A Study on the Joint Optimization of Content Caching and TCP Congestion Control in LEO-MEC Networks

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Abstract

This paper proposes to investigate joint optimization of content caching and TCP congestion control in LEO-satellite MEC networks to maximize network throughput, minimize latency, and enhance QoS experience of users. We then propose to employ deep reinforcement learning (DRL) approach to learn the caching and CC policies due to its adaptability and scalability.

Ⅰ. Introduction

In recent years, the convergence of low Earth orbit (LEO) satellite networks and mobile edge computing (MEC) has emerged as a promising solution to enhance the ubiquitous connectivity and low-latency edge computing capabilities, making them suitable for a wide range of applications such as multimedia video streaming. On one hand, introducing edge caching (EC) capability in LEO-satellite-MEC networks alleviates network congestion by storing popular content closer to users. On the other hand, TCP congestion control (CC) mechanisms adjust the rate of data transmission to ensure reliable data transmission. Optimizing caching and CC jointly as an integrated approach addresses the issues of network throughput, minimizing latency, and enhancing the overall Quality of Service (QoS) for users.

Recently, inspired by the success of ML algorithms, there have been researches focusing on caching and CC separately [1-2]. However, these problems have not been studied so far as an integrated effort. Therefore, it is imperative to address the challenges posed by the joint optimization of content caching and TCP CC in LEO-satellite-MEC networks. this paper, we propose to investigate the joint optimization of caching and CC in LEO-satellite-MEC networks to achieve efficient and reliable content delivery.

Ⅱ. Method

We propose to employ deep reinforcement learning (DRL) for the joint optimization of caching and CC and define the state, action, and reward accordingly. The state space considers factors such as content popularity, current caching strategy (hit rate, content availability), network congestion indicators (throughput, loss rate). Then the action is defined by the decision related to both caching and CC such as caching placement and adjusting transmission rates. While the reward function reflects overall objective considering factors such as maximizing cache hit rate, minimizing content delivery latency, maximizing network throughput while minimizing packet loss rate. By defining appropriate state, action, and reward components, we propose to leverage DRL approach to learn effective joint optimization strategies due to its ability to adapt to dynamic conditions and handle large and high dimensional state and action spaces, ultimately achieving efficient and reliable content delivery in LEO-satellite-MEC networks.

Ⅲ. Conclusion

Although previous researches address caching and CC separately, there is a need for joint optimization to enhance network throughput, minimize latency, and enhance overall QoS experience of users. This paper proposes to explore the joint optimization of caching and CC as an integrated approach using the DRL algorithm.

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