GUEST EDITORIAL

KEY TECHNOLOGIES AND APPLICATIONS OF PRESENT AND FUTURE SATELLITE COMMUNICATIONS


MARIO MARCHESE ABBAS JAMALIPOUR

In June 2004, during the IEEE International Conference on Communications (ICC '04) in Paris, an important panel was dedicated to the "Role of Satellites in Future Broadband Networks." Dr. Riccardo De Gaudenzi, European Space Agency, the session organizer, together with the panelists, Harald Skinnemoen, Nera, Jacques Couet, Alcatel, Roberto Campitelli, Hughes, and Benjamin Pontano, Viasat Comsat, raised the following key questions: What is the role of satellites in bridging the digital divide? Are emerging standards going to make broadband satellite technologies affordable? What are the key space and ground technologies required to be able to economically complement terrestrial networks in the medium and long term? Are there new applications which can boost the exploitation of broadband satellite networks?

In practice, the key points are: the evaluation of the social impact of satellite communications; the convergence of the technological choices of enterprises through the standardization issue; the evaluation of new technologies that can provide improved quality at reasonable costs; and the analysis of the applications that can be either used only via satellite or whose added value is particularly meaningful if transported via satellite.

Concerning the digital divide, it is interesting to highlight that in Europe, the enlargement of the community to 25 countries has increased the challenge. Recent estimations indicate that in Europe, composed of 25 countries, more than one million residential users and 100,000 institutions are not covered by terrestrial broadband access. The very nature of satellites joined to new technical solutions allows offering immediate coverage at high speeds. The challenge is to see whether satellite technology can fill the digital divide at service cost, reliability, and quality comparable to terrestrial solutions. Great challenges concerning the digital divide are also evident in Africa, Asia, and South America, and satellites have a real chance to play a key role. Also, in the United States, "… The lack of economical access to wired broadband resources at a significant number of facilities will pose a critical hindrance to business operations…Satellites will be essential to enable comprehensive broadband services with the performance required to support the mission-critical applications needed by corporate, SME, and SOHO markets." (reported by Frost and Sullivan, February 2004).

SATELLITE COMMUNICATIONS TECHNICAL ISSUES

Concerning the technological issues, the principle of standardization is topical to help integration among networks of different providers. Standardized products will help reduce costs, lowering the industrial risks and competition, and driving up mass production. New promising standards are IPoS, DVB-RCS, and DVB-S2. IPoS means IP over satellite, and incorporates the new satellite-independent service access point (SI-SAP) interface whose detailed definition is in progress within the Satellite Earth Station Broadband Satellite Multimedia (SES BSM) ETSI group. SI-SAP isolates the physical layers (i.e., satellite physical, MAC, and link control, strictly satellite-dependent) from the satellite-independent layers (i.e., IPv4 or IPv6) and offers specific quality of service (QoS) to IP and higher layers.

DVB-S2 for the forward link is suitable for interactive satellite broadband networks, and allows high physical layer performance, a wide range of spectral efficiencies, and adaptive coding and modulation (ACM) profiles for interactive applications. DVB-RCS for the reverse link is flexible and subject to further improvement. It is becoming accepted worldwide.

The success of satellites is strictly linked to new technological solutions. In this context, key points of concern are power- and bandwidth-efficient modulations, ACM for uplinks and downlinks, improved access techniques for bursty traffic, resource reservation algorithms, onboard switching, high-performance transport layers, performance enhancing proxies (PEPs), low-cost terminals, multicast and caching, portable and mobile terminals, and network integration. The key words are heterogeneous architectures, bandwidth management, and QoS.

What about applications that can fully benefit from satellite environments or where satellite links are essential? A possible broad classification is service provision in remote and low-density population areas, aeronautical services, and interplanetary communications. Interesting applications are in the field of navigation and localization, disaster prediction, safety for critical users, search and rescue, Internet connection and data transmission for maritime environments, aviation, and trains.

