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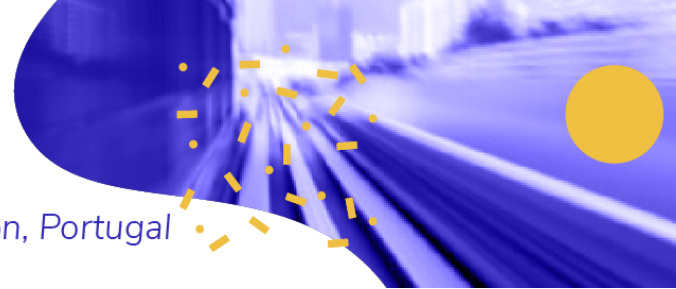
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Connected Freight Parking in Smart City Logistics

Yu LIU^a, Shenle PAN^a, Pauline FOLZ^b, Fano RAMPARANY^b, Sébastien BOLLE^b,
Eric BALLOT^a, Thierry COUPAYE^b

^aCentre de Gestion Scientifique - I3 - UMR CNRS 9217, MINES ParisTech, PSL Research University, 60 boulevard Saint-Michel, 75006 Paris, France

^bOrange Innovation, France

Abstract

1. Overview and motivation

Following the UN report in 2018, there will be 43 megacities around the world by 2030, each of them having more than 10 million inhabitants [1]. Within this trend, the demand for city logistics will surge with the growing population and increasingly demanding service level (e.g., speed or flexibility). This increase in last-mile delivery will result in the growth of delivery density simultaneously, especially in the metropolitan area. The issue of freight parking management is therefore obvious, due to the shortage or inefficient use of freight parking areas downtown. For example, a study in Seattle downtown shows that cruising for parking takes the freight vehicles more and more time, around 28% of the trip time on average, which accumulates to 1.1 hours each tour [2]. These unnecessary and inefficient goods and vehicles movements, in turn, exacerbate congestion and air pollutant emissions. Motivated by that, this work investigates how the new technologies and paradigms (such as Smart Cities, Digital Twins, Internet of Things, Semantic Web) can help improve the performance of city logistics via better management of freight parking areas.

2. Methodology, results and main contributions

Generally, Smart City Logistics is supported by a set of technical systems for the identification, localization, and condition monitoring of different objects or systems in logistics from freight to vehicles until the infrastructure, for goods distribution in the urban area [3]. Such technologies could further enable the interconnection of objects (or of systems), in order to share the logistics resources, assets, or services, such as in Smart Cities. To this end, we first propose an architectural framework to describe the modeling of Smart City Logistics in the context of Smart Cities and the Web of Things (WoT) [4] (see Figure 1).

In *Layer 1 Physical Logistics System*, smart objects used in logistics systems are present, which are objects with sensors or tagged products. Moving up to *Layer 2 Cyber Logistics System*, objects and their connection are modeled with Property Graph (PG) to shape their informational representation, namely Digital Twins or avatars of physical entities [5]. In this layer, the objects are connected while their relationships are displayed and registered. Real-time data source (in Layer 1) related to each avatar will be injected and updated to make sure it is living. Layer 1 and 2 together can be seen as Cyber-Physical Logistics System (CPLS) in logistics. In *Layer 3 Semantic Logistics System*, Web Ontology Language (OWL) is used to define the objects and concepts to describe the domain (and the knowledge) of the logistics system. Since Ontology is defined as a formal, explicit specification of a shared vocabulary [6], the CPLS modeled is able to communicate with other existing systems or objects in this level, i.e., the context including shared infrastructures or assets, stakeholders' systems, etc. [7]. This layer is of foremost importance in the context of Smart Cities where WoT is present, and to enable the Plug-and-Play and interoperability of systems. A query language like SPARQL can be used to query the ontology in Layer 3. The results will be injected into *Layer 4 Logistics Web Application*, where decisions (e.g., scheduling of vans and drivers, route planning) will be made based on the more comprehensive information and knowledge on the whole system and its context. Decisions will then be communicated to the corresponding avatars located in Layer 2. After the status of the digital twins is synchronized, the action of the physical objects in the first layer will be determined.



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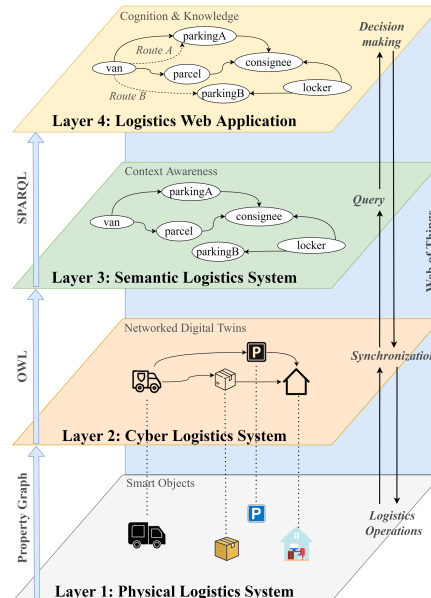
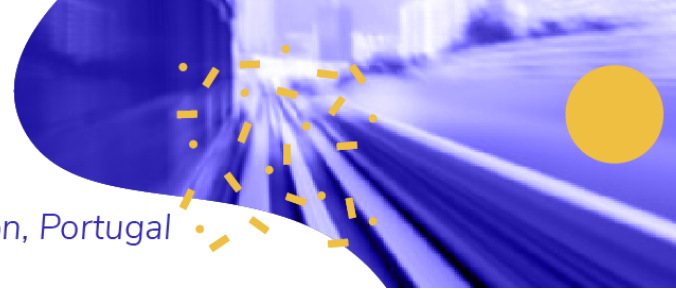


Figure 1. Architectural framework of Smart City Logistics

3. Conclusion and future works

This work investigates city logistics in the context of Smart Cities, Digital Twins and the Web of Things, with special attention to freight parking problem. An architectural framework of Smart City Logistics is proposed to model the physical and cyber logistics systems, and their communication with other objects or systems at semantic level for decision making. Therefore, the Plug-and-Play and interoperability of systems is enabled. An optimization-based simulation model is being developed to illustrate the potential of the approach, with special regard to freight parking management and to sustainable issues. This work is supported by the *Physical Internet Chair* at Mines ParisTech, and the project *ASAP* (Awaken Sleeping Assets Project), supported by the European Commission and funded under the Horizon 2020 ERA-NET Cofund scheme under grant agreement N° 875022.

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Keywords: City Logistics; Smart Cities; Freight Parking Management; Sustainability; Digital Twin; Property Graph; Ontology; Semantic Web.