Assisting Vessel Transport in the Busy Port Environments with the 5G testbed and Edge Network Applications (EdgeApps)

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Abstract—The paper presents an Assisted Vessel Transport use case, which is deployed and tested on the Antwerp 5G Edge Network Application (EdgeApp) testbed. The goal of the use case is to demonstrate how 5G Standalone (SA) connectivity and 5G-based EdgeApps can increase the efficiency in the Transport and Logistics (T&L) inland shipping sector. Specifically, the use case addresses the challenges faced in port areas, such as safety issues, long waiting times, and excessive fuel consumption. To overcome these challenges, the use case involves remote vessel monitoring in real-time over 5G, which increases situational awareness, and optimizes vessel navigation by defining the optimal routes and speed.

Index Terms—5G SA, testbed, EdgeApp, Assisted vessel transport

I. INTRODUCTION AND MOTIVATION

Edge Network Applications (EdgeApps) are an important factor in promoting growth within the Transport & Logistics (T&L) sector. By abstracting the complexities of the underlying 5G infrastructure, EdgeApps enable T&L application developers to reduce service creation and deployment times and optimize the utilization of 5G resources, ultimately leading to reduced service deployment costs. These applications operate at the edge of the network and offer several advantages, including lower latency, alleviating network load in core networks, and enabling the storage of data locally for privacy and security purposes. By leveraging these benefits, we refer to our network applications as EdgeApps. One solution for deploying distributed edge solutions is through Edge computing at the EdgeApp platform.

To help to accelerate this growth, adoption, and economic benefits that come along with EdgeApps in the T&L vertical, the European Commission has launched the VITAL-5G project [1]. VITAL-5G provides an enhanced 5G-empowered experimentation facility, with a portfolio of appropriate EdgeApps, which enables T&L application developers to test and validate their T&L applications within 5G ecosystems, in a user-friendly and intuitive manner, thus significantly reducing operational inefficiency and reducing market entry barriers prior to deploying their T&L service to live 5G networks [1,2].

In this paper, we focus on the Assisted Vessel Transport use case with its dedicated EdgeApps that are composed out of
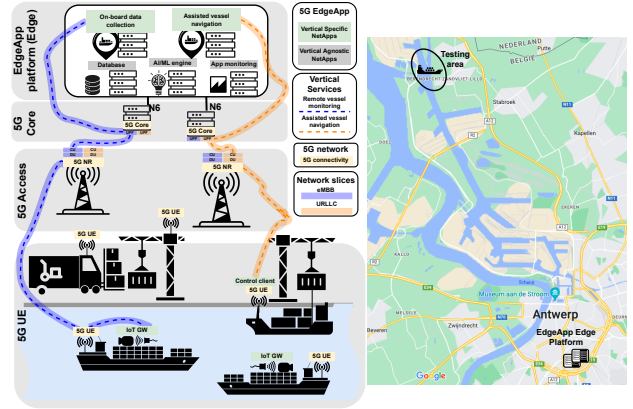

Fig. 1: VITAL-5G Antwerp 5G testbed and T&L pilot site.

two vertical services. We aloso explain in briefly the Antwerp testbed.

II. ASSISTED VESSEL TRANSPORT USE CASE

We designed and deployed the Assisted Vessel Transport use case using the Antwerp 5G testbed within the VITAL-5G project[1], see section III. This use case is built upon two vertical services, i.e., Remote Vessel Monitoring and Assisted Vessel Navigation, and each of these vertical services consists of different EdgeApps presented in Figure 2. In this use case, 5G connectivity and network slicing principles are used to assist semi-autonomous vessels in the challenging environment of a busy port area such as Port of Antwerp. High-bandwidth camera feeds and sensor data (radar and location/speed/heading) are sent in real-time from the vessel to the EdgeApps running on the 5G network edge. Based on such data, the real-time assistance to the captain is provided on the enhanced monitoring dashboard that is showing detected obstacles, optimized routes, and optimal speed [2]. Due to the limitations in current 4G networks in terms of QoS (coverage, throughput and latency), the reliable deployment of remotely controlled vessels in a port
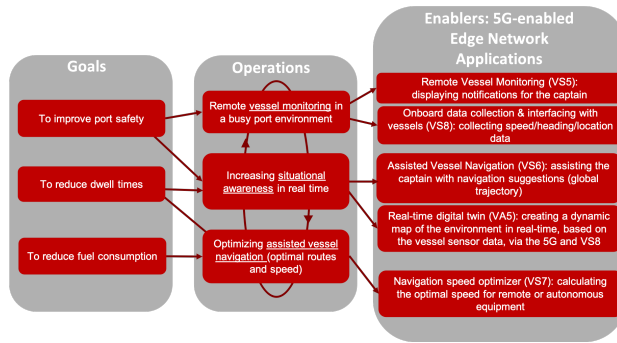
[1]https://www.vital5g.eu/

