HYPERCONNECTED CITY LOGISTICS: SMART LOCKERS TERMINALS & LAST MILE DELIVERY NETWORKS

Louis Faugere[1,2], Benoit Montreuil[1,2,3]

1. School of Industrial and Systems Engineering, Georgia Institute of Technology
2. Physical Internet Center, Georgia Institute of Technology
3. Supply Chain and Logistics Institute

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ABSTRACT

Over the last decade, the e-commerce industry has revolutionized the way people are shopping, and transformed the B2C industry, increasing the needs for home delivery. In a world where urbanization creates mega cities, last mile delivery becomes a real issue for both urban planning and logistics providers' operating costs. In line with the Physical Internet's concepts, networks of openly available Smart Lockers Terminals bring a solution to absorb the growth of e-commerce in urban areas, leveraging consolidation opportunities, or crowdsourced delivery opportunities. Several companies already implemented this solution, sometimes along with a network of partnered business access points. Some of these companies are parcel delivery service providers, others are e-commerce retailers, while others are focused smart locker service providers. We examine in this paper the different business models and capabilities currently active in the market. We highlight trends and options relative to designing and operating Smart Lockers Terminal networks.

The e-commerce industry is dramatically growing, and last mile deliveries to customers (B2C) is becoming a major challenge for integrated on-line companies and parcel logistics providers. This challenges are emphasized by the urbanization trends; indeed, in 1950, 30% of the world's population was living in urban areas, in 2014 it was already 54%, and it will be over 65% by 2050 (World urbanization prospect, United Nations). Thus, among the many challenges that will be faced by urban planning, last mile delivery is one of the major, as it critically impacts the city from congestion to emissions.

In a world where everything has to be faster and faster, with higher and higher service levels, end-to-end supply chains are critical, and e-commerce shopping, convenient for customers allowing them to compare several offers at the same time without leaving their houses or their offices in just a few minutes, as well as reading reviews and report on products and companies. In one or two clicks on your computer, one can order a product that will be delivered from the opposite side of the world to its home in just a few days.

But, as urban population increases growing demand for e-commerce delivery along with needs related to last mile delivery, it becomes a challenge to deliver the package at the very moment it is convenient for both the transporter and the customer. Thus, deliveries tend to happen at the end of day, when customers are going home, but also when rush hours are occurring, resulting in huge levels of congestion in and around cities, and increasing the length of the delivery window to several hours when the customer is asked to be home, thus resulting in low service levels and customers' experience. There are clearly inefficiencies (late and unsuccessful deliveries) to be tackled in last mile city logistics in order to sustainably absorb the fore coming growing demand.

Here, we are exploring opportunities for consolidated last mile deliveries, and particularly the Smart Lockers Terminal solution for e-commerce deliveries.

Impact of consolidated last mile delivery on stakeholders

It is important to take in consideration and to understand the impact of such solution on all stakeholders involved, which are in this case: customers, logistics providers, on-line retailers, and cities.

Customers – It can be a real problem for a customer to adapt his schedule to the expected delivery time slot, especially when this slot is wide and prevent him/her to leave home. Consolidated last mile delivery would allow customers to pick up packages on their daily commuting path at any time convenient for them, within a time frame of some days where the package will be hold by the terminal/access point. Thus, the customers gain time and the customers' satisfaction level increase. Indeed, flexibility is one of the major factors influencing the consumer choice of delivery method along with cost and speed (Last mile delivery, Barclays).

What we are trying to do here is to take a step back on the supply chain and involve the last customer in the process. By using delivery consolidated delivery points, we require the customers to move and

pick up their packages by themselves. But, if this done in a smart way, the delivery location could be on a commuting path (gas stations, supermarket, mall, ...), or right next to offices, which would make pick-ups convenient for consumers, while eliminating the stress of not being at home when a package is being delivered.

Logistics providers – An increasing urban population will increase demand and thus needs for assets such as delivery vehicles and deliverers. By bringing opportunities for consolidated deliveries, we limit the needs for assets, since delivering several parcels at the same location decreases the number of stops required, increasing time capacity for more deliveries.

The use of automated delivery terminals also eliminates unsuccessful deliveries due to an absent recipient, which can be costly and requires more delivery capacity.

