Novel Architecture and Key Technologies for Achieving High Capacity and Low Cost Space and Terrestrial Integrated Networks

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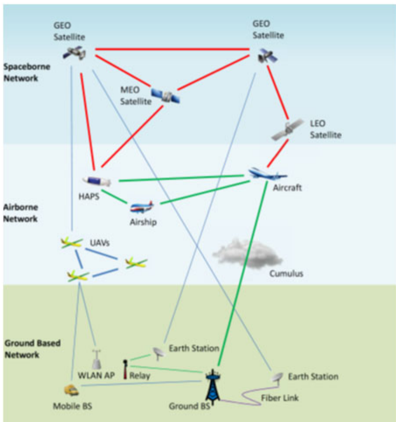
ABSTRACT

Space and terrestrial integrated network (STIN) is of critical importance for industries such as logistics, mining, fishery, and defence, and will improve digital equality for our society. This poster reviews the wireless communication technologies suitable for providing backbone links to the STIN and discuss the two bottlenecks, i.e., the available bandwidth and area spectral efficiency, that limit the current STIN capacity. A novel STIN architecture that makes use of the civil airliner network to form a low cost airborne network is then proposed. Combined with the emerging high-speed long range millimetre wave communication systems as the backbone and access links, the proposed architecture can achieve high capacity STIN with low cost, providing a viable solution to problems currently encountered in the effort to build future STIN. Some key enabling technologies are also discussed.

INTRODUCTION

Future information network must be the one that integrates the space network with the terrestrial network seamlessly, which is actually one of the main targets of the sixth generation (6G) wireless systems. An architectural illustration of a typical space and terrestrial integrated network (STIN) is shown below, which can be divided into three layers: spaceborne network, airborne network, and ground based network.

Though many efforts have been made to integrate space networks with ground based networks, there are still a number of grand technological challenges for achieving the STIN with high capacity and low cost. The two predominant bottlenecks that limit the current STIN development are both related to the airborne network: the available bandwidth and the area spectral efficiency (ASE).



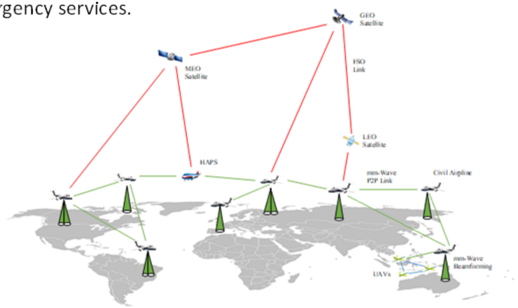
AERIAL BACKBONE OPTIONS FOR STIN

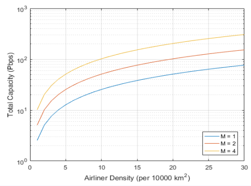
The table below provides some comparative results for the above-mentioned backbone links in terms of their attainable data rate and communication range, using Common Data Link (CDL), advanced CDL, Free Space Optics (FSO) and FSO with Wavelength-Division Multiplexing (WDM) for an air-to-air link under clear weather conditions. Similarly, the data rates and range achieved using CDL, advanced CDL, and mm-wave air-to-air links and air-to-ground links (assuming a 20 km airborne platform height) with a cloud layer underneath are also shown.

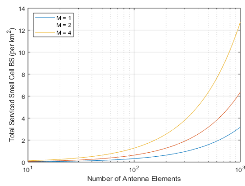
Link Type	Capacity per Link (Gbps)	Range (km)	Conditions
mm-Wave (Air-to-Ground)	100	100	Clear weather and with cloud layer
mm-Wave (Air-to-Air)	100	200	Clear weather and with cloud layer
FSO	10	>400	Clear weather only
FSO with WDM	100	>400	Clear weather only
CDL	0.274	>400	With cloud layer
Advanced CDL	3	≈350	With cloud layer
CDL	0.274	>400	Clear weather
Advanced CDL	3	>400	Clear weather

NEW ARCHITECTURE USING CIVIL AIRLINER NETWORK

First, mm-wave links are used as the air-to-air and air-to-ground backbones to replace conventional microwave links. This will significantly increase the available bandwidth and meet the data rate requirements. The FSO links serve as the high-speed links in the space network and between satellite and airborne platform. Second, a low-cost airborne network is formed by the civil airliners, i.e., the passenger airplanes, supplemented by a few permanent high-attitude platforms. UAV networks can also be used to provide hot spot and emergency services.

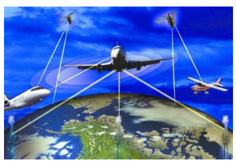


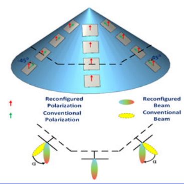




KEY ENABLING TECHNOLOGIES

- Dynamic Modelling of Spaceborne and Airborne Networks
- High-Speed Long Range mm-Wave Transmission
- Reconfigurable Conformal Antennas
- 3-Dimensional (Space-Air-Ground) Networking and Optimisation
- High-Speed Communication Protocol Optimisation
- Data Compression and Fusion





CONCLUSIONS

Available bandwidth and area spectral efficiency are the two bottlenecks for building the future high capacity and low cost space and terrestrial integrated network.

The novel STIN architecture based on civil airliner network and mm-wave communication technology can realise a high-speed and low cost airborne network that is at the core of the STIN.

This architecture can significantly improve the available bandwidth and the area spectral efficiency of existing satellite communication systems and hence the total capacity of the entire network.

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