A Tutorial on the Integrated Computing and Networking for LEO Satellite Mega-Constellations

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LEO 위성 거대 별자리를 위한 통합 컴퓨팅 및 네트워킹에 대한 튜토리얼

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Abstract

Low earth orbit (LEO) satellite mega-constellations currently have been considered a critical part of future networks, which can provide wide coverage, low delay, and large communication capabilities. With the advancement of edge computing, cooperation of satellite edge is promising to improve resource utilization and overcome the inherent single-point satellite bottlenecks. Addressing the heterogeneity and large scale of the satellite mega-constellations, this paper focuses on the integrated computing and networking for (LEO) satellite mega-constellations.

Ⅰ. Introduction

The existing terrestrial networks have restricted capabilities in extending the connectivity to remote areas owing to geographical location and installation expenses .[1].

To deal with the above challenges of the terrestrial networks, low earth orbit (LEO) satellites are considered a potential candidate to achieve global coverage and seamless connectivity due to their low orbital altitude (1000 km). Recently, LEO satellite mega-constellations have been gained significant attention from both academia and industry [2].

In addition, with the rapid development of the Internet of Remote Things (IoRT), the demand for computing resources of devices in remote regions is rising significantly. Moreover, computation-intensive tasks may not be processed efficiently because the devices have because of the limited computing and power resources. Fortunately, with the advancement of edge computing, edge servers can be integrated into the satellites to improve the processing efficiency of the tasks transmitted from remote devices.

In satellite edge computing, resource computing is critical for the computing efficiency of the satellite networks. To cope with the single-node bottlenecks and enable effective resource utilization, satellite edge cooperation is considered a promising approach where different satellites cooperate to share the resources. Moreover, satellite edge cooperation for LEO satellite mega-constellations imposes huge challenges due to the heterogeneity and large scale of the networks. Motivated by the above observations, we survey the architecture of the integrated computing and networking for LEO satellite mega-constellations (ICN-LSMC).

Ⅱ. Method

There are four parts in the architecture of ICN-LSMC, including IoRT users, LEO satellite mega-constellation, medium earth orbit (MEO) satellites, and ground controller. Specifically, IoRT users are devices with limited resources, whose tasks can be transferred for processing in the LEO satellites. LEO satellite mega-constellation comprises ultra-dense LEO satellites equipped with powerful computing, sensing, and communication capabilities, which provide high-quality service performance for tasks from the IoRT users or self-generated tasks. MEO satellites are associated with domain controllers. ICN-LSMC separates a large number of LEO satellites into computing domains to reduce the management overhead. Each domain controller manages a computing domain by performing network management and intra-domain task scheduling. Ground controller is deployed in the ground station, which is responsible for inter-domain task scheduling, and global control.

Ⅲ. Conclusion

In this part, we presented a tutorial of ICN-LSMC. First, we provided the motivations of the application of ICN-LSMC. Then, we discussed the basic architecture of ICN-LSMC.

ACKNOWLEDGMENT

This research was supported by the MSIT (Ministry of Science and ICT), Korea, under the ITRC(Information Technology Research Center) support programs(IITP-2024-RS-2022-00156353 and IITP-2024-RS-2023-00258639) supervised by the IITP(Institute for Information & Communications Technology Planning & Evaluation).

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