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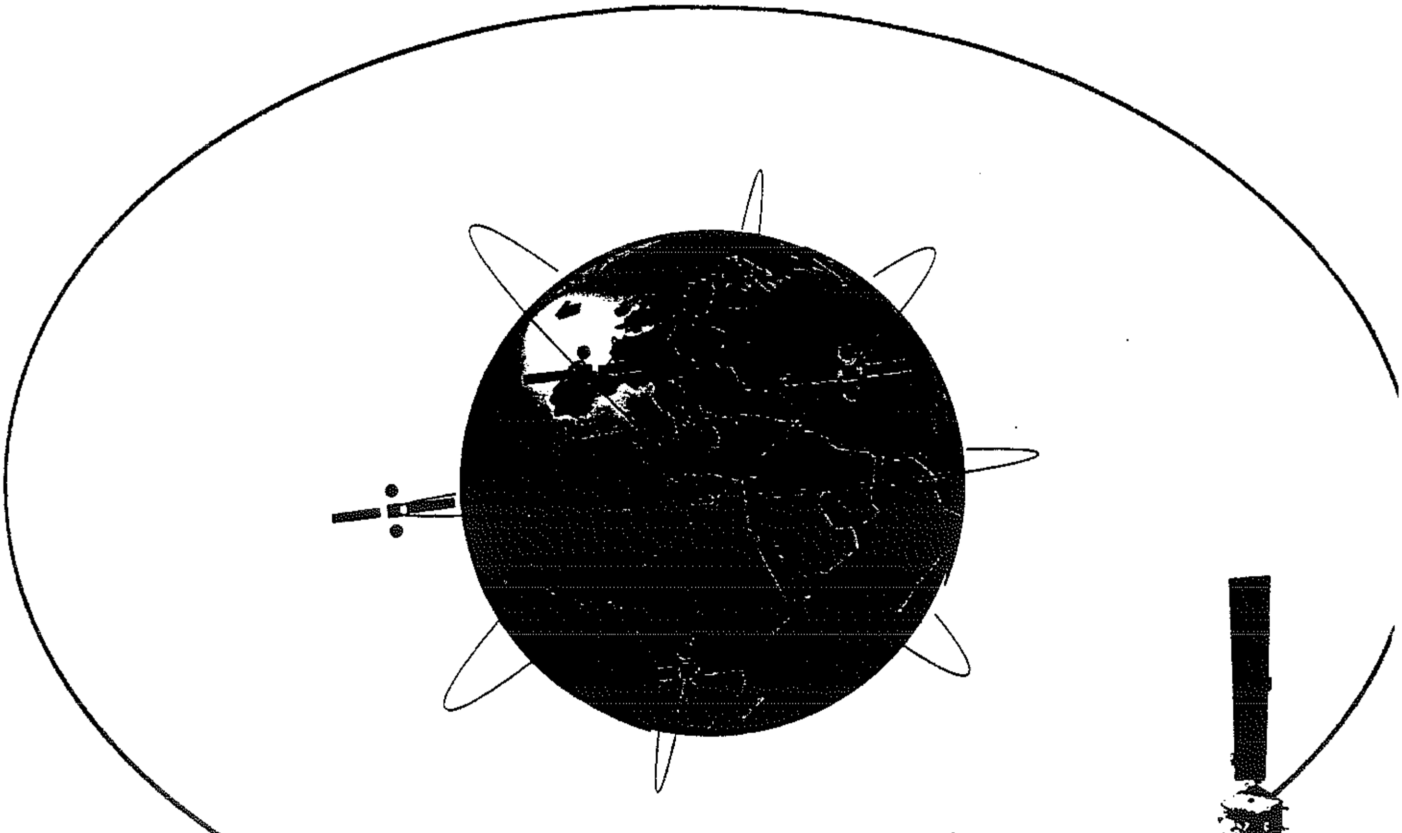

FOURTH EUROPEAN CONFERENCE ON SATELLITE COMMUNICATIONS

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BURSTY DATA TRAFFIC VIA SATELLITE: PERFORMANCE COMPARISON BETWEEN TWO TDMA ACCESS SCHEMES

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Synopsis This paper reports the simulation results of a performance comparison between two centralised thin route TDMA satellite access schemes, in terms of bursty data transmission delay in the context of LAN interconnection traffic. The schemes compared are CFRA[(1)] and FODA/IBEA[(2)]. The study is limited to the bursty traffic generated by the LAN, which consists of a mixture of interactive and non interactive data. The simulation tool used is *FRACAS*[(3)], which was designed and implemented at CNUCE for the performance evaluation of satellite access schemes.

