ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2010. No. 1(97)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 125 AUTOMATION, ROBOTICS
AUTOMATIZAVIMAS, ROBOTECHNIKA

Multi Layered-Hierarchal Satellite System

M. Husár
Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava
R. Volner
Department of Informatics, Pedagogical faculty, The Catholic University in Ruzomberok,
Nám. A. Hlinku 56/1, 034 01 Ružomberok, e-mail: rudolf.volner@fedu.ku.sk

Introduction

Satellite systems have the advantage of global coverage and inherent broadcast capability, and offer a solution for providing broadband access to end-user. This paper proposes a multilayered satellite conception and the most powerful routing protocols for such systems as traditional satellite systems seem to be forceless for these brand new challenges.

Global Feature Plane

The Global Feature Plane offers a simplified view to the networked multimedia system, suitable for an application designer. Within the service logic many aspects of multimedia communication are hidden by abstractions which we call Application Building Block (ABB). These Application Building Blocks are software objects which offer the needed logical view via their operations. They are used by the application objects that are written by the application designer. We offer seven Application Building Blocks on the Global Feature Plane of our Multimedia Reference Model. These seven ABBs are shown on the right side of Fig. 2, which outlines their use in a multi-user game application. This Fig. only indicates the 'use' relation between an application instance, i.e. multi-user game, and the ABBs. It does not give a complete specification of a service logic and of the timely order of the invocations.

In the following, we describe as an example the communication control object class which is a very important one. The operations forming its public interface are:

- *changeTopology,* which adds respectively removes a new construct to respectively from a session, i.e. a medium, a relator, a
- synchronization relation, or even creates a complete session. The relator is an enhanced version of the Touring Machine.
- *changePrivilege,* which supports a wide variety of communications privileges of the participants in an application. Besides the classic privileges “read” (i.e.
- also 'listen' or 'watch') and write (Le. also 'speak' or 'show'), sophisticated ones are provided like 'read but not copy'.
- *changeQuality*, is used for the modification of quality of service characteristics (such as bandwidth, delay, jitter, or synchronization). Additionally, the required confidence of communicated data is arranged with this operation.
- *setDP* makes the explicit event handling for the multi-user, multimedia session possible. Detection points (DPs) can be activated for a collection of session events. If the corresponding event occurs, the DP fires and the communication control object informs the service logic. The basis of our DP mechanism are the ITU- T recommendations for IN.

Architecture

A combination of different layers of satellites can provide a more efficient network with better performance then these layers individually. The core grid layer is formed by the satellites situated at MEO and GEO constellation, in which the function of core and switching as well as the access are implemented. An intelligent access grid layer is formed by LEO satellites, in which the function of CAC (Connection Access Control) is implemented. An autonomous area indicated by area A or B in Fig. 1 is formed by a center satellite node and its adjacent nodes. A communication link must be available between any adjacent nodes.

Communication

Satellites in the same layer are connected to each other via inter-satellite links (ISLs), while the communication between different layers is accomplished over inter-orbital links (IOLs). The sources and destination of information are assumed to be gateways on the Earth. Satellites communicate with terrestrial gateways through user data links (UDLs). Each link in the network is associated with *delay* and *cost* metric. The delay of a link includes processing, propagation and queuing delays. The cost of the link is related to the available bandwidth and the type of the link in the satellite network.

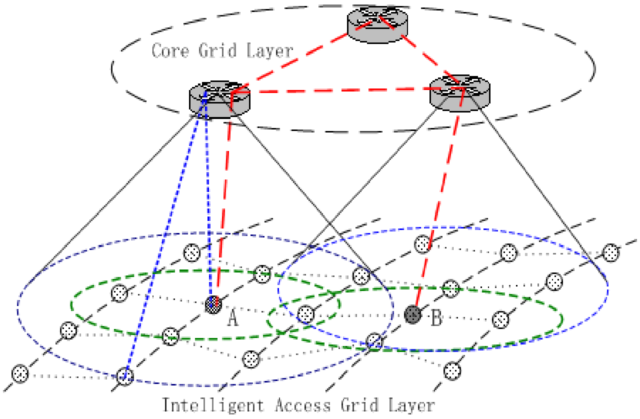

Fig. 1. Hierarchal three-dimensional architecture of satellite-based system

Routing processing

In multi-layered hierarchal satellite system packets are being processed and re-distributed individually in every satellite on their way. The connections must be established and maintained in the satellite network, which is very dynamic environment. Therefore, this is so called connection-less routing system. Routing decisions are stored in routing table's onboard satellites directly. These tables must be updated periodically to sustain highest level of performance. Several routing algorithms were proposed for this.

Routing algorithm for 3 dimensional satellite system

The Multi-Layered Satellite Routing algorithm (MLSR) [1] was designed for a satellite network that consists of satellites in three layers. In MLSR, the logical location concept is used to isolate the mobility of the LEO satellites from the satellites in upper layers. The LEO satellites in the coverage area of a MEO satellite form a LEO group. All LEO satellites in a LEO group are managed by the MEO satellite that covers them. Similarly all MEO satellites in coverage of a GEO satellite form a MEO group. In order to reduce huge computational complexity in satellites and the communication load in the network, all satellites of LEO group are presented as one node for particular GEO satellite. Satellites groups are shown in Fig. 2 and following view of GEO satellite is proposed in Fig. 3.