SATELLITE COMMUNITY RESEARCH

This Special Issue was launched in 2004 with the aim to cover most satellite communications aspects and to individuate key technical challenges that can make the exploitation of satellite networks feasible.

It is now interesting to check the response of the satellite community to the call for papers. We received a large number of submissions that imply the great activity in satellite research.

In more detail, it is interesting to report a classification for topics of the articles submitted: 14 percent of them focused on evolution of satellite communication and description of projects; 11 percent were dedicated to transport layer and reliable transport architectures, partially including security issues; 18 percent were devoted to DVB-RCS/S technology, including onboard switching issues; 30 percent of the articles focused on quality of service, many of them related to bandwidth management; 9 percent were dedicated to CDMA technology; and 7 percent to ARQ techniques. Other work concentrated on peer-to-peer, fault diagnosis, optical communications, UMTS, and tomography.

Two percentages deserve special attention: 18 percent for DVB-RCS/S, which proves to be a really challenging technology for the future; and 30 percent for QoS and bandwidth management, a research topic always of main interest. Other topics, such as satellite networking in challenging environments, probably of topical importance for the future, deserve more attention.

Articles were solicited from companies involved in development of new satellite systems and key technologies, operators, and public bodies, as well as research centers and academia. Most of the articles received were from academia (68 percent), but the involvement of industry (27 percent) is worthwhile. Public bodies were involved in 5 percent of the submitted articles.

FUTURE CHALLENGES

The provision of QoS-based service is topical for commercial success. A complete end-to-end QoS implementation for a satellite broadband network depends on specific resource allocation algorithms, link impairments, mitigation techniques, congestion control, and classification of service mechanisms. From a user perspective, end-to-end QoS in a satellite/terrestrial network depends on the QoS achieved at each layer of the network based on functions to be performed at the layer interfaces. This means that QoS requires the cooperation of all network layers from top to bottom, as well as of every network element. At each layer, user performance requirements are achieved by using efficient technologies and counteracting any factor of performance degradation, as stated in the article "Blockage Mitigation Techniques in Satellite Communications" by William W. Wu, which proposes systematic approaches to minimize severe channel degradation and enhance performance. QoS at higher layers is achieved providing guaranteed bandwidth at the data link and network layers by using efficient bandwidth on demand multiple access schemes and studying the interaction of mechanisms in the presence of congestion and fading. The provision of specific bandwidth implies the existence of a bandwidth allocation scheme that shares the bandwidth available among the different user terminals with different traffic classes, as in the IP differentiated services (DiffServ) case.

A dynamic capacity allocation scheme based on combined free/demand assignment multiple access (CF-DAMA) over IP DiffServ satellite networks is proposed in the article "Dynamic Capacity Allocation for Quality of Service Support in IP-Based Satellite Networks" by N. Iuoras and T. Le-Ngoc. The framework of IP DiffServ is also used in the article "QoS Provisioning in GEO Satellite with Onboard Processing Using Predictor Algorithms" by F. Chiti, R. Fantacci, S. Kota, T. Pecorella, and D. Tarchi, which matches the issue of QoS provisioning for packet traffic through resource allocation schemes, including bandwidth allocation techniques and priority-driven onboard switching algorithms.

The choice of a specific technology is often a key point to guarantee QoS. DVB family standards are now a reality, but many topics are still open for research. The article "Critical Issues of Onboard Switching in DVB-S/RCS Broadband Satellite Networks" by N. Courville, H. Bischl, and J. Zeng discusses the QoS mechanisms supported over onboard switched DVB networks. The current DVB-RCS security standard and the principal gaps in the provision of secure multicast over DVB-RCS are investigated in the article "Securing Multicast in DVB-RCS Satellite Systems" by H. Cruickshank, M. P. Howarth, S. Iyengar, Z. Sun, and L. Claverotte. The article "VoIP over DVB-RCS with QoS and Bandwidth on Demand" by H. Skinnemoen, A. Vermesan, A. Iuoras, G. Adams, and X. Lobao addresses the role of bandwidth on demand (BoD) in the optimization of bandwidth allocation for VoIP and assesses the impact of BoD mechanisms on voice quality over satellite networks based on the ETSI DVB-RCS standard.