1 Introduction

CFRA and FODA/IBEA are two thin route TDMA centralised access schemes. They support in an effective way a combination of different types of traffic (*aggregated* traffic), which is typical of Local Area Network (LAN) interconnection traffic. The aggregated traffic includes real-time traffic, also known as *stream*, and non real-time traffic, also known as *bursty*. Stream traffic includes constant bit rate traffic (CBR, such as video and audio with well defined bit rate requirements), and variable bit rate traffic (VBR, such as a video source generating MPEG coded data). Bursty traffic includes both bulk and interactive data, the latter with a transmission priority higher than bulk traffic.

This paper reports the results of a comparison between these two satellite access schemes in identical conditions of bursty traffic when a *composite* traffic generator (described in Section 3) is used. It should be underlined that no such comparison has previously been made since other authors generally present simulation results under specific traffic loads, and with different software tools. The paper is organised as follows. Section 2 briefly introduces the two access schemes. Section 3 describes the network model used. Section 4 shows the simulation results and Section 5 contains the conclusions.

(1) Combined/Fixed Reservation Assignment

(2) Fifo Ordered Demand Assignment/Information Bit Energy Adapter

(3) FRAmed Channel Access Simulator

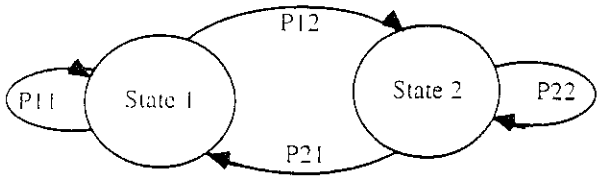
2 The access schemes

2.1 CFRA

CBR traffic (hereafter *stream*) is handled by means of fixed assignments (in the same quantity of the request) as this type of traffic usually requires a fixed delay, which cannot be guaranteed by demand-assignment techniques. The bursty traffic is handled according to a combination of a fixed assignment, for *short bursts*, and a demand-assignment, for *long bursts*. The distinction between short and long bursts is made by the L_0 parameter, expressed in *number of cells*. A burst consisting of less than L_0 cells is *short*, and *long* if it consists of more than L_0 cells. Two consecutive bursts are separated by an entire frame without any cell reception. The short burst, when stored in the station input buffer before transmission, does not trigger the demand for more capacity than the standard R_{min} value. When a long burst is recognised, a demand in the form of a *start of burst* (S) message is sent by the station to the master to get the larger capacity R_{max}. The station continues to transmit the burst with the R_{min} capacity until it receives the assignment for the larger allocation. When the long burst ends the station transmits to the master the *end of burst* (E) message, which initiates the de-allocation of the capacity R_{max}-R_{min} . The R_{max} and R_{min} constants are set to 1 and 30 slots per frame, respectively, while the constant L_0 is set to a burst length of 10 ATM cells. These seem to be the best values for bursty traffic, as the results in [5] show.

The frame duration is 29 ms. It consists of 132 time slots with 55 bytes per slot, and 10 bits of guard times between bursts. It begins with four slots used for signalling and synchronisation. The remaining 128 time slots are available for data, with N_{stream} slots for transmission of stream traffic cells and N_{bursty} slots for bursty data transmission. These latter slots can be conceptually divided into two parts: one made by a number of fixed capacity slots equal to N_{bursty}-R_{min} N_{vsat} (where N_{vsat} is the number of VSAT stations), and the other consisting of the slots available for assignments on demand.

Connections for traffic handling are assigned on demand by a master station. The role of the master is only for timing reference and for implementing the centralised which are then delivered at two different rates scheduled by a two-state Markovian machine (Fig. 2).



State 1 inter-arrival time: constant (5ms) + exponential; mean = 50 pkt/s
State 2 inter-arrival time: constant (5ms); mean = 200 pkt/s
packet length: constant; 512 bytes
P12=P21=0.2; P22=P11=0.8

Fig. 2. Two-rate model of a file transfer

The interactive traffic generator delivers packets with a constant (10 ms) plus exponential inter-arrival distribution, with a mean chosen in order to get the desired interactive traffic load. The packet length is generated according to the histogram reported in Table 2, which gives a mean value of 165.5 bytes.