Each GEO satellite calculates the routing tables for all MEO satellites and LEO groups in its coverage. Upon receiving the routing table of its LEO group from the GEO satellite, each MEO satellite generates individual routing tables for the LEO satellites in its LEO group. Only one LEO satellite communicates with adjacent nodes and MEO satellite through summary link computed by relevant calculation. This is very efficient way of packet routing in 3 dimensional satellite networks.

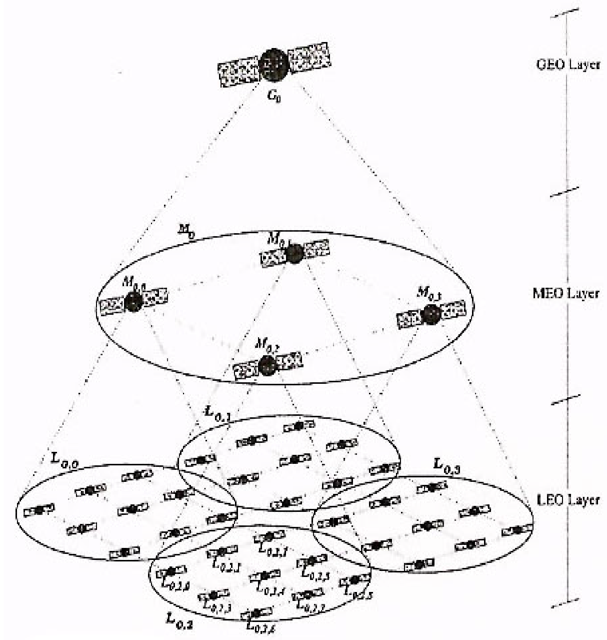

Fig. 2. Satellites groups

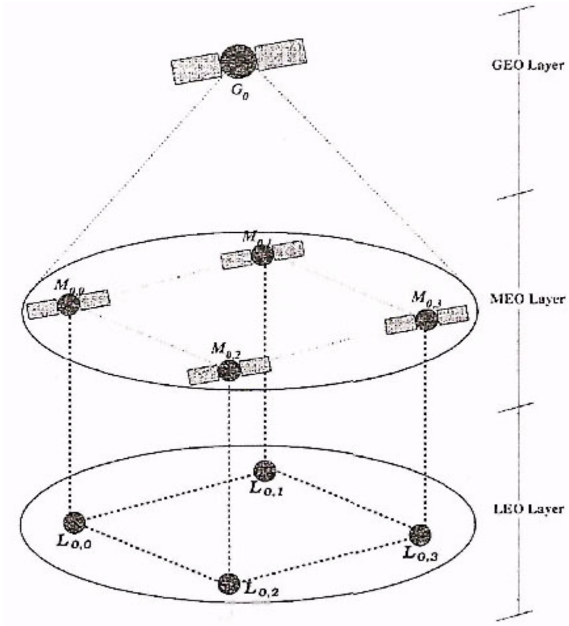

Fig. 3. GEO satellite view

Routing algorithm for 2 dimensional satellite system

The purpose of Satellite grouping and routing protocol (SGRP) protocol is to forward packets with minimum delay and distribute routing tables to multiple MEO satellites. SGRP protocols operate just with LEO and MEO satellite layers. The LEO constellation is assumed to be Walker Star, but not obligate. The SGRP protocol divides all networks due to snapshots performed by MEO satellites. The MEO footprints are needed to determine the group membership of LEO satellites. The snapshots are created duo to following criteria.

Distributed Hierarchal Routing Protocol

Distributed Hierarchal Routing Protocol (DHRP) also gathers the topology information within the plane firstly, and then exchanges the summary information within whole constellation as SGRP. But in DHRP, the task of routing table calculation is performed by so-called plane speaker, which is voted by other satellites in the same plane. DHRP divide whole network into planes as discripted below.

