Guest-editorial

On-Board Processing

Multimedia services make up an increasing share of the traffic in terrestrial networks. In the future, regenerative satellites with on-board switching and multibeam narrow-beam antennas can be used to provide this service to small user terminals all over the world. Taking advantage of the large bandwidths available in Ka-band, On-Board Processing (OBP) technology will become an important means for the completion of the Global Information Infrastructure (GII).

The main advantages of satellite systems with OBP are:

– Improved link quality with respect to transparent systems, due to signal regeneration on board.
– Direct interconnections between user terminals through on-board switching. Switches in the satellites provide short latency and thus improve the quality of service (QoS) with regard to systems using hub stations on ground.

These benefits, however, demand payloads with higher complexity. Today, many scientists and engineers in universities and companies are working in this field. This issue on OBP presents a broad survey of study work development activities being performed at this time to prepare the essential technologies. The issue is subdivided into four sections:

Section 1. Survey
Section 2. System Aspects
Section 3. Simulation Studies
Section 4. Systems and Hardware under Development

In the first section, 'Survey', a comprehensive synopsis of ATM satellite communication and future satellites with on-board switching is given in the article 'Broadband satellite networking'. Economic aspects are discussed in 'The multimedia migration: transponder versus processing payload VSAT networks'. Costs of VSAT systems with transparent and OBP satellites are compared. The article shows a clear advantage for the new technology, even under very conservative assumptions.

General system design considerations are presented in Section 2, 'System Aspects'. Access methods and management procedures suitable for transparent as well as OBP satellite systems are discussed in 'Broadband satellite access for interactive multimedia services'. Access, modulation and coding methods are discussed in 'Air interface and payload architecture for GEO multimedia communications satellites'. OBP payload architectures are proposed and design standards are presented using examples and technical data of planned systems. In 'Architectural solutions for a GEO satellite multimedia system', the fundamental design criteria of the EuroSkyWay system are shown. In addition to discussion of system architecture, ground segment and recent developments, some design criteria for satellite links and payload are given. The architecture of a Code Division Access and Switching System, including system control and transmission parameters, is proposed in 'Code division access and switching for multibeam satellite communications'. Switching is based on a code division switch (CDS), allowing direct switching between uplink and downlink by means of user and beam codes, without demodulation on board.

Section 3, 'Simulation Studies', deals with the provision and guaranty of service qualities in OBP satellite systems. This mainly applies to the management of bandwidth resources under various operational conditions. Methods of resource management are described and the performances are studied and optimized by means of system simulations. In 'Performance study of end-to-end resource management in ATM geostationary satellite networks with on-board processing', the problem of bandwidth reservation is discussed and solutions for service-oriented booking are given. Access and resource management problems in LEO satellite systems are elucidated in 'Service mapping and QoS provisioning in broadband satellite multimedia networks'. A new method of bandwidth reservation, the Adaptive Bandwidth Reservation Scheme (ABRS), is presented and its suitability is demonstrated using both analytical methods and simulations. The problem of TCP traffic under high load conditions is consid-

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ered in ‘Achieving QoS for TCP traffic in satellite networks with differentiated services’. The role of buffer management for different traffic types is explained and the reactions of the network are described. Basic transmission experiments using a hardware simulator are presented in ‘A simulation study for the performance of an on-board ATM switching scheme for broadband satellite communications network’. The tests were performed using TCP/IP and ATM PVC/SVC links with AAL5 and 155 Mbit/s.

Recent commercial systems and equipment developments are introduced in the last section, ‘Systems and Hardware under Development’. In ‘EUTELSAT multimedia satellites’ current EUTELSAT satellites with Skyplex payloads are discussed. The satellite and ground segment functions are elucidated in some detail, together with the prospects for possible future developments. The ESA OBP activities are described in ‘Achievements of the on-board processing development activities (ARTES Element 2 of the European Space Agency)’. The on-board equipment (breadboards and engineering models) of the ARTES 2 program are shown and a prospect for the ARTES 3 program (SkyBridge, West and EuroSkyWay) as well as further ESA developments are given. In this section a number of papers from EMS Technologies in Canada and Bosch SatCom in Germany are presented. Both companies are active in the design and development of satellite OBP equipment. Part of the work presented was performed in the framework of ESA programs. In ‘Advanced digital demodulators for on-board processing payloads’ past and recent demodulator developments are presented. Based on various projects currently under the aegis of ESA programs, new developments are summarized. New components are used to provide wide bandwidths and high flexibility for use in various systems with different transmission parameters. The assumptions and system considerations for the development of an on-board demodulator for DVB-RCS applications are presented in ‘A high-speed, on-board multi-carrier demodulator for DVB-RCS applications’. The hardware implementation of the demodulator, including ASICs, is presented and measured results are shown. ‘SpaceMux™: an on-board mesh processor’ summarizes development activities for an on-board processor to be used for direct connections between small ground terminals without using a terrestrial hub. This processor will be used in a hybrid satellite which is equipped with a transparent repeater for Internet services and a processing transponder for direct user-to-user connections. ‘On-board switching architectures for multimedia satellite systems’ presents architectures of on-board switches for different throughput requirements. For a novel switch with up to 10 Gbit/s throughput, an architecture is proposed consisting of a generic switch fabric and input/output processors for adaptation to various transmission modes. In ‘A broadcast congestion control scheme for OBP satellites’, a method for avoiding blocking in GEO satellite systems is described. It is based on on-board load measurement and transmission of cell rate modification requests to all ground terminals. Simulation results demonstrate the function and show the efficiency of the method. The development of an on-board scheduler is described in ‘On-board scheduling for multimedia applications’. The fundamentals and implementation options for an on-board hub are given together with simulation results. In ‘Terminal timing synchronisation in DVB-RCS systems using on-board NCR generation’, timing options are discussed. Bandwidth requirements and delay measurements are compared for systems with their reference clock on the ground and on-board.

The great interest in satellite OBP work all over the world shows the importance of this technology. There seem to be, however, certain aspects that must be considered in more detail before wide application of such complex satellites becomes economically feasible. As mentioned above, OBP satellites provide a number of advantages with regard to transparent satellites. But such satellites are significantly more expensive and less flexible to modifications of transmission parameters. Design and development demand reliable knowledge of future user needs and trends in communications technology. This seems to be vital for the introduction of successful public satellite systems.

Presently, no reliable predictions regarding numbers of users and their long-term behavior are known. After a period with many design presentations, this seems to be the main reason for the slow implementation process. Since the design of OBP equipment demands reliable data about future developments, close cooperation among service providers, system designers and satellite manufacturers seems to be indispensable. Furthermore the fast developments in personal communications technology seem to be inconsistent with the increasing lifetime of modern satellites. It is the experience of the last 10 years that users accept and adapt to new communication technologies very rapidly. Satellites could improve the availability of modern communication services in many parts of the world. But such satellite services should be similar to terrestrial services, with regard to features and cost. Within the 10 to 15 years life of a satellite, considerable modifications of user demands and behavior must be expected and the OBP satellites need to be able to cope with such changes. This will be a great challenge for satellite systems engineers as well as for investors.

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