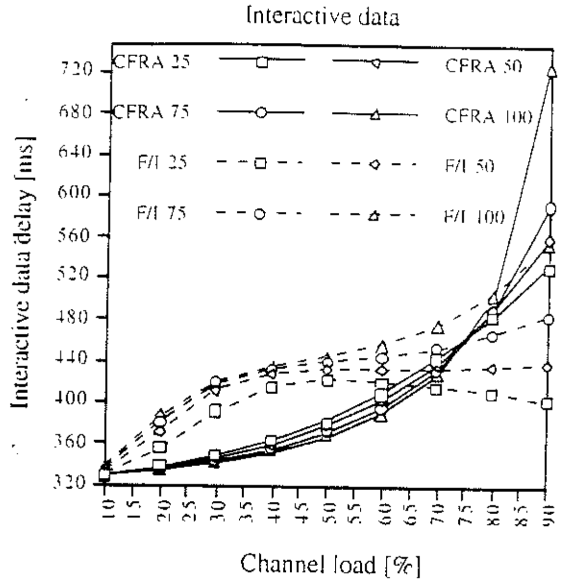
cumulative distribution	packet length
0.8	10
0.85	50
0.90	100
0.95	1000
1	2000

Table 2. Histogram for interactive packet length

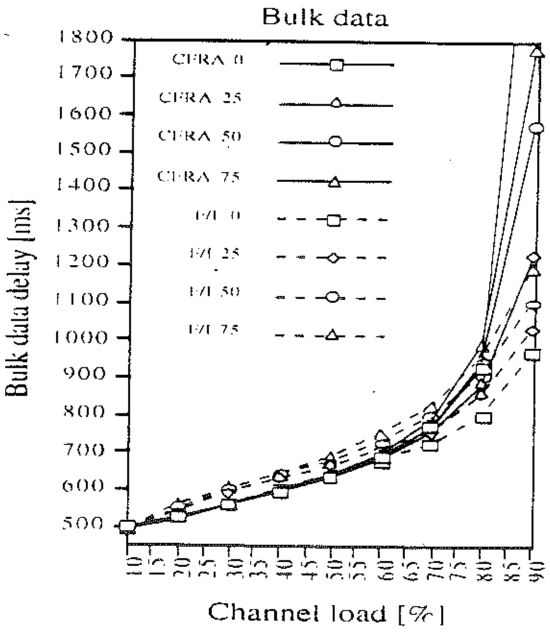
4 Simulation results

We simulated both FODA/IBEA and CFRA by means of *FRACAS*, which is a C language specialised emulator developed at CNUCE in order to evaluate the performance of TDMA satellite access schemes [4]. *FRACAS* is a *discrete time* emulator with a granularity of one frame. In general, the delays obtained with *FRACAS* have an error in the interval [0; -1 frame] but, unless the distribution of the delay is concentrated over a period of a few frames, it can be approximated with an error of -1/2 frame. This means that the difference (FODA/IBEA delay) - (CFRA delay) has an error in the interval [-20; -29] ms, because 20 and 29 ms are the frame lengths of the two access schemes, respectively. The mean error deriving from this effect is therefore -4.5 ms. The 95% confidence interval of the simulation results is less than ±5% for all the values resulting from the simulation.

In all the tests we used a network of 16 stations which generate bursty traffic alone. A net information bandwidth of 2 Mbit/s is available for both access schemes. This approach avoids all the problems in comparing the overheads of the two access schemes, allowing one to concentrate on the relative merits of the "pure" allocation process. The evaluated performance is the delay experienced by the single traffic cells when crossing the satellite network.



3a) Interactive delay

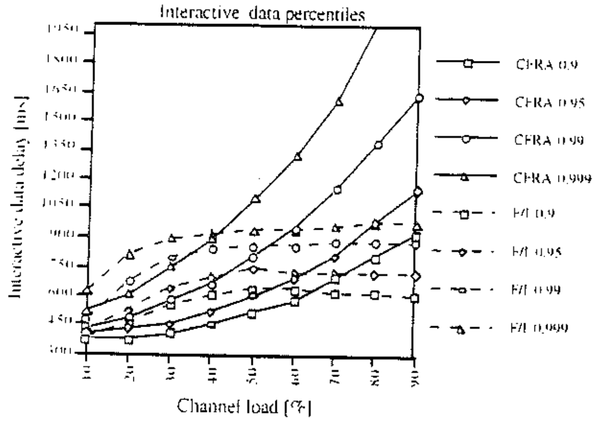


3b) Bulk delay

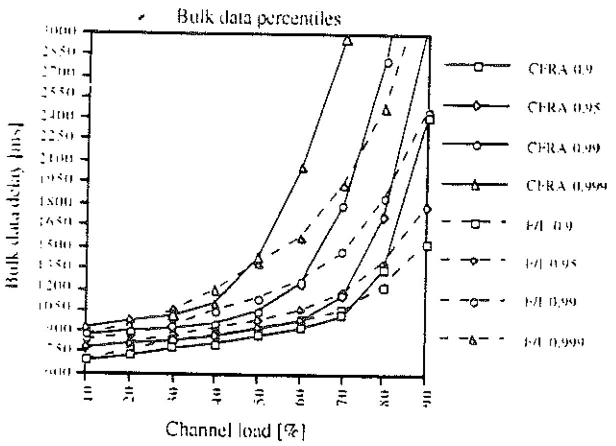
Fig. 3. Mean cell delay versus channel load for different quotas of interactive traffic. The load is distributed evenly among all the stations.

