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Control-based Connection Admission Control and Downlink Congestion Control procedures for satellite networks ☆

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Abstract

This paper focuses on the resource management procedures for a geostationary (GEO) satellite system. The objective of these procedures is the efficient exploitation of the link resources, while assuring the agreed Quality of Service to the traffic entering the satellite network. The main novelties are (i) the integration between Connection Admission Control and Downlink Congestion Control procedures, and (ii) the original adaptation of Kalman filtering theory to cope with these procedures. The proposed solution is validated by simulations.

Keywords: Resource management; Connection Admission Control; Congestion Control; Satellite networks; Kalman filtering

1. Introduction

Control-based modelling and methodologies are becoming extremely important as powerful tools for dealing with networking problems of recent multimedia communication networks. Even more, the authors consider telecommunication networking as one of the

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most promising areas for development and application of control-based concepts. In fact, standard communication methodologies (e.g. queuing theory) demonstrate some limits in coping with the complex multimedia networking problems. Conversely, essential (high-level) networking dynamics can be satisfactorily caught by a proper control-based modelling; even more, control methodologies such as game theory, predictive control, and robust tracking are demonstrating enough flexibility to efficiently cope with communication problems. In particular, the *resource management* of multimedia-based communication networks is particularly suitable for the application of control-based methodologies ([2–4]).

Recent multimedia networks are characterized by a large amount of connections generating traffic often characterized by high burstiness (namely, the ratio between the traffic variance and the traffic mean), which is hardly predictable (i.e., it can be hardly modelled). In addition, a key concept of recent multimedia networks is that the network has to satisfy Quality of Service (QoS) requirements (in terms of bandwidth, transmission delay, and packet loss); each connection type (e.g., voice, ftp, web, etc.) is characterized by its own peculiar QoS requirements. In this respect, by resource management we mean the set of procedures aiming, on the one hand, at maximizing the resource exploitation (in particular, the transmission capacity) and, on the other hand, to meet all the connection QoS requirements. The problem is challenging due to the variety of connection QoS requirements, the bursty nature of the considered traffic, the complexity of the considered networks, and the requirement of keeping the signalling overhead limited.

With respect to *wired* terrestrial networks, resource management is even more important in a *wireless* framework, due to the limitation of the available bandwidth. Geostationary (GEO) satellite systems are characterized by very limited (and hence highly valuable) capacity availability, and the system architecture is complex due to the presence of two different wireless links (the uplink from the ground terminal to the satellite and the downlink in the opposite direction) and of a plurality of uplink/downlink spot-beams. Moreover, satellite payloads have limited processing capabilities, so that on-board complex and/or heavy computations have/has to be avoided. Finally, resource management procedures have to consider the large propagation delay of satellite links (about 250 ms from the transmitting terminal to the receiving one).

As for QoS, whenever a communication network accepts the set-up of a connection, the network has to meet the QoS requirements characterizing the *Class of Service*[1] the connection in question belongs to. The main QoS requirements of a generic Class of Service are: (i) *Bandwidth requirements*, specifying the minimum bandwidth to be guaranteed in any traffic condition; (ii) *Packet Delay requirements*, specifying the maximum tolerated Packet Transfer Delay (PTD) from the transmitting terminal to the receiving one; and (iii) *Packet Loss requirements*, specifying the maximum tolerated Packet Loss Ratio (PLR) from the transmitting to the receiving terminal. Connections with no QoS requirements belong to the so-called Best-Effort (BE) Class of Service. In this paper, BE connections will be considered as belonging to a Class of Service with minimum bandwidth equal to zero and maximum PLR and PTD equal to infinity.

This paper deals with some key aspects of resource management for multimedia satellite systems. Our attempt is to demonstrate how this problem can be effectively coped with by using control-based tools to model some key aspects of the considered system and

[1]A Class of Service identifies a group of connections characterized by the same QoS requirements.