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THE ITALIAN CONTRIBUTION TO THE INTEGRATION OF TERRESTRIAL AND SATELLITE NETWORKS

Nedo Celandroni [(1)], Erina Ferro [(1)], Francesco Potortì [(2)]

[(1)] CNUCE, Institute of National Research Council
Via S. Maria 36 - 56126 Pisa - Italy
Phone: +39-50-593207/593312/593203
Fax: +39-50-589354 - Telex: 500371
E-mail: n.celandroni@cnuce.cnr.it
e.ferro@cnuce.cnr.it
[(2)] CNUCE consultant
E-mail: pot@cnuce.cnr.it

ABSTRACT

This paper presents the Italian interconnection of terrestrial and satellite networks by means of the FODA/IBEA system. A bridge implemented the interconnection of the satellite network on one side and the Ethernet and Token Ring terrestrial networks on the other side. With such an architecture, an experiment of videoconferencing was proved between Pisa and Florence, while data generated by TCP/IP based applications were also transmitted. The satellite network is described in the first part of the paper, while the bridge to access the satellite network is presented in the second part. This bridge is part of a multimedia network which also includes the applications (voice, video and a file transfer application based on TCP/IP) and the internal communication media.

1. THE SATELLITE NETWORK ENVIRONMENT

We assume that end-user applications, which generate both real-time (stream) and jitter-tolerant data (datagram), run on hosts connected to a LAN. Different LANs converge data to a bridge which communicates with the satellite access system. The access to the satellite is obtained in TDMA by means of the FODA/IBEA(*) access scheme which runs on an hardware developed ad-hoc. The satellite network can work in any frequency band, even the 20/30 GHz frequency band where the attenuation of the transmission signal due to bad atmospheric conditions constitutes a major problem. A protocol (*GAFO* protocol, [1]) provides the bridge with the access to the FODA/IBEA system. Fig. 1 shows the network scenario.
The hardware was designed by CNUCE, in collaboration with Telespazio, and developed by Marconi R. C. (U.K.). It consists of a TDMA controller, which includes a variable coding rate

(*) Fifo Ordered Demand Assignment /Information Bit Energy Adapter codec, and a variable bit rate burst modem. The TDMA controller is split in two parts: the *UP controller,* for transmissions toward the satellite, and the *DOWN controller,* for receiving data from the satellite.

Both the transmit *control processor hardware* and *the receive control processor hardware* consist of a MOTOROLA MVME147S-1 processor board and a transition module MVME712M. The processor board uses a 68030 processor card containing 4Mbytes of RAM. It runs at 25MHz and occupies one 4E wide VMEbus slot. The operating system supplied by Motorola on the board is called MVME147bug.

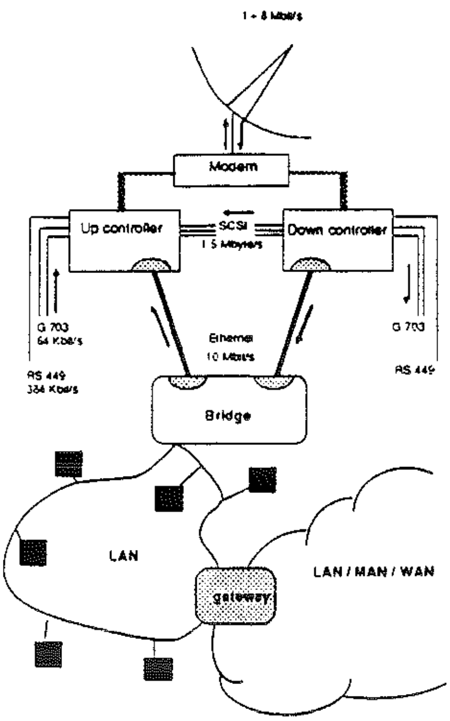

Fig. 1. Network scenario

The codec supports variable coding rates: *1/2, 2/3, 4/5 and uncoded PSK.* Punctured codes, derived from the 1/2 convolutional encoder, are adopted. The decoder operates asynchronously at 8 Mbit/s information bit rate with 3 bit sign/magnitude soft decisions.

Guaranteed error rates that are better than 10^{-4}, 10^{-6} and 10^{-8} for the various services are offered, respectively, by adapting the code rate to the signal/noise conditions.

