffic Allocation Model for LEO Satellite Communication Networks," by McMahon *et al.*, proposes a genetic algorithm linear programming and the extended Dijkstra shortest path algorithm that allows bandwidth to be reserved for demand with a high quality of service requirement. The proposed algorithm is to solve the traffic allocation problem in low earth orbit satellite communications with multiservice requirements. Through analysis and simulation it is shown that the proposed algorithm has a better traffic allocation capability than a greedy algorithm.

IV. DIRECT VIDEO BROADCASTING

The direct video broadcasting (DVB) is considered as one of the main applications in modern multimedia satellite communication systems. This section includes three papers related to this topic. The first paper in this section, "Interactive IP-Network via Satellite DVB-RCS," by Skinnemoen *et al.*, outlines the direct video broadcasting-return channel system (DVB-RCS) standard and explains the main features of such a system. Measurement results and experiences from DVB-RCS installations are presented in detail.

The second paper, "A Real-Time Algorithm for Timeslot Assignment in Multirate Return Channels of Interactive Satellite Multimedia Networks," by Lee and Chang, focuses on high-speed multimedia services using a DVB-RCS system, and states that for such services it is important to assign the timeslots to terminals according to their various demands dynamically. Through a mathematical formulation of the problem into a non-linear integer programming, the authors developed an efficient real time solution. Simulation results are also presented to justify their findings.

The last paper in this section, "Optimization of Satellite Access Lower Layers for the Transport of IP Datagrams," by Leconte and C. Morlet, uses the concept of variable size packets for the transport of IP datagrams or any packet type from the network layers that are characterized by a highly variable size. After explaining the principle of variable size packets (VSP), advantages and possible high-level system tradeoff are presented. DVB-RCS is considered as a potential system to use the concept of VSP.

V. MULTIPLE ACCESS

This section of the special issue gathers the most contributions in the field of multiple access in satellite network; an important topic that has been addressed in several special issues in the past due to its importance. The first paper in this section, "Proposal and Performance Evaluation of an Efficient Multiple-Access Protocol for LEO Satellite Packet Networks," by Fantacci *et al.*, proposes a modified version of the packet reservation multiple-access protocol for handling real-time and best effort traffics in low earth orbit satellite communication systems. The proposed protocol is to adopt the requests from voice and data terminals when transmitting messages.

The second paper, "Burst Targeted Demand Assignment Multiple Access for Broadband Internet Service Delivery Over Geostationary Satellite," by Mitchell *et al.*, looks at ON/OFF type traffic to be transported over geostationary satellite systems. The paper details the performance evaluation of burst targeted demand assignment multiple-access scheme that employs original approach used in the traditional demand assignment multiple-access protocol. The end-to-end delay performance is said to be improved using this scheme.

The third paper, "A Dynamic Reservation Protocol for LEO Mobile Satellite Systems," by Chan *et al.*, proposes a dynamic reservation protocol for low earth orbit (LEO) satellites. Access probability and reservation bandwidth are dynamically varied to improve the performance. A contention pattern analysis is also proposed in the paper to estimate the number of contending terminals at the start of each frame.

The fourth paper, "Spread-Spectrum Techniques for Provision of Packet Access on the Reverse Link of Next-Generation Broadband Multimedia Satellite Systems," by del Rio Herrero *et al.*, gives a comprehensive tutorial on performance of spread-spectrum-based techniques in IP and multimedia satellite systems. Theoretical analysis of spread-Aloha multiple-access scheme for the case of forward error correction (FEC) coded systems is also presented.

The last paper, "Multiuser Detection of DS-CDMA Signals Using Partial Parallel Interference Cancellation in Satellite Communications," by Ghotbi and Soleymani, presents multiuser detection using parallel interference cancellation technique in satellite systems that use the direct-sequence code-division multiple access (DS-CDMA). A new scheme combining soft and hard parallel interference cancellation detectors is presented, which is said to have superior performance over previous suboptimal detectors.

VI. ARCHITECTURE

The last section of this special issue consists of one paper, "Scalable Architecture and Evaluation for Multiparty Conferencing Over Satellite Links," by Sun *et al.* In this paper, different conferencing models for the proposed architecture of a multiparty conferencing system are presented. In particular, a session initiation protocol to support the quality-of-service in DiffServ networks over satellite communications is proposed. Analysis of end-to-end quality-of-service parameters for voice and video in a prototype system is provided in the paper.

VII. CONCLUSION

This special issue is devoted to the numerous research activities currently ongoing toward the realization of the broadband IP via satellite networks. It is aimed at gathering research and progress and at highlighting technical challenges in the field of satellite IP and related technologies. A fair combination of papers from industry and academia is presented in this special issue.

The papers included in this issue cover the most up-to-date research topics for satellite Internet communications mostly related to lower layers of the network protocol stack including switching, flow control, traffic control, direct broadcasting, multiple-access schemes, and network architecture. As for any other telecommunications system, an efficient satellite communications network would not be feasible without a proper combination of all pieces that form the overall network and this special issue aims to provide a reference literature that gathers all those pieces.

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