Retailers – To be competitive, online retailers must offer low shipment rates, consumers don't want to pay for anything else than the product they want, and are now expecting free delivery. The opportunity to consolidate deliveries in one terminal/access point will decrease the transportation costs by reducing the number of mobile resources needed, and by reducing the time needed to deliver the daily amount of parcels (shorter delivery tours, with shorter and less length variable stops). In other words, the improvement in carriers' efficiencies will be a trigger to reduce costs on the retailers' side.

However, this solution requires to keep an eye on the delivered goods as long as they haven't been picked up by the consumers, and eventually requires to pick them up from the terminals/access points for return or redeployment. Visibility on flows enabled by hyperconnectivity then appears to be essential.

Cities – Finally, these stakeholders are evolving in cities, and consolidated deliveries could result in more efficient flows thus limiting the impact on congestion, obviously potentially helping to reduce the impact on the environment (emissions) contributing to a better quality of life.

SMART LOCKERS TERMINALS

The Smart Lockers Terminals (figure 1) are parcel capable locker units located in convenient and public locations in living neighborhoods, storing packages for all customers in a certain area for a certain amount of time (a few days), they are automated consolidation delivery points. The customers, at their most convenient time, can pick up their belongings by logging themselves to an intelligent terminal interconnected with the delivery company's system through the IoT (Internet of Things), using a code sent by email, text, a smartphone, a government ID, or a credit card. Though this solution requires the customer to move from home to get the package, if the units are smartly deployed over the city, it will take only a few minute to access it, especially when the customer will have the opportunity to choose the most convenient location available, with the possibility to choose a unit somewhere on the customer's commuting path. Additionally, cutting the last step of home delivery,

transportation companies will be able to consolidate their parcel deliveries by units, and will be able to effectively put the packages in the smart lockers at any time and limit congestion.

Smart Locker Terminals can be compared to Access Points, which are business partners serving as consolidation delivery points for carriers. The difference is for the customer, who doesn't have human interactions since Smart Locker Terminals are automated units. They are also accessible at any time, since business hours are not a constraint anymore, depending on the location of the terminal (public space or not).

Figure 1: Inpost Smart Locker Terminal in Poland (*Source: http://portalvendingowy.pl/polska/Odbierz_przesylke_w_paczkomacie*)

Here follows an example (Zhilai) of how Smart Lockers units can be automatically operated in a few steps for both the deliverer and the customer:

Couriers using steps:

1. Login with company's credentials
2. Access Data and address customer's information
3. Choose an available compartment
4. Scan the package
5. Put the package in the compartment, lock it and confirm delivery

Recipients using steps:

1. Login using unique credential/confirmation number received by email/text, or using official document such as Government ID or Credit card
2. Pick up package from correspondent opened locker and confirm

METHODOLOGY

For the purpose of this paper, we studied 12 relevant companies over the world summarized in the table 1. We don't assume to demonstrate all the stakeholders or models of the developing industry, but we are trying to assess the best practices currently implemented and experimented by the innovative companies, and to analyze their business models in order to have a good idea of what the industry is trying to develop on last mile delivery to cope the issues of scale and congestion they face in cities. Here follows the methodology we used to draw our analysis:

1. Data collection based on online press and company's websites and press releases.
2. Identification of a business model pattern based on understanding of the data gathered and the similarities between companies.
3. Comparison with the literature of the Physical Internet in order to evaluate the solutions.
4. Presentation of the business model and network.

Company	Service	Dimensions Capacity	Weight Capacity	Sources
InPost	*Paczkomaty*	25x16x15 in.	55LB. (25kg)	twoj.inpost.pl
Deutsche Post DHL	*Packstation*	24x14x14 in.	77LB. (35kg)	www.dhl.de
Norway Post - Bring	*MyQuickBox*	24x14x14 in.	77LB. (35kg)	www.posten.no; www.bring.com
Osterreichische Post AG	*Post 24*	40x24x24 in.	66LB. (30kg)	www.post.at
Bpost	*Packstation*	27x16x12 in.	66LB. (30kg)	www.bpost.be
Itella	*SmartPOST*	24x24x14 in.	77LB. (35kg)	uus.smartpost.ee
Post Danmark	*Dognposten*	24x14x14 in.	22LB. (10kg)	www.postdanmark.dk
Groupe La Poste	*Cityssimo*	24x17x14 in.	44LB. (20kg)	www.colissimo.fr
DPD Groupe	*PickUp*	24x17x14 in.	44LB. (20kg)	www.dpd.com
UPS	*UPS My Choice*	32x10x10 in.	44LB. (20kg)	www.ups.com
Amazon	*Amazon Locker*	16.5x13.8x12.6 in.	10LB. (5kg)	www.amazon.com
Zhilai	*Webox*	20x19x18 in.	44LB. (20kg)	www.smartelocker.com

Table 1: Capabilities of the set of services selected

The supply chain industry is fast moving, and new generation last mile delivery solutions are already being tested in many places around the world. Here follows the analysis we built about what services can be found using the concept of Smart Lockers Terminals which has been around since the early 2000's, based on the major stakeholders of this cutting-edge initiative. Although others solutions will appear in our study, we will focus on and develop the Smart Lockers Terminals capabilities.

