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Technische Universität Berlin

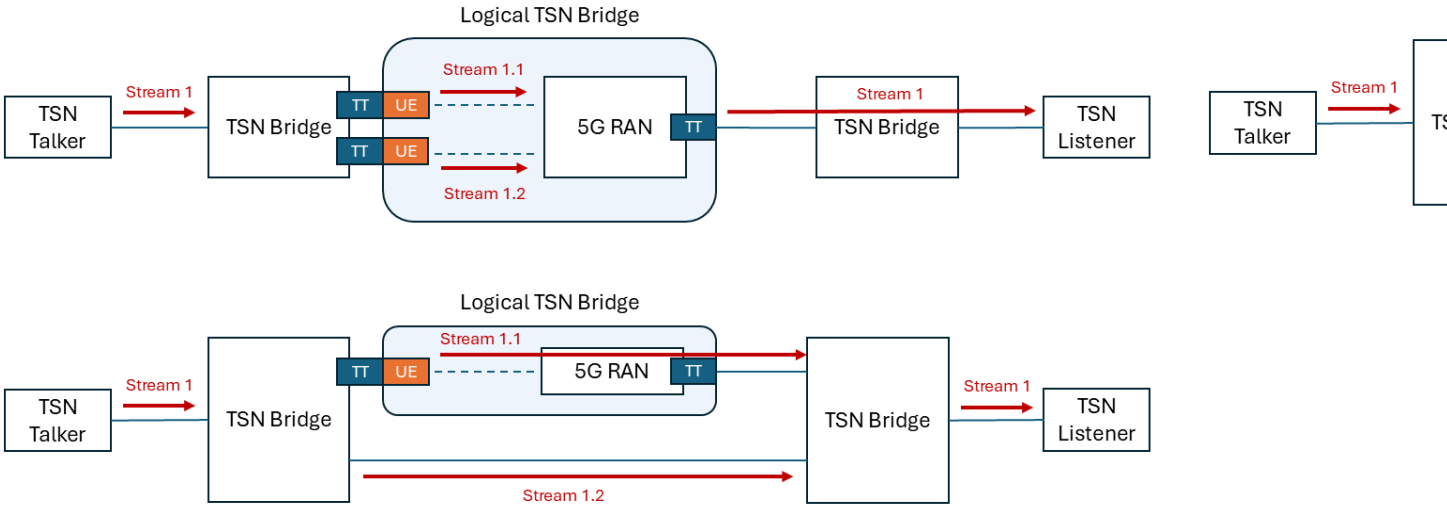
Bachelor's Thesis

End-to-End Redundancy for Hybrid 5G-TSN Networks

Abstract

Modern industrial systems have become complex and heterogeneous networks of static and mobile nodes with strict latency and reliability requirements. Emerging networking technologies address these requirements: IEEE 802.1 Time-Sensitive Networking (TSN) protocols enable time-sensitive communication over standard wired Ethernet networks, and 5G promises ultra-reliable and low-latency communications for wireless networking. Although their individual performance has been well-investigated in the literature, their convergence to realize end-to-end hybrid wired-wireless communication remains an emerging research area.

In this thesis, you will focus on the resilience of hybrid 5G-TSN networks against failures and degraded link quality. For this, you will adapt a prominent redundancy protocol, IEEE 802.1CB Frame Replication and Elimination for Redundancy (FRER), for 5G systems, which mimic logical TSN bridges. The overall goal is to investigate the benefits of end-to-end redundancy over wired (TSN) and wireless (5G) links in different network settings, under varying link conditions and failure scenarios. The following settings illustrate redundancy (a) within a 5G logical bridge over two tunnels, (b) over two different RANs, and (c) over hybrid wired and wireless links.



Objectives

In the context of this thesis, you will:

- design and configure 5G-TSN hybrid network settings in the OMNeT++ simulator.
- use an open-source project, 6GDetCom, to simulate 5G systems as logical TSN bridges.
- adapt FRER for the 5G logical TSN bridge to enable redundancy over 5G as well.
- simulate various failure scenarios and the cases for asymmetrical link conditions across redundant paths to investigate reliability and worst-case latency benefits of FRER.

Requirements

It is a big plus to be experienced in (or strongly motivated to learn) the following:

- Fundamentals of wireless communication, particularly cellular networks/5G.
- Proficiency in programming with C++.
- Familiarity with network simulators, such as OMNeT++

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Literature

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- L. Haug et al., “A data-driven simulation framework for logical 5G-TSN bridges,” International Conference on Networked Systems 2025 (NetSys 2025), Ilmenau, Germany, 2025, pp. 21–24, doi: 10.22032/dbt.67110.