The modem supports variable symbol rates: *1/2, 1, 2, and 4 Msymbol/s,* switchable on a sub-burst basis, with two different modulation schemes (BPSK and QPSK) to allow operations within a 5 MHz bandwidth. The bit rate is variable in the range 1-8 Mbit/s.

A special feature of the modem is that it is capable of dynamically adjusting its transmission rate within a data burst. This allows the individual data sub-bursts (DSB) of a data burst (DB) to have different symbol rates (and, hence, different energies), as required. The symbol rates available are 512, 1024, 2048 and 4096 Kbaud using either BPSK or QPSK modulation formats. The system thus has available a bit rate range of 512-8192 Kbit/s. In order to meet the dynamic rate requirements the modem is implemented using digital signal processing (DSP) techniques.

A detailed description of the hardware can be found in [2], [3], [4], [5] and [6].

The adopted hardware allows users to implement a wide range of TDMA systems in software but it does imposes some necessary restrictions since, in some cases, the software would be unable to react quickly enough to external events.

- Each burst must start with a carrier and bit timing recovery sequence (CBTRS). This is actually a restriction of the modem.
- The frame must include a reference burst (RB) containing the master unique word (MUW). The MUW maintains synchronisation of the receive hardware frame counter. Apart from the MUW the remaining content of the RB is unimportant to the hardware. Only one MUW must appear in each frame. The maximum frame length is 64 ms.
- Each data burst must consists of a control sub-burst (CBS) followed by a number of data sub-bursts (DSBs). The CSB is decoded by the hardware and provides information necessary for the reception of the following DSBs.

2. UNFADED/FADED CONDITIONS

FODA/IBEA is the TDMA satellite access scheme, developed at CNUCE, suitable for simultaneous transmissions of stream and datagram data. It maintains the class of service required by the sending application even when a fade of the signal due to bad weather conditions occurs. The basic principle used in the present system to cope with different levels of the signal attenuation is the variation of the energy contained in an information bit. This is done by varying the transmission power when possible, along with the data coding rate and the data bit rate. High data rates are used under unfaded conditions, when the signal-to-noise ratio is sufficiently high. The data rate too is progressively reduced when deep fades occur to allow the decoder to work with a suitable value of the E_b/N_0 (bit energy over noise density) ratio and to allow the modem to acquire in a reasonable interval of time.

The design of the FODA/IBEA-TDMA satellite access scheme is based on a centralised control supported by a master station which also acts as a slave station. It is the master station's responsibility to control the access to the common resource and to maintain the synchronisation of the slaves. Although there is only one master station at each time in the network, all the controllers are capable of operating as master. The master station may be replaced, in case of fault, by any traffic station that has been declared available to do this task.

In normal conditions, the space in the frame reserved for stream transmissions lasts up to certain threshold NSUB (Normal Stream Upper Boundary); the remaining space in the frame is reserved for datagram transmissions. If no stream traffic is present, the datagram can occupy almost the whole frame. When fades take place, data is redounded by a redundancy information

Three stations were involved, one in Florence and two in Pisa. Two stream applications, running on PCs, sent compressed digital video and sampled digital audio data through the FODA/IBEA system. Both local (Pisa-Pisa) and remote (Pisa-Florence and vice versa) connections were established. The total traffic on the satellite channel exceeded 2.5Mb/s. Datagram connections were also tested with TCP/IP packets, both alone and with stream traffic. Data was transmitted at 8 Mbit/s, uncoded, to the EUTELSAT satellite, in the 12-14 GHz band, accessed by means of 3.5 m mobile antennas.

7. CONCLUSIONS

Two important aspects result from the experience of this project:

- the satellite link can be divided among many users, as any other terrestrial link;
- the already existing infrastructures (LANs) can be used for the multimedia applications.

As far as the first point is concerned, one only satellite channel may interconnect more sites with a complete net, working with a good quality of the service even in bad weather conditions. This type of interconnectivity is not easily achievable with the terrestrial links. One only channel multiplexes together stream and datagram data, reserving to the datagram data the available bandwidth after the stream handling. It is possible to define high-level software protocols which reserve a minimum space to the datagram data and handle the stream sessions in an adaptive way (by reducing the performance if too many requests must be handled).
Referring to the second point, it was demonstrated that multimedia applications on the satellite can be conveniently realised by using already consolidated LAN technologies. With this type of solution advantages result both in economics terms and in terms of local diffusion of the services.

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