NETWORK

Smart Lockers Terminals can be compared to business partners serving as consolidation delivery points also called Access Points. In certain markets, last mile delivery networks are often composed of both Smart Locker Terminals and Business Partners, to balance between automation and human interaction, and to face investments in equipment and real estate while growing the network.

Smart Lockers Terminals – Networks composed of Smart Lockers Terminals try to cover the population in order to be close enough to last customers, to make sure it is worth it to choose a Smart Locker Terminal delivery over regular home delivery. The terminals are located in high frequented areas such as train stations, malls, shopping areas, or public spaces. With different capacity and layouts available, they adapt themselves to every location and any demand. Figure 2 shows an example of Inpost's developed network of Smart Locker Terminals in Poland, composed of 1,300 Terminals in 260 cities, located in public areas such as railroad stations, megastores, malls, …
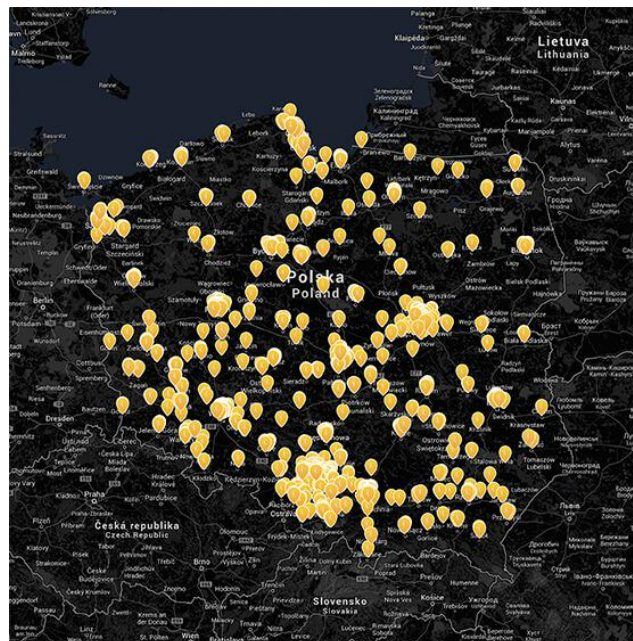

Figure 2: Inpost Smart Locker Terminals Network in Poland (*Source: https://b2b.paczkomaty.pl/en/get-to-know-paczkomaty/service-coverage*)

Access Points – UPS, BPost, and DPD Groupe use access points along with Smart Lockers Terminals to build their network. Access points are local businesses that partner with a logistics provider to receive and store parcels during the hours of operations, until the final customer pick its package up. Although it requires workforce (staff of the local business) to operate, and is limited to the hours of operation of the business, this solution allows to build a large network with a minimum of assets investments as it works through partnerships with existing facilities. Notice that it is also more flexible in term of capacity and deployment, as a partnership can be created or stopped if needed.

Both of this solutions to build networks are using consolidated delivery opportunities and allow logistics providers to save money and time in the last mile delivery (consolidation and successful first attempt), while allowing more flexibility to the time the packages get delivered.

The mix of Smart Lockers Terminals and Access Points seems to be the solution chosen to build a large network (UPS, DPD Groupe) with acceptable investments. We can notice in the table 2 there is a demand for this kind of last mile delivery solution supported by the scale of some successful networks such as Inpost and its 3,500 Smart Locker Terminals in Europe.

We also notice that services sometimes require customers a special membership, and are sometimes limited to a set of partnered online retailers such as InPost and its 6,500+ retailer, or Amazon.

