Performance Evaluation 87 (2015) 37–46

Contents lists available at ScienceDirect

Performance Evaluation

journal homepage: www.elsevier.com/locate/peva

An efficient utilization of intermittent surface–satellite optical links by using mass storage device embedded in satellites

Kazuma Kaneko [a,*], Yuichi Kawamoto [a], Hiroki Nishiyama [a], Nei Kato [a], Morio Toyoshima [b]

[a] Graduate School of Information Sciences, Tohoku University, Sendai, Japan

[b] Wireless Network Research Institute, National Institute of Information and Communications Technology (NICT), Tokyo, Japan

ARTICLE INFO

Article history:
Available online 30 January 2015

Keywords:
Satellite networks
Optical communication
Mass storage device
Traffic control

ABSTRACT

Recently, earth observation system by using satellite network has attracted much attention due to its wide coverage and disaster resistance. Although the system is useful for collecting various data, which have an effect on a natural disaster, ecology and so forth, earth observation satellite hardly send the collected observation data to the ground station. This is because that the earth observation satellite needs to orbit near surface of the earth to get high-precision data, and it limited the time that can be used to send the observed data traffic to the ground station. Additionally, the amount of the observed data drastically increase in these days. Thus, we focus on the data relay satellite using optical communication in this network. By relaying observed data to traffic to the relay satellite, which has geostationary orbit, it is possible to increase the chance of sending data for the observation satellite due to the wide coverage of the relay satellite. In addition, laser light that is used in optical communication in satellite network has high frequency and it can deliver large data compared with radio wave. However, laser light is greatly influenced by atmosphere, and optical link capacity between satellite and ground station drastically changes according to weather condition. Therefore, we propose a new data traffic control method to use the network constructed by satellites which has mass storage device effectively according to the condition of optical downlink between satellite and optical ground station. The effectiveness of the proposed method is evaluated with numerical result.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Recently, it is mentioned that damage caused by extreme weather such as heavy rain and extreme heat poses a serious problem to human society. Additionally, threat of natural disasters such as earthquake and tsunami is known to greatly affect the life of disaster victims. In order to correctly and promptly predict and deal with these drastic problems, the causes of these problems need to be understood. With the development of satellite networks, it is possible for researchers and others to gain access to the information, such cloud formations that can lead to heavy storm or check the damages caused by natural disaster in order to provide better disaster relief services. Additionally, satellites which are orbiting near surface of the earth

* Corresponding author.
E-mail addresses: kaneko@it.ecei.tohoku.ac.jp (K. Kaneko), youpsan@it.ecei.tohoku.ac.jp (Y. Kawamoto), bigtree@it.ecei.tohoku.ac.jp (H. Nishiyama), kato@it.ecei.tohoku.ac.jp (N. Kato), morio@nict.go.jp (M. Toyoshima).

http://dx.doi.org/10.1016/j.peva.2015.01.004
0166-5316/© 2015 Elsevier B.V. All rights reserved.

are able to observe global environment in detail. One of the earth observation satellites named Advanced Land Observing Satellite (ALOS) is launched in 2006 by Japan Aerospace eXploration Agency (JAXA) and ALOS made a great contribution by checking the damage of the tsunami at East Japan Catastrophic Disaster in March 2011 [1]. While satellites are used for earth observation all over the world, satellites have serious problem in that the amount of time that it can communicate with the ground base station is limited due to the fast orbital speed of the satellites. Although the satellites are able to buffer the data that cannot be sent to the ground base station immediately, it is important to be able to quickly send the data to the ground base station because those data are not useful until they actually reach the ground base station. Due to this reason satellite communication that uses laser light instead of radio wave has attracted much attention because of the feature of its ability to deliver a large amount of data. Furthermore, it is possible to improve the performance of earth observation satellites downlink by using the concept of data relay satellite. The data relay satellite, which has high altitude and large coverage area makes it possible to extend the time that earth observation satellite can send the observed data traffic to the ground station by relaying the data. In recent years, to realize a more efficient earth observation satellite system, the data relay satellite that uses laser light to communicate with other satellites and ground stations is becoming mature enough for practical use. In fact, European Space Agency (ESA) developed Advanced Relay and Technology Mission (ARTEMIS), which is a data relay satellite for optical satellite experiment. However, optical communication has an important problem in that they are easily affected by weather condition. This is because light refracts from the edge of different refractive index profile in atmosphere. Therefore, the link condition of the link between satellite and ground station is affected by the weather and unstable due to the laser having to travel through atmosphere. In the case of the earth observation satellite system using the data relay satellite, it is not only optical link between earth observation satellite and ground station but also optical link between the data relay satellite and ground station that is affected by weather condition. Therefore, in this research, we propose the new traffic control method for earth observation satellite system to effectively send the observed data traffic to ground station.

