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SYSTEM DESIGN STUDIES OF A LOW EARTH ORBIT RADIO-OPTICAL HYBRID COMMUNICATION SATELLITE CONSTELLATION WITH A MODULARIZED SIMULATOR

Abstract

There are various demands that a LEO radio-optical hybrid communication satellite constellation can serve. With global real-time access to the Internet, the maritime and aviation industry can synchronize a large amount of generated sensor data with the ground for real-time monitoring and offer Internet access to passengers. The automotive industry can offer passengers a rich "infotainment" service via the Internet even when the vehicle is in an area without a mobile connection. IoT devices installed on buildings, bridges, etc., can send real-time data and help operators react quickly in case of anomalies. An Earth observation satellite can downlink data via the constellation at any time, reducing the time between the observation and downlink and removing the bottleneck of the downlink rate, otherwise constrained by the ground station visibility. A LEO radio-optical hybrid communication satellite constellation has advantages over conventional systems. It offers lower latency than GEO satellites, a larger coverage than ground infrastructure, and larger bandwidth and narrower beamwidth than RF.

To design and evaluate such a system's feasibility and performance, we need to conduct analyses in

various system layers, such as satellite orbit propagation, communication topology building, communication link availability analysis, and routing algorithm. This has led to the modularized structure of our in-house simulator called COSMICA. Rather than building a single executable simulator, we have decomposed core functions into modules and implemented them as a toolbox. This way, we only need to write a thin execution layer on top of a modularized, extensible toolbox, making various analyses easy to conduct. This study presents an update on the development of COSMICA, including its modularized structure and improved capabilities.

One analysis required to assess system feasibility is the long-term deployment strategy under the large uncertainty in future demand. Optimizing the final snapshot of the completed system against a fixed future demand scenario will give an optimistic evaluation, as it may perform poorly in different scenarios. Meanwhile, optimizing the final snapshot against various scenarios (i.e., robust optimization) will give a pessimistic evaluation because, in reality, the system can be adapted as the uncertainty reduces over time. This study presents how adaptive system deployment strategies perform under future demand uncertainty.