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Throughput–complexity trade-off for ABR traffic in an ATM satellite network under cell loss constraints

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Abstract

This work refers to an ATM satellite system, supporting different QoS classes via the standard ATM traffic categories, i.e. Constant Bit Rate (CBR), Variable Bit Rate (VBR), Available Bit Rate (ABR) and Unspecified Bit Rate (UBR). The focus of this work is on ABR (i.e. closed loop control) and the central issue is to find trade-offs between a high ABR throughput and processing burden/buffer space required on board satellite, under the constraint that no buffer overflow occurs. ABR fairness issues are not central to this work and hence are not considered.

The focus of the paper is to evaluate how adaptive prediction of higher priority CBR/VBR traffic can enhance ABR traffic performance, with respect to a simpler worst case based approach. Results show that a significant improvement of performance can be obtained even with rather straightforward prediction algorithms. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: ATM satellite communications; Available bit rate traffic; Reactive congestion control; Traffic prediction

1. Introduction

A large interest is currently addressed towards the convergence between Asynchronous Transfer Mode (ATM) and satellite technologies [1–6]. Satellite systems are inherently able to provide interconnection functions over a wide geographical area (including remote, urban and rural) and to potentially support high bandwidth communications. Further advantages can be achieved by using the broadcast capabilities and configuration flexibility of the satellite systems and the on-demand bandwidth access flexibility of ATM [2].

A critical issue in a satellite environment is efficient exploitation of the link bandwidth, yet supporting different QoS classes. In the context of ATM, traffic management functions have been specified by ITU-T and ATM Forum [7,8], based on the definition of a number of service categories: Constant Bit Rate (CBR), Variable Bit Rate (VBR), Available Bit Rate (ABR) and Unspecified Bit Rate (UBR). Real time traffic can be carried by means of CBR/VBR connections; these traffic are given priority over other traffic categories, namely ABR and UBR, to meet the strict performance requirements, especially as for delay and delay jitter. However, high media utilization requires efficient exploitation of the spare bandwidth, including the one left unused by high priority CBR/VBR traffic, due to source activity (i.e. actual usage of assigned capacity may be less than 100% for a CBR/VBR connection [13]). ABR and UBR traffic categories lend themselves to such statistical multiplexing, but ABR should also offer some QoS guarantees, i.e. essentially lossless cell transfer (no buffer overflow) for delay insensitive data.

ABR uses a feedback control loop per ABR Virtual Connection (VC) between data source and destination to control the congestion phenomena that statistical multiplexing can cause. Application of such a congestion control strategy to a satellite environment is critical due to the very large propagation delay of the satellite hop and the affordable complexity on board satellite, both as for buffer space and processing power.

The specific focus of this paper is on the definition and evaluation of an ABR *Explicit Rate* (ER) computation algorithms, based on the exploitation of an adaptive prediction scheme to account for the real activity of CBR/VBR traffic. The ABR capacity computation algorithm is aimed at avoiding on board ABR buffer overflow. Since emphasis is on the

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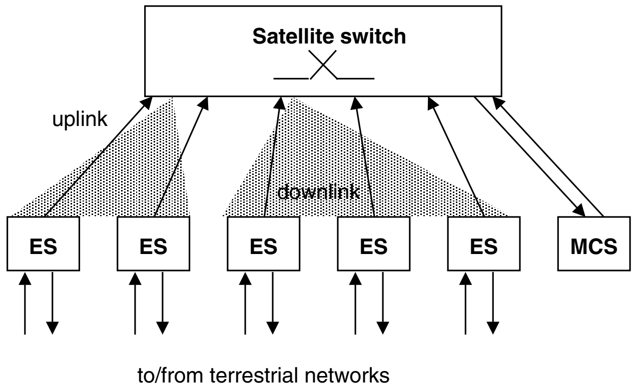

Fig. 1. Satellite systems and its component parts.

ability of increasing ABR throughput with as minimum as possible a priori knowledge of the high priority CBR/VBR traffic and on board resource (buffer space and processing power), fairness is not a prime issue in the present context and no special consideration has been devoted to complex fair algorithms for sharing the ABR bandwidth among many sources. Motivation for this study arose in the framework of a pilot project carried out under the support of European Space Agency (ESA), including the realization of an emulation testbed of the satellite system and a field trial.

