Port Digitalization through an Activities Scenario Model as a First Step for a Digital Twin of Port

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Paper abstract

The activities of the port industry are increasingly complex and involve heterogeneous stakeholders. The amount of data generated by the port ecosystem is growing. However, the data are often heterogeneous and not very interoperable, making their understanding and overall analysis non-trivial. In addition, there is a set of barriers that make the digitization of ports complex, including a lack of open-source solutions for managing, centralizing, and analyzing data. One of the main challenges of the port of the future is to succeed in its digital transformation to better control its social and environmental impacts. It is with this objective that PIXEL (H2020 funded project) has aimed at creating the first smart, flexible and scalable solution reducing the environmental impact while enabling optimization of operations in port ecosystems. PIXEL ports solution enables a two-way collaboration of ports, multimodal transport agents and cities for optimal use of internal and external resources, sustainable economic growth and environmental impact mitigation, towards the Ports of the Future. Built on top of the state-of-the art interoperability technologies, PIXEL platform centralizes data from the different information silos where internal and external stakeholders store their operational information. PIXEL solution leverages an IoT based communication infrastructure to voluntarily exchange data among ports and stakeholders to achieve an efficient use of resources in ports. In this whitepaper, we will focus on one of the main results of the PIXEL project: the Port Activities Scenario (PAS) model. This model could be seen as a first step for building a digital twin of maritime ports, starting by terminal operations and growing upon to the whole ecosystem extent. The concept of digital twin of port is one way to better understand, represent and simulate the port activities.

In the first part of this whitepaper, we describe the PIXEL platform which is the needed infrastructure to be able to build a digital twin leveraging PAS features. This platform is composed of five components. The Data Acquisition Layer (DAL) has the mission of gathering data from heterogeneous data sources and persist them in a single storing point. The Information Hub (IH) is a functional block in charge of centralizing all the data retrieved from DAL, homogenizing and storing in a database capable to support big queries and scale horizontally. The Operational Tools (OT) are devoted to enable the analysis and reasoning over the data gathered by the platform both in real time and in batch processes. These tools are built to support models and algorithms. The Dashboard and Notifications (DN) module has the capability of representing the data registered in the IH in meaningful combined visualizations in real time. Finally, the Security block is a cross-

layer module that will perform the security of the other blocks, including authentication and authorization control.

In the second part, we focus on the PAS model and explain why it is a modular and central hub towards a digital twin, tightly linked with the principles of the Physical Internet model. The knowledge of the operations, the resources and the sequencing (type and number of machines, duration of use, position in the port all these referred as “supply chain” in PIXEL), allow to know the energy sources used, quantification of local emissions of pollutants but also to estimate the flow of cargoes entering or leaving the port and the resulting traffic. Port activity is generated by incoming and outgoing cargoes transition into the port ecosystem. The main input for PAS modelling is the cargo arrival planning, completed with parameters relatives to the sequence of operations required and the corresponding machines with their technical specifications. To build the PAS, three steps are followed: i) cargoes inventory, ii) supply-chain mapping, iii) operation schedule calculation. This model allows to do this in an automatic and schedule way. The Port Activities Scenario is designed to be flexible in its adoption from different ports and for different cases. It is based in the following principles: modularity (provide link with different models), flexibility (can allow the future development of additional models describing other ports’ use cases) and adaptability (being able to operate with varied amount and accuracy of data, PAS provide results of varying certainty).

The third part of this whitepaper describe the different outcomes and key results directly linked to the PAS: list of operation, energy demand, pollutants quantification, machines usage rate, area occupancy (linked with a COVID use-case). We show how the PAS outputs are used as an input for the environmental evaluation of the port. We describe how PAS directly interact with the other main results of the PIXEL project: the Port Environmental Index (PEI). We explain how the operational activities of the ports as modelled by PAS contribute to the build-up of an emission inventory for the calculation of the PEI. By quantifying the emissions of air pollutants through the supply chain modelling, PAS model can directly feed the PEI algorithms with emissions data related to operational activities of the ports. Furthermore, PAS aggregates the actions (operations) of a port within a certain time period and can make rough estimations for feeding PEI calculation. In this third part we also reflect the potential role of the PAS to become a definitory enabler for the Physical Internet in the area of maritime transportations. To a certain extent, PAS can be considered as a “black box” simulating the “processing” (input, operations, timeline, output) of a “node” in the network (supply chain).

The project results described in the current whitepaper are directly based on real pilots and clearly contributes and extends previous research, by i) focusing on modelling small and medium-sized European port operations, considering both the available data and the required degrees of modelling precision, ii) placing emphasis on the environmental impacts of port operations, iii) boosting the benefits of port IoT infrastructure to enhance the efficiency of the modelling approach, iv) aligning the outputs of a research project with the principles designed by ALICE.