Above the network layer, the transport protocol needs to be optimized for guaranteed throughputs, delay, and minimum delay variations over a satellite environment mitigating link impairments. The article "Evaluation of SCTP for Space Networks" by S. Fu, M. Atiquzzaman, and W. Ivancic investigates the suitability of the Stream Control Transmission Protocol (SCTP) for data communications over satellite networks. The article "Recent Trends in IP/NGEO Satellite Communication Systems: Transport, Routing, and Mobility Management Concerns" by T. Taleb, N. Kato, and Y. Nemoto discusses the issues of transport and routing with emphasis on Transmission Control Protocol (TCP) performance in non-geostationary (NGEO) satellite networks. A key innovation called Recursive, Explicit, and Fair Window Adjustment (REFWA) that significantly improves the efficiency and fairness of TCP in NGEO satellite systems is proposed in this article.

CONCLUSIONS

This feature topic is devoted to key space technologies and technical challenges that can make the exploitation of satellite networks feasible. The articles included in the issue cover the most important topics in satellite communications concerning channel degradation counteractions, QoS, resource allocation, and transport layer.

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BIOGRAPHIES

MARIO MARCHESE (S'94-M'97-SM'04) received a Laurea degree (cum laude) from the University of Genoa, Italy, in 1992, his Qualification as a Professional Engineer in 1992, and a Ph.D. degree in telecommunications from the University of Genoa in 1996. From 1999 to 2004 he worked with the University of Genoa Research Unit, Italian National Consortium of Telecommunications (CNIT), where he was head of research. Since 2005 he has been an associate professor in the Department of Communication, Computer and Systems Science (DIST), University of Genoa. He is founder and still technically responsible for the CNIT/DIST Satellite Communication and Networking Laboratory (SCNL), University of Genoa, which contains high-value devices and tools, and implies the management of different units of specialized scientific and technical personnel. He is Vice-Chair of the IEEE Satellite and Space Communications Technical Committee. He is author and coauthor of more than 80 scientific papers in international magazines, international conferences, and book chapters. His main research interests include satellite networks, transport layer over satellite and wireless networks, quality of service over ATM, IP, and MPLS, and data transport over heterogeneous networks.

ABBAS JAMALIPOUR [St'86, M'91, SM '00] is with the School of Electrical and Information Engineering at the University of Sydney, Australia, where he is responsible for teaching and research in wireless data communication networks, wireless IP networks, network security, and satellite systems. He holds a Ph.D. in electrical engineering from Nagoya University, Japan. He is the author of the first technical book on networking aspects of wireless IP, *The Wireless Mobile Internet — Architectures, Protocols and Services* (Wiley, 2003). In addition, he has authored another book on satellite communication networks with Artech House in 1998 and coauthored three other technical books in wireless telecommunications. He has authored over 130 papers in major journals and international conferences, and given short courses and tutorials at major international conferences. He has served on several major conferences' technical program committees, and organized and chaired many symposia at international conferences. Currently he is chair of the Wireless Communications Symposium, IEEE GLOBECOM 2005, and a Co-Chair of symposia at IEEE ICC 2005, ICC 2006, and GLOBECOM 2006, as well as a Vice-Chair of IEEE WCNC 2006. He is a Fellow Member of IEAust; Chair of the Satellite and Space Communications Technical Committee; Vice Chair of the Asia Pacific Board, Coordinating Committee Chapter; and Vice Chair of the Communications Switching and Routing Technical Committee, IEEE Communications Society. He has organized several special issues on the topic of 3G and beyond systems as well as broadband wireless networks in IEEE magazines and journals. He is a technical editor of *IEEE Wireless Communications*, *IEEE Communications Magazine*, and Wiley's *International Journal of Communication Systems*.