FOR-FREIGHT: A Next-Generation Platform for Optimizing Multimodal Logistics and Enhancing Sustainability

Andreas Gavrielides[1], Ngoc Quang Luong[1], Georgia Ayfantopoulou[2], Sofoklis Dais[2], Katerina Batzou[2], Giota Lilli[4], Jorge Feliu Escagüés[5], Alicia Enríquez Manilla[5], Jorge Melero Corell[6], Gonzalo Sandiás Corbillón[6], Stefan Stefanescu[7], Andra Luciana Marcu[8], Nicoleta Capbun[7], George Suciu Jr.[7], George Agapiou[3], Sokratis Barmpounakis[3], Grigorios Koutantos[3], Panagiotis Demestichas[3], Johann Marquez-Barja[1]

[1]University of Antwerp-imec, IDLab-Faculty of Applied Engineering, Antwerp, Belgium – {andreas.gavrielides, ngoc.quang.luong, johann.marquez-barja}@imec.be
[2]Centre for Research & Technology Hellas/Hellenic Institute of Transport, Thessaloniki, Greece – {gea, dais, kbatzou}@certh.gr
[3]WINGS ICT Solutions S.A., Athens, Greece – {gagapiou,, sbarmpounakis, gkoutantos, pdemest}@wings-ict-solutions.eu
[4]eBOS Technologies Ltd., Nicosia, Cyprus – Giotal@ebos.com.cy
[5]Fundación Valenciaport, Valencia, Spain – {jfeliu, aenriquez, jlcarcel}@fundacion.valenciaport.com
[6]Terminal Industry Committee 4.0, Madrid, Spain – {jmelero, gsandias}@tic40.org
[7]BEIA Consult International, Bucharest, Romania – {stefan.stefanescu, nicoleta.capbun, george}@beia.ro
[8]Danubius University, Galati, Romania – andramarcu@univ-danubius.ro

***Abstract*— The FOR-FREIGHT project aims to revolutionize multimodal logistics by optimizing transport capacity, sustainability, and efficiency. The platform integrates technologies such as IoT, AI/ML, and Big Data to enhance logistics systems and reduce freight transport costs. A key focus is integrating legacy systems, ensuring compatibility and fostering interoperability across stakeholders. The platform streamlines freight flows while promoting standardization and sustainable practices within the logistics sector. As the project progresses, it will set new standards for multimodal logistics and explore the potential integration with 6G networks to optimize transportation systems. This poster paper demonstrates the impact of the project by highlighting the development and demonstration of the capabilities of the FOR-FREIGHT platform and associated solvers and solving processes.**

Keywords—Transport & Logistics; AI; Solvers; Multimodal Transport, Sustainability

I. Introduction

The FOR-FREIGHT project aims to enhance the efficiency and sustainability of multimodal freight transport by optimizing capacity utilization and reducing transport costs through the integration of innovative solutions with existing logistics systems [1]. The project focuses on end-to-end optimization of multimodal logistics processes, improving access to transshipment services and ensuring smoother transitions of goods across hubs and transportation modes.

Achieving interoperability with legacy systems poses a significant challenge, requiring effective solutions to address compatibility issues [2]. The use of AI/ML and IoT, along with regulatory concerns, further complicates implementation. A collaborative, comprehensive approach is needed to overcome these challenges, involving stakeholder cooperation and tailored technological solutions.

A core element of the project is the integration of three trial sites into a unified cloud-based platform, as shown in Figure 1. This platform enables real-time monitoring and systematic validation of logistics solutions for real-world applications. The design begins with a lightweight prototype, adaptable to specific needs, and is validated through extensive trials.

FOR-FREIGHT also develops sustainable business models and collaborative multimodal service plans to ensure long-term success. By optimizing freight transport capacity, the platform reduces emissions, maximizes resource use, and fosters a more sustainable, interconnected logistics ecosystem.

