Technology and scientific aspects of the satellite-based and mobile cellular communication services integration

Zoltan Gal

Faculty of Informatics, University of Debrecen, Hungary

gal.zoltan@inf.unideb.hu

The integration of satellite-based and terrestrial mobile communication systems represents a key challenge in the evolution of next-generation networks. This paper investigates the scientific and technological aspects of merging 5G mobile services, standardized by the 3GPP technology program, with Starlink's LEO satellite infrastructure. The analysis highlights Starlink's architecture and service capabilities, emphasizing quality of service (QoS) variations as a function of the physical position of the mobile terminal. Particular attention is given to Doppler-related phenomena, including Doppler effect, Doppler rate, and Doppler latency rate, which significantly impact link stability and performance in high-mobility scenarios. To address the delay time, an auto-encoder-based prediction framework is introduced for accurate modelling of round-trip time across LEO and terrestrial networks. The findings provide insights into efficient resource allocation, seamless service continuity, and improved end-user experience in hybrid communication environments.

References

[1] Z. Gál, M. B. Gál, D. Talbi, Autoencoder-based Prediction of the LEO and Terrestrial Network Round-Trip Time Features, *Proceedings of the 2025 IEEE the 8th International Conference on Computer and Communication Engineering Technology (CCET), Institute of Electrical and Electronics Engineers (IEEE), [Piscataway]*(2025) 1–5.

[2] Z. Gál, D. Talbi, Insights into Low Earth Orbit Satellite Communication Dynamics: Quality of Service Analysis of Connection Behavior, Latency, and Doppler Shift, *Proceedings of the 2024 IEEE 4th International Conference on Electronic Communications, Internet of Things and Big Data (ICEIB), Institute of Electrical and Electronics Engineers (IEEE), [Piscataway]*(2024) 116–121.

[3] Talbi, D., Gál, Z., Sztrik, J.: Low Latency and High-Speed Communication Service with LEO Satellite Constellation. *Proceedings of The International Conference on Information and Digital Technologies (IDT), Institute of Electrical and Electronics Engineers (IEEE), [Piscataway]* (2023) 251–256.