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DISTRIBUTED BACKUP ROUTING IN CASE OF LINK FAILURE IN LOW EARTH ORBIT OPTICAL COMMUNICATION CONSTELLATION NETWORK

Abstract

In recent years, there has been a growing demand for space communications driven by the increased utilization of Earth observation satellites, the necessity for alternative communication channels during terrestrial disruptions such as natural disasters, and the need to offer rich internet connectivity in maritime and aerial areas. To meet this demand, there has been a focus on developing a non-terrestrial network that integrates optical communications, which offer significantly higher data rates than traditional radio communications, with a Low-Earth-Orbit(LEO) satellite constellation that ensures broad coverage with low latency.

LEO optical communication constellation networks face unique challenges, including the dynamic nature of communication links due to satellites' orbital motion, interruptions caused by cloud cover, and the heightened risk of equipment failure or malfunction in the harsh space environment. Applying conventional routing methods used in terrestrial networks directly to the LEO optical communication constellation networks would result in frequent link switching and unexpected link failures, leading to data loss and increased latency. Therefore, there is an urgent need for communication routing methods tailored to the specific characteristics of optical communication satellite constellations. While existing research has addressed periodic communication link interruptions due to orbital motion, there has been insufficient exploration into addressing sudden disruptions caused by factors like cloud cover or equipment failure.

In this study, we propose a routing method to reduce packet loss and delay during unpredictable link failures. The proposed approach involves pre-computing backup routing tables that account for specific link failures, enabling each satellite to autonomously determine which backup table to utilize based on the network's current conditions. Additionally, we develop criteria for prioritizing the selection of specific links to address link failures. Each satellite selects specific links to assume potential failures based on the number of hops from itself to the link and ground station placement in the overall network.

To evaluate the effectiveness of our proposed routing method, we model the structure and data flow of a LEO optical communication satellite constellation network, enabling accurate simulation of network behavior. Through numerical simulations, we demonstrate that our proposed method outperforms conventional approaches in maintaining communication performance under the condition that sudden link disruptions may occur.