Network Control in ATM-Based LEO Satellite Networks

PETIA TODOROVATodorova@fokus.fraunhofer.de
FHG-Fokus, Kaiserin-Augusta-Allee 31, 10589 Berlin, Germany

Abstract. Low Earth Orbiting (LEO) satellite networks with on-board asynchronous transfer mode (ATM) switches hold the promise of offering an economically viable extension of terrestrial ATM systems by providing connectivity to areas where existing terrestrial networks are either infeasible or impractical. Network management in ATM LEO satellite networks is typically performed by the Network Control Center (NCC). The main contribution of this paper is to propose a network management system configuration with a standby solution and to describe an experimental Satellite Management Information Base (SMIB) that we have developed for implementation in ATM LEO satellite networks.

Keywords: ATM LEO satellite network, Network Control Center, Satellite Management Information Base

Introduction

Recent years have seen two major developments in telecommunication networks and services. On the one hand, asynchronous transfer mode (ATM) has proven itself as a reliable transport mechanism in terrestrial fiber-optic-based networks supporting Quality of Service (QoS) guarantees to a vast user community. Consequently, there has been a tremendous amount of effort involved in the design and use of terrestrial fiber-optic-based ATM networks serving a growing community of users that demand high-speed and QoS guarantees. On the other hand, it was noted that satellite networks hold the promise of providing effective and inexpensive global coverage, providing connectivity in areas where existing terrestrial networks are either infeasible or impractical to deploy [Blefari-Melazzi and Reali, 4; Compareto and Ramirez, 6; Hu and Li, 12; Hung et al., 13; Iera et al., 14; Jamalipour, 15; Mertzanis et al., 17]. An important new development in satellite technology is the emergence of LEO satellites deployed at altitudes ranging from 500 Km to 2000 Km. LEO satellites feature low propagation delays as well as low power requirements, allowing hand-held devices to interface directly with the system. It is anticipated that in the near future LEO satellite systems will feature low cost-per-minute utilization charges, making them ideally suited for the ever-growing market of Personal Communication Services (PCS) [Chitre and Yegenoglu, 5; Compareto and Ramirez, 6; Hu and Li, 12; Jamalipour, 15].

The communication infrastructure of the future will be characterized by the seamless integration of LEO satellite networks with broadband networking technologies in order to support mobile multimedia services and global coverage. A key role in
this integration effort will be played by the deployment of ATM as the basic transport mechanism in support of Broadband-Internet, Broadband-ISDN and other technologies. The idea of endowing LEO satellites with on-board ATM switching capabilities is novel and combines the advantages of LEO systems with those offered by ATM including faster transmission rate, bandwidth on-demand, compatibility with previous existing protocols and guaranteed QoS. The recent literature contains numerous proposals for moving the centralized, earth-based, traditional ATM paradigm into ‘the sky’, by placing ATM switches in LEO satellites. Many of these papers discuss in detail various architectural issues and protocols for ATM LEO satellite networks including multiple access, resource management, admission control and related implementation issues [Blefari-Melazzi and Reali, 4; Chitre and Yegenoglu, 5; Compareto and Ramirez, 6; Delli Piccoli, 9; Hu and Li, 12; Iera et al., 14; Jamalipour, 15; Mertzanis et al., 17]. However, to the best of our knowledge, the important issue of network control was not addressed thus far.

A typical ATM LEO satellite network comprises a ground-based segment, a satellite-based segment as well as a Network Control Center (NCC). Network management is performed by the NCC with the help of the on-board S-ATM switches and provides the overall control of the ATM LEO satellite network.

The main contribution of this work is to examine basic NCC requirements in ATM LEO satellite networks. We go on to propose an architectural configuration for a network management system with a stand-by solution and investigate the protocol stack to be implemented in the network control. Finally, we describe an experimental Satellite Management Information Base (SMIB) that we have developed for implementation in ATM LEO satellite networks [20].

The remainder of this work is organized as follows. The first two subsections of section 1 set the stage for our solution by discussing basic network management requirements in ATM LEO satellite networks. The last two subsections of section 1 spell out in detail our proposed architectural configuration for a network management system. Section 2 proposes the details of our management interface reference architecture. Section 3 presents our view of the protocol stack to be implemented in the NCC. Section 4 discusses the details of our experimental SMIB. Section 5 describes implementation issues. Section 6 offers concluding remarks and directions for future investigations.

1. Network management systems

1.1. Basic architectural assumptions

We assume that for each S-ATM switch there is a one to one relationship between physical ports and beams and that each beam has at least one downlink carrier. We also assume that one terminal supports one carrier. The baseline LEO system involves a constellation of satellites deployed in a number of polar orbits. As an illustration, the Motorola Iridium system involves 66 satellites deployed in six polar orbits [Chitre and Yegenoglu, 5]. The connectivity between satellites is provided by Inter Satellite Links (ISLs). Specifically, each satellite is connected by ISLs to four satellites: two neighboring satellites in