The delay is thus the sum of the satellite round-trip delay, which we set to 254 ms, the processing delay, which we set to 1 frame time, and the input queuing

delay. A processing delay of one frame is the minimum achievable unless most of the access scheme is implemented in hardware, which would be impractical for schemes of this complexity. Since the frame length of CFRA is greater than that of FODA/IBEA, CFRA's minimum delay is 283 ms, when no queuing occurs, while the minimum for FODA/IBEA is 274 ms. In the legends of all the figures F/I stands for FODA/IBEA.
Figure 3 shows the mean delay of the cells crossing the network when all the stations are loaded with the same mix of bulk and interactive data. The total traffic load varies from 10% to 90% of the channel, while the quotas of interactive data are 0, 25, 50, 75, and 100% of the channel load. The mean cell delay averaged over all the stations is plotted separately for the interactive and the bulk traffic.



4a) Interactive delay



4b) Bulk delay

Fig. 4. Cell delay percentiles versus channel load when the interactive traffic is 30% of the channel load. The load is distributed evenly among all the stations.

CFRA performs better than FODA/IBEA for traffic loads in the range of 20÷60% of the channel capacity, getting delays lower by 20÷80 ms, for both interactive and bulk traffic. Note how the interactive traffic is privileged in both systems, since it has a mean delay significantly lower than bulk in all situations. On the other hand, FODA/IBEA makes better use of the channel capacity at high traffic loads, as can be seen looking at the delays for loads higher than 70% of the channel.

Figure 4 shows the length of the tails of the delay distributions. The system is evenly loaded as in Figure 3. The quota of the bulk traffic is 70% of the channel load, while the remaining 30% is devoted to the interactive traffic. Four percentile values are represented, namely 90, 95, 99, and 99.9. As in the previous case, CFRA performs better at traffic loads lower than 50% of the channel space, while FODA/IBEA performs better at high loads.

Figure 5 shows the system response when a sudden high traffic burst is applied to one of the stations. All the stations are equally loaded with constant interactive and bulk traffic, 25% and 75% of the total input traffic respectively, which is set to 30% of the channel capacity.

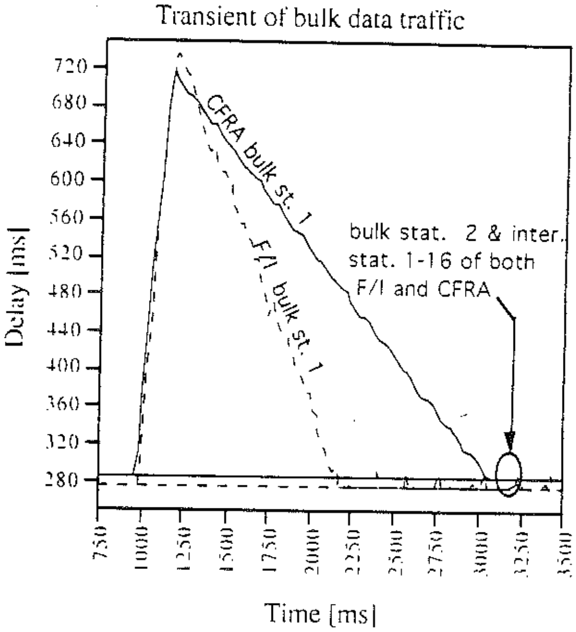
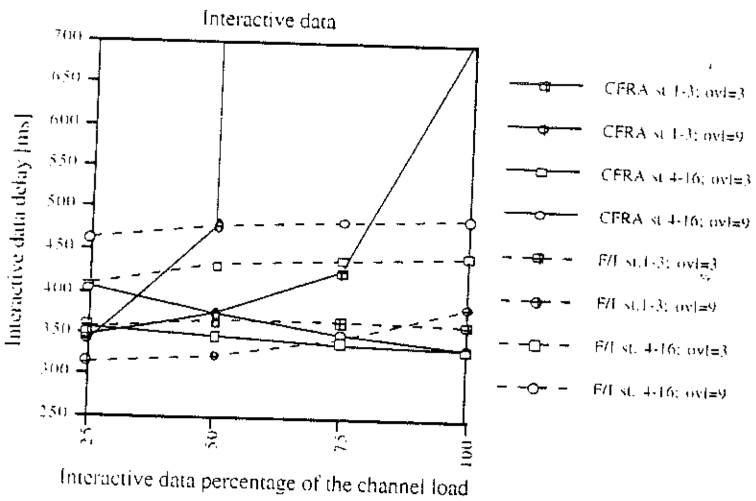
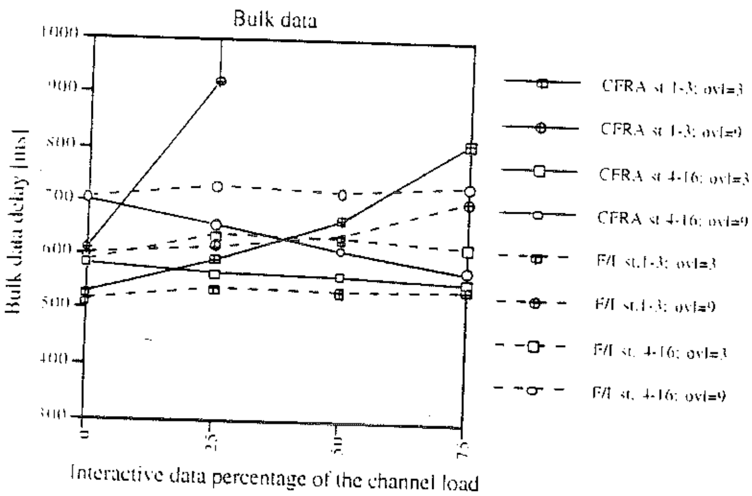


