Resource Allocation Methods for Control Packets in Converged Satellite and Terrestrial Networks

Kwang-Chun Go†, Mi-Jeong Hoh‡, Jae-Hyun Kim†
Ajou University†, Agency for Defense Development‡

Abstract

A converged satellite and terrestrial network (CSTN) can be used for globally unified networking in areas where there is no infrastructure. However, the different characteristics between a satellite network and a terrestrial network lead to research on converged network architectures, data transmission methods, resource managements, and etc. In this paper, we deal with these research issues in terms of efficient routing of user data and the employment of routing protocols in the CSTNs. Especially, we concentrate on the resource allocation for control messages on satellite links.

I. Introduction

In military space, it is important to configure communication networks rapidly, because the information sharing on the state of combat area can be critical to military operations. A satellite communication is a key technology that can help to communicate in shadow areas where there is no infrastructure. The satellite communications is good way to overcome the limitation of geographical features in tactical area.

In recently, the converged satellite and terrestrial networks (CSTNs) have been studied to make up the deficits of terrestrial networks [1]. The CSTNs can reduce the network configuration time as well as shadow areas. Also, the CSTNs can improve the reliability of data transmissions.

The digital video broadcasting by satellite (DVB-S) and the digital video broadcasting return channel via satellite (DVB-RCS) have been proposed for commercial networks [2], [3]. DVB-S and DVB-RCS systems provide digital television broadcasting services and interactive broadband communications. A satellite terminal offers an Ethernet interface to users that can be used for interactive internet protocol (IP) connectivity. IP terrestrial networks are connected to DVB-RCS networks through gateway stations. In DVB-RCS networks, most of terminals are static. Thus, DVB-RCS system supports static routing and may optionally support dynamic routing [3].

However, terminals in the tactical networks can move around the operation areas. The network topology can be changed dynamically. Thus, the static routing in DVB systems is not appropriate for tactical networks. Therefore, the dynamic routing should be applied for efficient routing in the CSTNs.

In the literature, there have been several key issues to integrate satellite networks and terrestrial networks; e.g., network architecture design, employment of dynamic routing protocol, mobility management, and resource allocation. In existing work, authors dealt with network architecture and dynamic routing protocol [4]. In these work, authors focused on the network architecture design and modification of the dynamic routing protocol in CSTNs. Especially, the authors considered the signaling process for connection setup between satellite terminals, control overhead for exchange of control packet, and mobility management. However, resource allocation for control packet was not considered. The satellite

Table I. Control Packets and Functions in OSPF

Packet type	Functions
Hello	- To establish and maintain neighbor relationships - Send periodically on all interfaces: Default 10 seconds
Database Description	- To send the complete database - Exchange the message when an adjacency is initialized
Link State Request (LSR)	- To request link state - When a router finds that parts of its database is out-of date
Link State Update (LSU)	- To send the link state - When a router receive a LSR or link state is changed
Link State Acknowledgement (LSA)	- To acknowledge the LSU

links have limited bandwidth. Thus, it is important to allocate resources of satellite links appropriately. In this paper, we deal with resource allocation methods for control packets in satellite links.

Ⅱ. Resource Allocation Methods

In dynamic routing protocol, the control packets for connection setup and maintenance occurs frequently. For example, OSPF generates the five types of control messages frequently as shown in Table I [5]. Thus, an appropriate resource allocation method is required for the transmission of the control messages. We consider three resource allocation methods and compare the characteristics among these methods as shown in Table II. The satellite networks which use multi-frequency time division multiple access (MF-TDMA) as a medium access scheme may use a demand assigned multiple access (DAMA) method and a random access (RA) method to allocate channel resource. When using the DAMA, satellite networks allocate resources to a satellite terminal for service traffic and the control messages, respectively.

In the first method, a satellite terminal requests traffic channel resources when the OSPF packets are generated. For example, the satellite terminal requests resources for the initial connection setup, the transmission of periodically-generated OSPF packet, and routing information update. This method can improve channel utilization because an NCC or a hub assigns only required resources. However, a satellite terminal needs additional time for the resource allocation to transmit the OSPF packets. Therefore, the first method is appropriate for the consecutive packet transmission such as initial connection setup.

The second method exploits a control channel to transmit the OSPF packets. In the control channel, a control packet is periodically generated. The OSPF packets can be piggybacked on the control packet. In this method, the OSPF packets may not experience the additional time for the resource allocation. However, more resources should be assigned for the control channel when compared with the first method. Thus, resource utilization can be worse than the first method. Therefore, this method is appropriate for tiny and periodically-generated packets.

The last method is to use an RA channel. A satellite terminal can transmit OSPF packets by competing with other satellite terminals. This method does not suffer from the overheads for resource allocation, but transmission reliability can be reduced due to the collision between transmitted packets. With this regard, the authors have developed the reservation-based slotted ALOHA [6]. The reservation-based slotted ALOHA such as reservation-slotted

Table II. Resource Allocation Methods for Control Packets in Satellite Links

Resource allocation method		Characteristic	Advantage	Disadvantage
Demand assignment	Traffic channel	Perform resource allocation every packet generation	Good channel utilization	Overhead for resource allocation
	Control channel	Fixed channel resource for synchronization and resource request	No additional times for resource allocation	Decrease channel utilization
Random access		Compete for medium access	No overhead for resource allocation	Low transmission reliability

ALOHA (R-SA) and reservation-contention resolution diversity slotted ALOHA (R-CRDSA) can improve the transmission reliability, throughput, and channel utilization in the satellite networks.

Ⅱ. Conclusion

In this paper, we considered three resource allocation methods for control packet of dynamic routing protocol in satellite links. For efficient routing in CSTNs, a number of issues should be considered pertaining to a network architecture, the exchange of the control packets, mobility management, and the resource allocation of satellite links. For employing CSTNs to tactical networks, more research is needed to discover issues and solutions.

Acknowledgment

This work has been supported by National GNSS Research Center program of Defense Acquisition Program Administration and Agency for Defense Development.

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