Fig. 2: Overview of goals, operations, and enablers, for assisting vessel navigation with the help of 5G SA.

area environment is still challenging. Today, it is mandatory to have two captains onboard, and before this number can be reduced to one or even zero persons onboard, guarantees relative to both reliability and redundancy are required [2]. As connectivity is currently a main bottleneck, 5G is enabling these challenging requirements, and in the VITAL-5G project we are validating the impact 5G network has on the performance of such use case.

As illustrated in Figure 2, 5G-enhanced EdgeApps are designed as main enablers of enhanced situational awareness and assisted vessel navigation. The EdgeApps such as real-time digital twin are created around the vessel to support the remotely controlled (and later on autonomous) vessels [1]. In parallel, real-time route planning EdgeApp is leveraged to optimize port operations and avoid idle times. In future, this could be linked to the different planning systems in the port, including the system of automated vessels. The enhanced Mobile Broadband (eMBB) slice is used for delivering real-time video streams from the vessel on the uplink to the EdgeApp platform, while Ultra-Reliable Low-Latency Communication (URLLC) is used for providing optimal navigable points and speed based on the analysis and enhanced observations provided by EdgeApps. In addition, Figure 2 also briefly lists and describes all the EdgeApps that support the Antwerp use case and thus run on the enhanced 5G testbed, thereby enabling operations for remote vessel monitoring, increasing situational awareness, and optimizing vessel navigation.

III. 5G TESTBED

The Antwerp 5G testbed spans the usual 5G Standalone (SA) ecosystem components:

- User Equipment i.e., a commercial vessel equipped with 5G modem, sensors and cameras
- Radio Access Network (RAN) with three gNodeBs installed in the selected aread of the port of Antwerp
- Transport and Core network
- 5G Edge network that hosts the EdgeApp platform, designed and deployed to provide Network Function Virtualization (NFV) resources for hosting and orchestrating EdgeApps tailored to Assisted Vessel Transport use case,

by using Open Source MANO (OSM)-based orchestrator and OpenStack/Kubernetes.

IV. THIRD PARTY EXPERIMENTERS

In the VITAL-5G project, vertical stakeholders, i.e., third-party experimenters such as Small and Medium-sized Enterprises (SMEs), companies, and research groups, are getting the chance to exploit 5G-based experimentation facilities that are tailored to T&L verticals. This experimentation is creating unique opportunity for third-party experimenters to validate their T&L-related solutions and services utilizing real-life resources that would otherwise be inaccessible to them [1,2]. The experimentation is facilitated through the usage of an open, flexible testing platform based on VNF and Service Function Chaining (SFC) [1,2]. The concept of EdgeApps enables experimenters to experience ultra-fast service creation, dynamic customization of the service, and flexible adjustment to real-time conditions. The role of the third-party experimenters in the VITAL-5G project, as well as the overall procedure of getting involved and starting with experimentation, are described on the project website[2]. Along with the other experimentation facilities, VITAL-5G testbed in Antwerp is offering various assets to the third-party experimenters. For example, EdgeApps such as VS8, VS5, VS7, and VA5, which are described in Figure 2, could be reused when creating new vertical services. Also, datasets with real-time information on the vessel's navigation (speed, location, heading) along with the radar data could be reused by third-party experimenters to train their own algorithms for improving operations in the port environments. Finally, the real-life data collected from the 5G network is also accessible for experimenters who are interested in testing 5G network performance in challenging environments such as Port of Antwerp.

V. CONCLUSION AND FUTURE WORK

In this work, we presented how 5G SA connectivity and 5G-based EdgeApps can benefit the T&L inland shipping sector. To do so, we showcased the Antwerp Assisted Vessel Transport use case that makes use of the Antwerp EdgeApp testbed. We briefly explained all the EdgeApps that compose the Assisted Vessel Transport use case. We also provided a quick overview on how third party experimenters can make use of the EdgeApp testbed.

VI. ACKNOWLEDGEMENT

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[2]https://www.vital5g.eu/get-involved/