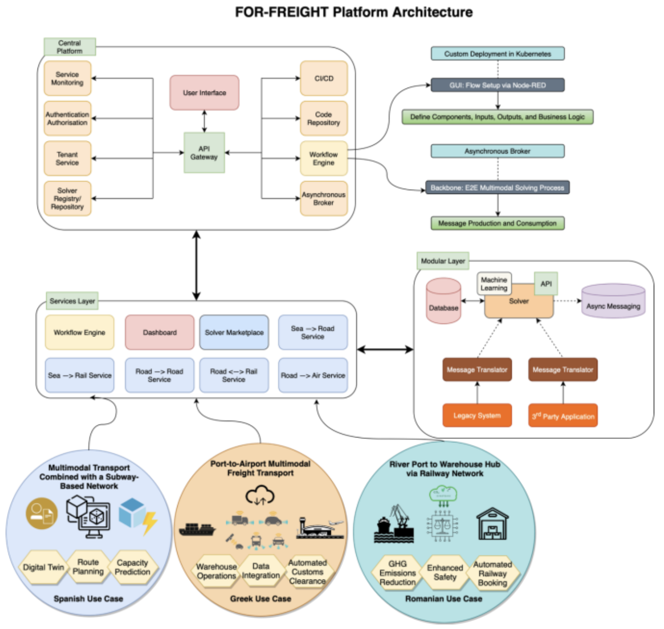

Figure 1 High-level architecture of the FOR-FREIGHT platform in relation to the use cases of the project

II. FOR-FREIGHT Platform Architecture

The FOR-FREIGHT platform is a cloud-based solution The FOR-FREIGHT platform is a cloud-based solution designed to optimize multimodal logistics by integrating IoT, AI/ML, and Big Data management. It models logistics networks based on operational needs and translates KPIs into technical challenges such as prediction, simulation, and optimization. The platform integrates existing systems and third-party applications to enhance performance and ensure smooth data exchange, focusing on real-time decision-making and end-to-end logistics management.

A central component of the platform is the Central Platform Layer, which includes subcomponents like service monitoring, authentication, and tenant services. These components ensure functionality, security, and data isolation for multiple organizations. The Solver Registry/Repository stores optimization algorithms, facilitating their selection and update, while the API Gateway streamlines communication between microservices. The platform also includes external components like the CI/CD system, which supports rapid deployment and version control, and the Workflow Engine, which orchestrates logistics workflows, ensuring efficient task execution and reliable communication.

The Modular Layer includes key components such as databases, machine learning models for predictive analytics, and solvers for logistics challenges like route planning and load balancing. The Integration Layer ensures seamless interaction with external systems through message translators and APIs, facilitating data transformation and synchronization across diverse platforms. The Services Layer manages core logistics functions, with key services like the Solver Marketplace for deploying solvers, and a User Interface designed to provide real-time monitoring and task management, making the platform intuitive and user-friendly for diverse users.

The Workflow Engine is a flexible and scalable tool designed to automate and orchestrate complex logistics processes. Built on Node-RED logic, it allows developers to create data flows and logic through a web-based interface, ensuring agile and responsive operations based on real-time data inputs. The Workflow Engine serves as the “brain” of the platform integrating seamlessly with diverse data sources, including legacy systems, IoT sensors, and external APIs, enabling efficient real-time data processing, transformation, validation, and enrichment. This integration supports smooth operations across the logistics network and ensures standardized data for informed decision-making.

III. SOLVERS And Solving Processes DESIGN

The FOR-FREIGHT project develops a set of solvers to optimize multimodal logistics, addressing challenges overlooked by legacy systems. Key modules include the ETA Predictor for cargo arrival times, Dwelling Time Predictor for hub processing times, and Transport Cost and Emission Predictor for assessing costs and environmental impact. Additional modules like the Routing Recommender, Real-time Re-planner, and Next Transport Mode Recommender dynamically adjust logistics plans to optimize flow.

These solvers integrate real-time data from sources such as port facilities, warehouses, and external weather/traffic forecasts. For example, simulated data enhances ETA predictions for routes lacking historical data. Preliminary results show significant improvements in ETA accuracy, resource utilization, and reduced transport costs and emissions.

The solvers are orchestrated by the Workflow Engine, ensuring seamless interaction and real-time adjustments. Solving Processes address end-to-end logistics challenges across the three trial sites. This integrated approach, tailored for specific sites like Spain, Greece, and Romania, improves efficiency and responsiveness, ensuring optimal resource utilization and seamless goods movement across multimodal networks. Preliminary results demonstrate enhanced logistics efficiency, adapting to real-world challenges.

IV. Conclusions

FOR-FREIGHT aims to optimize multimodal logistics by integrating innovative solutions that enhance efficiency and sustainability while connecting with existing systems. The platform’s solvers address critical logistics challenges, driving sustainable freight management through real-time tracking, visualization, and optimized networks. Looking forward, the integration of 6G technologies offers exciting potential to elevate the platform’s capabilities. With ultra-reliable, low-latency communications, 6G can enable faster data transfer, dynamic route optimization, and enhanced automation across multimodal networks. This will improve decision-making and adaptability, leading to autonomous, hyper-connected systems that optimize resource allocation and address disruptions in real time. The integration of 6G will push the boundaries of logistics operations, setting new standards for efficiency and sustainability, ensuring FOR-FREIGHT remains at the forefront of innovation in the logistics industry.

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