The content of the paper is structured as follows. In Section 2 we briefly outline the overall system architecture and operation. In Section 3 we introduce the prediction based algorithm to evaluate the ABR allowable bandwidth. Section 4 is devoted to the performance analysis, obtained by means of simulations. Section 5 summarizes the main results of this work.

2. System architecture

The basic assumptions of the considered network scenario are:

(i) the system is composed of a regenerative, multiple spot, GEO *Satellite* (SAT) with on board ATM switching capabilities;
(ii) each spot covers a set of *Earth Station* (ESs), an ES can be ATM end systems or can perform interworking functions between terrestrial and satellite ATM network;
(iii) control and supervisory functions are carried out by a *Master Control Station* (MCS); SAT is not involved in any connection control and bandwidth allocation functions;
(iv) the satellite system is designed to support the ATM service categories defined by ITU-T and ATM Forum, namely, CBR, VBR, ABR and UBR [7,8].

Fig. 1 depicts the overall structure of the satellite system. An in-depth description of the architecture of the ATM satellite system is given in Ref. [9].

To avoid excessively large round trip delays in the end-to-end ABR control loop when including the satellite system, the ESs could be provided with Virtual Source/Virtual Destination capabilities. Actually, this is consistently assumed in the following, even if the specification "virtual" is dropped for the sake of simplicity.

Traffic handling in the satellite system is carried out according to whether real time or non real time traffic is concerned. A picture of the traffic handling functional block diagram of the satellite system is shown in Fig. 2. Service priority is given to CBR/VBR cells over ABR cells, both in the uplink and downlink. Further, ABR cells have priority over UBR cells, so that in the following UBR connections can be neglected.

ABR traffic is rate controlled by a closed loop signalling, supported by so called Resource Management (RM) cells and the Explicit Rate (ER) paradigm is here considered [7,8]. The ABR closed loop segment involving the satellite system is referred to as Reactive Congestion Control (RCC) in the following. A modification of the standard signalling scheme based on RM cells is defined in the RCC, by adding one field to RM cells in the satellite segment (RMsat cells) [9]. As a result, the round trip time of the ABR control loop includes only one satellite hop.

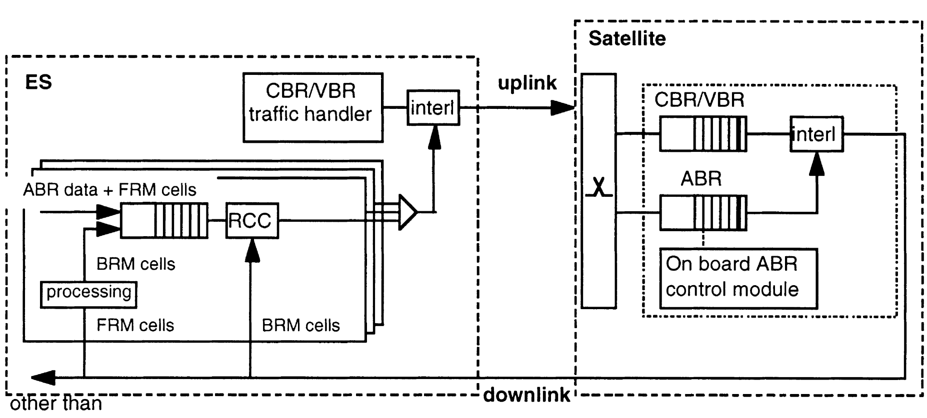

Fig. 2. Functional block diagram of traffic handling in the satellite system.