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Deep Learning-Based LEO Satellites

Yue Cai (ycai0276@uni.sydney.edu.au), Peng Cheng, Branka Vucetic, Yonghui Li

Introduction

As the number of users connected to the current network continues to increase, it has become imperative to develop a communication system that can support higher capacities and data transmission rates. One of the most potent solutions is Low Earth Orbit (LEO) Satellite Communication (SatCom). This approach promises global coverage, high throughput, and affordability [1]. However, the existing LEO systems face critical limitations, particularly in catering to users with varying Quality of Service (QoS) requirements simultaneously. Furthermore, a persistent challenge lies in successfully integrating the satellite network with terrestrial infrastructure [2].

Aims

1. Enabling low latency and high throughput service and automatically allocating resources for different services.

2. Improving the cooperation ability of LEO

3. Implementing the network slicing technology in LEO

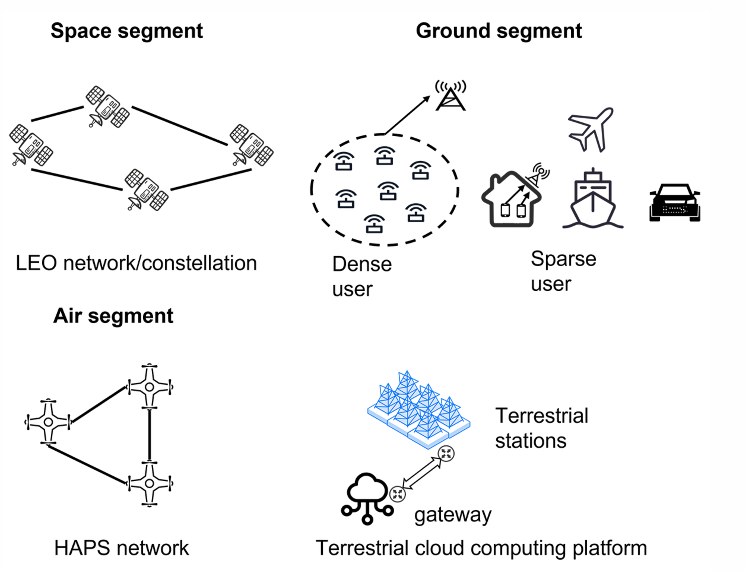
Methods

1. Using Lyapunov optimization to guarantee the long-term performance of the system

2. Multi-agent DRL

3. Continual learning

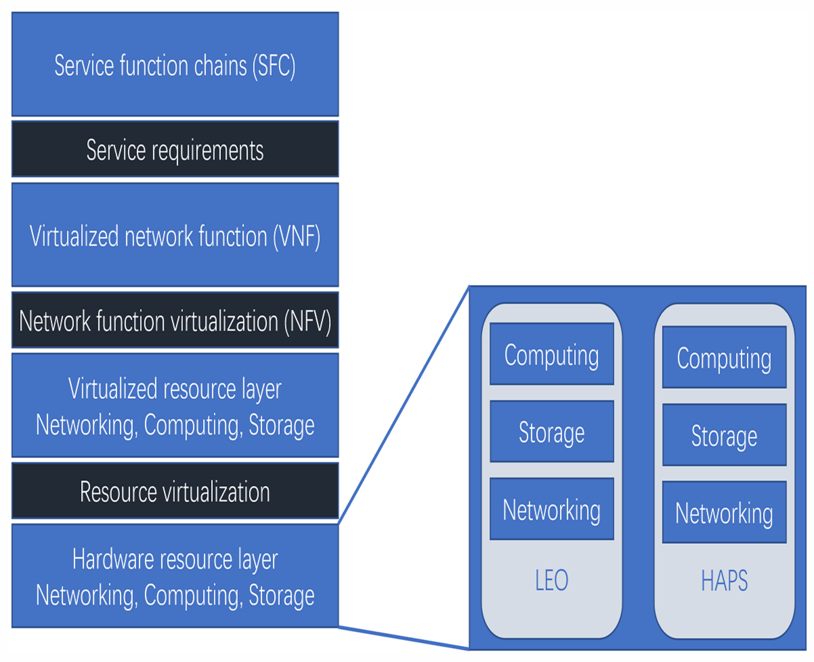
4. Autoencoder and DL methods



System architecture of the space-air-ground integrated network (SAGIN)

Possible Outcomes and Impacts

1. This project harbors the potential to significantly enhance the efficiency, effectiveness, and reliability of satellite operations. By refining the operational protocols and leveraging cutting-edge technologies, it seeks to revolutionize the current standards of satellite communication. An upgrade in system capabilities will not only streamline the satellite operations but also foster a more robust and resilient network that can withstand a range of adverse conditions, ensuring uninterrupted service delivery. Furthermore, improvements in efficiency and effectiveness are anticipated to pave the way for a host of new applications, effectively broadening the horizons for what satellite technologies can achieve.
2. Additionally, this project lays the groundwork for groundbreaking advancements in implementing deep learning (DL) and deep reinforcement learning (DRL) in the field of satellite communication. By integrating these advanced analytical techniques, it opens up avenues for smarter, data-driven decision-making processes that can optimize satellite networks in real time. The introduction of DL and DRL stands to usher in an era of autonomous satellite operations, where networks can self-optimize, adapting to changing conditions and user requirements dynamically. The consequent enhancement in performance would represent a leap forward in satellite communications, facilitating a new age of technological innovation characterized by heightened reliability and unprecedented operational efficiencies.



The network slicing architecture for LEO and HAPS

References

[1] P. -D. Arapoglou, K. Liolis, M. Bertinelli, A. Panagopoulos, P. Cottis and R. De Gaudenzi, "MIMO over Satellite: A Review," in IEEE Communications Surveys & Tutorials, vol. 13, no. 1, pp. 27-51, First Quarter 2011, doi: 10.1109/SURV.2011.033110.00072.

[2] T. Kim, J. Kwak and J. P. Choi, "Satellite Edge Computing Architecture and Network Slice Scheduling for IoT Support," in IEEE Internet of Things Journal, vol. 9, no. 16, pp. 14938-14951, 15 Aug.15, 2022, doi: 10.1109/JIOT.2021.3132171.

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