A Review of SATis5: Perspectives on Commercial and Defense 5G SATCOM Integration

This review provides a comprehensive review of past and existing works on 5G systems with a laser focus on 5G Satellite Integration (SATis5) for commercial and defense applications. The holistic survey approach is used to gain an in-depth understanding of 5G-Terrestrial Network (5G-TN), 5G-Non-Terrestrial Network (5G-NTN), SATis5 testbeds, and projects along with related SATis5 architectures. Based on the survey results, the review provides (i) outlook perspectives on potential SATis5 architectures for current and future integrated defense and commercial satellite communication (SATCOM) with 5G systems, and (ii) a thorough understanding of problems associated with anticipated outlooks and corresponding studies addressing these problems. The commercial SATis5 architectures discussed here can be extended to civilian SATCOM applications.

The fifth generation of mobile networks (5G) promises a near-ubiquitous and instantaneous connection for many devices globally. To achieve this promise, the 3rd Generation Partnership Project (3GPP) provided the first complete report on the standardization of 5G wireless technology report in 2018 (Release-15). This release-15 focused on 5G-TN. The next release, Release-16, finalized the first evolution of 5G systems. Currently, 3GPP continues to work on the further evolution of the 5G-TN expanding to 5G-NTN. 3GPP has recently released Release-17 with emphasis on 5G-NTNs. Unlike 5G-TN, the 5G-NTN focuses on networks that involve flying objects such as satellites, high-altitude platforms (HAPs), aircraft, or Unmanned Aerial Systems (UAVs). The HAPs and UAVs are considered by 3GPP as air-to-ground networks. This review focuses on the 5G-NTN scenarios utilizing low Earth orbit (LEO) and geosynchronous Earth orbit (GEO) satellites along with a UAV scenario. The UAV scenario is for improved Intelligence, Surveillance, and Reconnaissance (ISR) missions using 5G and satellite networks.

Since the implementation of 3GPP Release-17 on 5G-NTN, interest surrounding the integration of satellite systems into 5G networks (SATis5) has been growing significantly in both the commercial and defense aerospace industry. This review emphasizes the recent and current efforts in the development and investigation of SATis5 architectures that are fully compatible with 5G-NTN standards for commercial and defense applications. In order to achieve this goal, this review employs a holistic survey approach providing the opportunity to gain an in-depth understanding of recent and current SATis5 works. The survey emphasizes potential SATis5 architecture outlooks for commercial and defense applications. In addition to the outlooks, the review discusses potential problems associated with the architecture outlook and recommends a set of studies and investigations addressing these problems. Using our holistic survey approach, the review is structured as follows:

- Section 2 presents overviews of 5G-TN and 5G-NTN with emphasis on a high-level understanding of 5G technologies and key 5G system components—These overviews provide some insights into 5G functions related to SATis5 architectures described in the subsequent sections;

- Section 3 captures existing SATis5 survey results with the goal to understand (i) possible commercial and defense SATis5 architectures, (ii) the proposed commercial SATis5 architecture roadmaps, and (iii) associated technical challenges;

- Section 4 presents an overview of recent and existing commercial SATis5 Testbeds and projects available in the public domain;

- Section 5 describes an overview of recent and existing defense SATis5 Testbeds and projects available in the public domain;

- Section 6 discusses and provides our SATis5 architecture outlooks and associated problems and challenges for commercial and defense applications; and

- Section 7 concludes the review with a summary and discussion of our thoughts on the perspectives of SATis5 architectures presented in Section 6. Additionally, this section recommends a list of studies and investigations addressing the problems and challenges identified in Section 6.