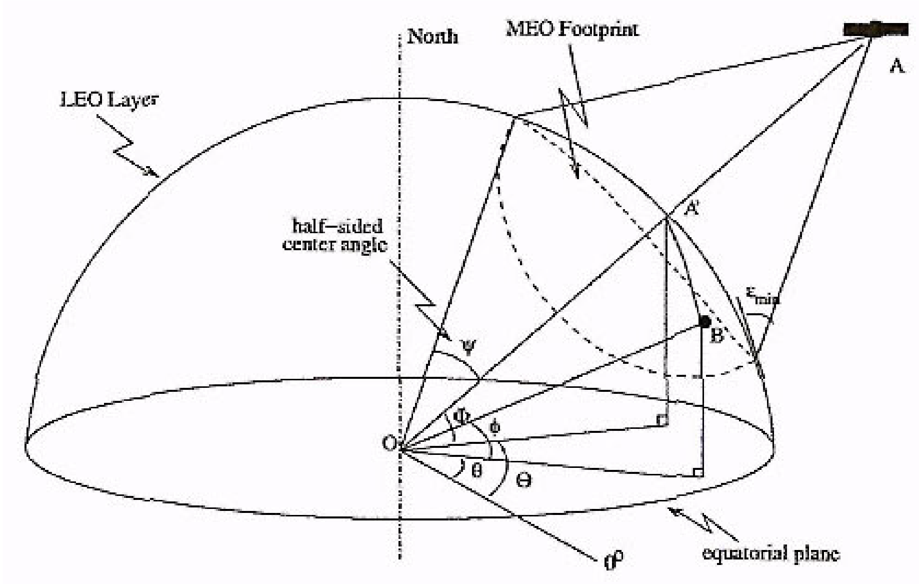

Fig. 4. MEO satellite footprint

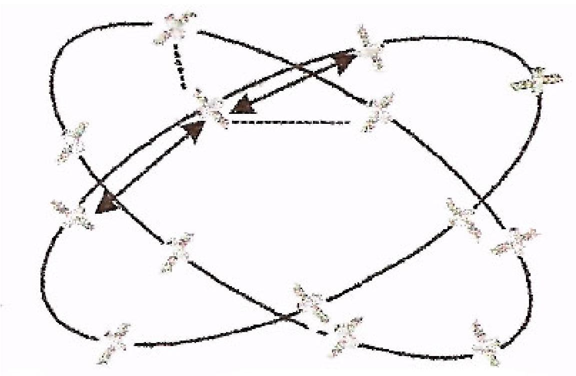

Fig. 5. Planes with so-called plane speaker

Advantage of this topology is that there is no „2D philosophy“ how to divide the network. All satellites, also the MEO layer, are divided into the planes. This provides more efficient link delay calculations and routing tables distribution. DHRP reaches up better results then SGRP.

Conclusion

In this paper, we introduce a conception of IP network consisting of LEO, MEO and GEO satellite layers together with several routing protocols designed for multilayered systems. As described above, only MLRS protocol can operate with 3 layered network, but obviously as the most powerful routing algorithm seems to be DHRP. In present there does not exist any of proposed systems in our space. Also this would be very expensive project for setting up, therefore only 2 dimensional networks are across to be functional in near future. But if satellite providers want to be able to offer fully broadband services, this conception is the most effective solution for establishment.

References

1. **Jianjun B., et al.** A Distributed Hierarchal Routing Protocol for Non–GEO Satellite Networks, 2004.
2. **Chen CH., et. al.** Satellite Grouping and Routing Protocol for LEO/MEO Satellite IP Networks, 2002.
3. **Akyilydz F., et. al.** MLRS a Novel Routing Algorithm for Multilayered Satellite IP Networks, 2002.
4. **Tichá D.** Analog Filter Design Based on Evolutionary Algoritms // International Review of Electrical Engineering. – May–June, 2008. – Vol 3. No. 3. – ISSN 1827–6660. – P. 566–572.
5. **Tichá D.** A Design of Filters with Distributed Losses Using DE Algorithms // Proceedings of 16th International Conference Radioelektronika, 2006. – Bratislava: Faculty of Electrical Engineering and Information Technology SUT, Dept. of Radio&Electronics. – ISBN 80–227–2388–6. – P. 46–49.

Received 2009 03 16

M. Husár, R. Volner. Multi Layered-Hierarchal Satellite System // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 1(97). – P. 49–52.

Satellites will continue play a major role in the implementation of the Next Generation Internet (NGI). In term of defensibility of contemporary satellite systems it is necessary to make their working more effective. This thesis is about the new conception of satellite systems (particular about multilayered / hierarchal satellite networks). The purpose of my thesis is to analyze the architecture of such networks and to describe and compare actually proposed routing protocols for these systems. I also deal with advantages (and disadvantages) of multilayered satellite systems. Ill. 5, bibl. 5 (in English; abstracts in English, Russian and Lithuanian).

М. Гусар, Р. Волнер. Исследование многоступенчатой иерархической спутниковой системы // Электроника и электротехника. – Каунас: Технология, 2010. – № 1(97). – С. 49–52.

Описываются возможности повышения эффективности спутниковых систем. Анализируются архитектура и новые маршрутные протоколы. Указаны преимущества и недостатки разработанных систем. Ил. 5, библ. 5 (на английском языке; рефераты на английском, русском и литовском яз.).

M. Husár, R. Volner. Daugiapakopės hierarchijos palydovinės sistemos tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 1(97). – P. 49–52.

Kuriant naujos kartos internetą palydovai vaidina svarbų vaidmenį. Dabartiniu metu siekiama padidinti palydovų efektyvumą. Čia analizuojamas naujos kartos, t. y. daugiapakopės hierarchijos, palydovinės sistemos. Analizuojama tinklų architektūra, apibūdinti ir palyginti siūlomi maršrutizavimo protokolai. Aptarti tokių sistemų privalumai ir trūkumai. Il. 5, bibl. 5 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).