Integration of LEO Satellite Networks with 5G and 6G Terrestrial Networks

Scoping a research problem

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**Research background and literature analysis**

The purpose of this research is mainly to investigate the approach of integration between 5G and 6G terrestrial communication networks with the LEO satellite network, as well as its potential challenges. This research is not only about discovering certain technologies but also discussing related minor-topics including regions’ policies, cultures, and geography.

Leo satellite is a quite important technology in modern society. For many IoT uses, devices are spread out over a very large area or in remote places without access to terrestrial infrastructure. Because of this, LEO satellite communication could help such area get remote control ability (Zhen et al., 2021).

Similarly, with the launch of 5G and plans for even faster wireless networks after that, there is a clear need for high-performance computing along with high-quality analogue functions. RF circuits will also need to be able to handle the push towards mm-wave and THz frequencies. So, many different technologies are needed, and there is a strong push for this to happen so that the system as a whole can gain (Gustavsson et al., 2021).

However, since this research topic involves a wide range of professions, not all minor topics will be discussed. Instead, an appendix provides additional information after the reference list to support the work documented within the report's main body.

This research was developed through the literature of previous excellent peer-reviewed studies from various background researchers. By synthesising insights from these various backgrounds, it may decrease the possibility of lacking consideration from different perspectives, ensuring feasible solutions are provided.

This research is expected to offer applied solutions for regions like low-income countries and areas with rugged landscapes that currently lack sufficient 5G coverage. Luo et al. (2024) mentioned that in a number of developing nations, a lot of people still can't use the fourth generation (4G) of information networks. Instead, older networks are still very important. 5G cannot be used right now in low-income countries because the infrastructure costs are too high.

**Research problem statement**

With the progress of the Internet of Things (IoT), communication technology has become more important in the past decade. Because of wireless and telecommunication technologies are bringing about a significant change in laptops and smartphones, people can receive the latest information about their lives very fast. Nowadays, as most of the artificial objects in outer space are in LEO, a fast, stable internet connection is also highly contributed by LEO satellites, not surprisingly.

Since the 1980s, LEO Satellite Communication Systems (SCSs) have seen significant development. With over 4700 satellites launched by 2021 (Yue et al., 2022), and the development of emerging technology, people’s daily lives have gotten a big jump into an information-fast-changing generation, which provides people with broadband internet access globally.

However, being required for 5G and 6G by LEO satellites is not implemented completely in every country, which increases the difficulty of integration between 5G and 6G technology into LEO satellites. This research is aimed at developing the key challenges in integrating LEO satellite networks with 5G and 6G terrestrial networks, including geographical difficulty, technical issues.

**Research Questions**

The integration of LEO satellite networks with 5G and 6G terrestrial networks have been presenting several key challenges and performance impacts in communication technology.

To achieve various application of LEO satellite, a lot of facilities are required to implement in broad ground and outer space, which increase the difficulty in manage entire network. It involves to protocol optimization, synchronization assurance, mobility management, etc (Luo et al., 2024). As a result, Ma et all., (2024) has found that it may be improved by a multi-layered network management architecture, through grouped MEO satellites as global controllers, and cluster head (CH) as local controllers.

On the other hand, random access (RA) procedure has a big influence on LEO satellite performance, primarily because it directly impacts how efficiently users can connect to the satellite network. Therefore, in order to provide a reliable, stable connection to users globally, it is necessary that IoT devices join the base station's network, and each one must start a RA process (Zhen et all., 2021). Finally, it is necessarily that continued innovation and optimisation in these areas will be essential to fully realising the benefits of LEO satellite systems in next-generation communication technologies.

**References**

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**Appendix**

The three excellent, careful papers have been published by Zhen et al. (2021), Luo et al. (2024), and Xiao et al. (2024) separately, while the researchers are from various profession backgrounds such as engineering science; global information and telecommunication; computing and information technology; electronics and information engineering, etc. Their main findings include, but are not limited to, how to improve LEO satellite’s connectivity through RA procedures; how SEO satellite accesses networks (LEO-SAN) helps broadband services for a large number of users; and the integration of geostationary earth orbit (GEO) satellites, medium earth orbit (MEO), and very low earth orbit (VLEO) satellites.