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Physical internet enabled Hyperconnected City Logistics

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Abstract

City Logistics and Physical Internet are two major concepts aiming to profoundly change freight transportation and logistics for increased economic, environmental and societal efficiency and sustainability. They share several basic ideas and are complementary, City Logistics providing the final and last segments of the Physical Internet logistics and transportation networks. We present the first study of the links and synergy between them, introducing the idea of *Hyperconnected City Logistics* systems and its nine fundamental concepts making up a rich framework for designing efficient and sustainable urban logistics and transportation systems. We conclude with a number of research and innovation challenges.

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1. Introduction

The transportation of goods into, within and out of cities constitutes both major enabling and disturbing factors for most economic and social activities at the core of urban life and prosperity (OECD, 2003). Since its inception,

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the main goal of *City Logistics* (CL) is to reduce the negative impact of freight-vehicle movements on city-living conditions, particularly in terms of congestion/mobility and environmental impact, while not penalizing its social and economic activities and fostering an efficient and sustainable transportation system (e.g., Taniguchi *et al.*, 2003, 2013). More precisely, it aims to reduce and control the presence and motorization of freight vehicles operating within the city, improve the efficiency of freight movements and their environmental footprint, and reduce the number of empty vehicles getting in, through and out of the city (e.g., Benjelloun *et al.*, 2010, Dablanc, 2007).

The *Physical Internet* (PI, π) is a new concept for freight transportation and logistics aiming to improve the economic, environmental and societal efficiency and sustainability of the way physical objects are moved, stored, realized, supplied and used all across the world (Montreuil, 2011; Physical Internet Initiative, 2012). Similarly to the Digital Internet, the movements of freight in the PI are independent of the actual operations of the transportation and terminal handling and storage infrastructure and services, and proceed in an openly consolidated way through a series of carrier services and relay facilities. The PI concept is gaining momentum in both research and applications, and has already shown significant potential gains in interurban transport and logistics (Ballot *et al.*, 2014; Sarraj *et al.*, 2014).

Cooperation, consolidation and a separation of the commercial transactions generating the demand and the way the actual transport and storage of the freight loads are performed are key concepts for both City Logistics and Physical Internet. The two are complementary, as City Logistics provides the final and last segments of the Physical Internet-enabled hyperconnected logistics and transportation networks. Yet, to the best of our knowledge, no study has explored the necessary links and synergy between these advanced freight transportation and logistics systems.

Our goal is to contribute toward bridging this gap by introducing the idea of *Hyperconnected City Logistics* systems and discussing its key concepts, potential benefits, and research and development challenges. The plan of the paper is as follows. Section 1 briefly recalls the main stakeholders and the general state of urban freight transport and logistics systems. The next two sections synthesize the main ideas of CL and PI, respectively. We introduce the Hyperconnected City Logistics and its key concepts in Section 4, and conclude with a number of major research and development challenges towards economically, environmentally and societally efficient and sustainable hyperconnected city logistics for people and freight.

2. Logistics and Transportation in Urban Environments

Freight logistics results from the interactions and combined decisions of numerous stakeholders that, in a rather synthetic way, may be classified as providers, enablers and users of logistics services, as well as legislators. Providers include carriers, third-party logistics service providers (3PLs), public and private storage facilities, single-modal and multimodal terminals, etc. Examples of enablers are brokers and freight forwarders (these often include carriers acting as integrators). Users include shippers, retailers, distributors, manufacturers, etc., as well as institutions, offices and private citizens receiving and sending packages and letters. Legislators broadly include the municipal, provincial/state, national and international governments and agencies that make up the operating policies and rules, without forgetting the taxation legislation, governing the transportation and logistics systems.

City transportation systems are complex multimodal networks made up of five main types of entities. The first two are the entities being transported: people and goods. People have individual dynamic needs for transport, with varying degrees of urgency and subject to budget constraints. They can self-transport by walking, driving themselves to destination in a vehicle, or be transported using taxis, buses, etc. Goods also have needs for transport from origins to destinations specified by their owners or representatives. They come in various unit loads (e.g., boxes, pallets, containers) and have to be transported on vehicles or on conveying systems. Infrastructures on which vehicles move are the third type of entities. They can be public (e.g., streets, tunnels, bridges, subways, waterways and airways) or private (e.g., rail in North America). The fourth are the mode-specific vehicles and convoys moving on particular routes according to particular schedules. The fifth are the public and private terminals such as logistics terminals, distribution centers, truck terminals, rail yards, ports, and airports. They handle vehicles (e.g. sort and assemble into convoys), load, unload, transship, store and, eventually, sort and consolidate goods. People-focused terminals similarly help people selecting vehicles and modes, waiting for boarding availability and switch from a vehicle/mode to another.