The assumed satellite constellation is presented in Section 2. In addition, the existing research for optical communication are introduced in this section. Section 3 describes our proposed method to effectively send the observed data traffic to the ground station. Section 4 contains an evaluation of the required time which earth observation satellite needs to send all observed data to the ground station in our proposed method. Finally, concluding remarks are provided in Section 5.

2. Earth observation using satellite networks and optical communication technologies

In this section, first, we introduce a satellite network consisting of satellites constellation. Second, we describe optical communication technologies for satellite communications. Finally, we summarize the assumed network which is used in this paper.

2.1. Classification of satellites and its feature

Satellites are generally divided into three types, which are Low Earth Orbit satellite (LEO), Medium Earth Orbit satellite (MEO), and Geostationary Earth Orbit satellite (GEO) according to their altitude. LEO satellites have the lowest orbit and MEO satellites are the second lowest one while GEO satellites have the highest orbit. GEO satellites are separated from the Earth's surface by 36,000 km, and have tremendously large coverage area [2]. What is special about GEO satellites is that they always cover the same region of the earth, because they orbit at the same speed but against the rotation of Earth. On the other hand, LEO satellite can extend their coverage area to cover a large region of the earth by constructing constellation with a number of LEO satellites. In one example of LEO satellite constellation, Global Precipitation Measurement (GPM), which is intended to collect the data on the distribution of rain on the globe. GPM is organized by various institutes from several countries, and its main satellite was launched on February 2014 [3,4]. LEO satellites orbit near the Earth's surface with low altitude of around 350–1400 km hence it has to orbit around the earth at high velocity. While the time that LEO satellites can communicate with ground station is strictly limited due to their velocity, LEO satellites can observe the earth in a higher detail when compared with GEO satellites, and this type of satellites are widely used for the earth observation. The data traffic that is not able to be sent to the ground station, is temporally stored in mass storage device embedded on LEO satellite and the satellite wait until when LEO satellite can send that data. Meanwhile, the data relay satellite employ GEO satellite because GEO satellite can always communicate with the same ground station and they can cover a large part of the orbit of the earth observation satellite.

2.2. Optical communication in satellite networks

As previously described, optical communication technology for satellites has been researched all over the world. In Japan, National Institute of Information and Communications Technology (NICT) achieved the world's first optical communication experiment between the GEO satellite of ETS-VI and a Optical Ground Station (OGS) [5–7]. Moreover, NICT carried out various experiments in cooperation with other institutes, and successfully establish optical link fifteen times out of twenty seven times. JAXA which promotes development of space technology in Japan has performed the laser communication experiment over one hundred times among satellites at Optical Inter-orbit Communications Engineering Test satellite (OICETS) program since 2005. They have succeeded in acquisition and tracking with over 90% probability. ESA has already succeeded in many optical communication experiments [8,9]. They created the optical experimental satellite, named ARTEMIS. ARTEMIS has

Download English Version:

https://daneshyari.com/en/article/464725

Download Persian Version:

https://daneshyari.com/article/464725

Daneshyari.com