Fig. 5. Cell delay versus time when station 1 is loaded with a step of bulk traffic (3 s long) starting at 1000 ms.

Station 1 receives a constant burst of bulk traffic equal to 20% of the channel capacity. All the other stations continue to receive the same input traffic. The burst ends after 3 s. The figure plots cell delay versus time for interactive and bulk traffic for both stations 1 and 2. Both systems react well to the transient load, increasing the delay of the overloaded station only, while the other ones remain unaffected. It must be noted, however, that FODA/IBEA is able to absorb bursts requiring throughput up to half the channel capacity from a single station, while CFRA can do the same only for about 1/4 of the channel capacity, specifically a quote equal to R_{max} / 128. An indication of CFRA's lower capacity to handle unbalanced traffic is the slope of the delay when the system recovers from the burst, which is higher for FODA/IBEA, highlighting a faster reaction.



6a) Interactive delay



6b) Bulk delay

Fig. 6. Cell delay versus interactive data percentage of the channel load for overloads 3 and 9 of the first three stations.

Figure 6 shows the ability of the access schemes to handle unbalanced traffic. The traffic of each station occupies the 1.40% of the channel capacity (base load), for a total traffic equal to the 22.5% of the channel capacity. In addition, stations 1, 2 and 3 receive an overload input traffic which is 3 and 9 times the base load. Highly unbalanced traffic loads are prohibitive for CFRA when the interactive fraction of the channel load exceeds 25%, while FODA/IBEA is not subject to this effect.

5 Conclusions

Both systems have shown a good capability to handle mixed bursty traffic composed of both low-burstiness interactive and high-burstiness bulk traffic.

By using the composite traffic generator, it results that CFRA performs better for both interactive and bulk traffic at low-to-medium channel loads when the stations have a similar traffic intensity. On the other hand, FODA/IBEA is able to handle high channel loads, and is fairer when different stations offer significantly different traffic loads. However, since the systems are comparable, further work was required to assess their ability to handle different patterns of traffic from those already tested. In [7] also the results of the comparison when a fractal traffic generator is used are reported.

It can be concluded that CFRA is more suitable for connecting the clusters of only a few stations and even individual ones, via a satellite network, and it would also perform well at connecting loosely related networks. FODA/IBEA, on the other hand, is better suited to internetworking closely related local area networks, with heavy traffic in between. FODA/IBEA also performs better under heavy loads, which is typical of traffic among networks with many hosts.

In addition to the results reported here, it is worth mentioning some features that have not been considered in the simulation work.

CFRA only supports CBR traffic, while FODA/IBEA also supports VBR traffic. In addition, FODA/IBEA implements a fade countermeasure technique in TDMA which makes it particularly suitable for working in the 20/30 GHz band, where the signal attenuation due to bad atmospheric conditions has a heavy impact on the performance of the transmission system. CFRA, on the other hand, does not consider any TDMA fade countermeasure techniques.

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