Company	Service	Network		Membership	Restrictions
		SL Terminals	Access Point		
InPost	*Paczkomaty*	3500	-		6500+ Retailers
Deutsche Post DHL	*Packstation*	2650	20000	Required	-
Norway Post - Bring	*MyQuickBox*	42	-		-
Osterreichische Post AG	*Post 24*	24	-		-
Bpost	*Packstation*	125	680		-
Itella	*SmartPOST*	480	-		-
Post Danmark	*Dognposten*	300	-	Required	-
Groupe La Poste	*Cityssimo*	31	-		-
DPD Groupe	*PickUp*	200	22,000		6600+ Retailers
UPS	*UPS My Choice*	300	12000		-
Amazon	*Amazon Locker*	200*	-	Required	Amazon
Zhilai	*Webox*	3000	-		-

Table 2: Networks of the set of services selected

Different channels are being used to support business models. Business 2 Consumer makes sense since we are looking at e-commerce deliveries to consumers, form retailers to consumers.

As shown in table 3, Consumer 2 consumer is available in some European areas (Germany and Denmark). It enables customer registered in a membership plan to send each other parcels within the smart locker terminal network, that becomes a drop in location, using payment terminals and label printers. We would be careful with this one, since it implies high risks, such as use of lockers to trade illegal drugs or weapons, or to simply bomb a public area where the terminal is sitting.

We also added Private here, to differentiate players like amazon, that only allow deliveries for their own customers, meaning for parcels ordered through Amazon.com (Retailer restriction).

Towards the development of Hyperconnected Smart Cities, business model enabling both B2C and C2C have more potential to use crowdsourced delivery as an efficiency leverage for city logistics. However, C2C capabilities bring security issues, as the package would need to be checked before being stored in the network.

Private business models on the other hand, by definition, are going against the concepts of the Physical Internet and the cooperation and collaboration leverages, limiting the use of the network for a specific company.

Company	Service	Area of Opertions	Business Model		
			B2C	C2C	Private
InPost	*Paczkomaty*	Worldwide	■		
Deutsche Post DHL	*Packstation*	Germany	■	■	
Norway Post - Bring	*MyQuickBox*	Norway	■		
Osterreichische Post AG	*Post 24*	Austria	■		
Bpost	*Packstation*	Belgium	■		
Itella	*SmartPOST*	Finland	■		
Post Danmark	*Dognposten*	Denmark	■	■	
Groupe La Poste	*Cityssimo*	France	■		
DPD Groupe	*PickUp*	Europe	■		
UPS	*UPS My Choice*	United States - Europe	■		
Amazon	*Amazon Locker*	United States			■
Zhilai	*Webox*	China	■	■	

Table 3: Business Models of the set of services selected

There is a wide range of technology solutions to ensure security, to provide good service levels, and capacities:

Logistics Providers Login – All the companies studied here are using the same type of protocol for logistics providers' login. The courier access the terminal through a touch screen, enter its credential (unique user ID and password) or scan a barcode or QR code through the terminal's scanner, and then provide an parcel identification code or barcode or QR code matching with the store manager database. An available compartment will open to receive the package. The process is similar while picking up packages for returns or shipping.

Customer Login – Once a package gets delivered in a Smart Lockers Terminal, a message is generated and automatically transmitted to the order's customer through email, text message, or by the intermediary of a smartphone application. Here follow two existing options to pick up the package:

The message received by the customer contains a unique access code along with a location that enable access to the touch screen terminal. Once this code provided, the correspondent locker opens and the package is ready to be picked up.

In the second option, the message still contains a location, and might contain an access code, but the customer can access the terminal using a government ID, a registered member access card, a smartphone, or a credit card linked to his order through the retailer's membership.

Security – Although the login processes prevent from basic fraud, some other features exist to increase the level of security. First of all, the units located in convenient and public areas are watched by cameras, either part of the terminal itself, or part of the infrastructure hosting them. However, these cameras don't seem to be connected to the logistics systems yet, and might require queries to be accessed for liability concerns. Ideally, we would connect these cameras to the system through a cloud capability to be able to access them and follow the goods at any point of the supply chain.

Finally, we haven't seen any security on the package side, checking the presence of the package in the compartment, or communicating with it. In the perspective of using Hyperconnected Modular Containers (PI-Containers), we expect the Smart Lockers Terminals to be able to communicate with the goods (for example through RFID technology) enabling the system to get information from sensors, tracking location, and to change routing decisions.

Scanner – Each Smart Lockers Terminal is composed of a barcode scanner to register a package when a courier delivers it into one of the compartment. This checkpoint allows the system to recognize the items delivered and to make sure they are at the right place, and also enables visibility over the supply chain, tracking the parcels.

Payment Terminal – Some manufacturers (Cisco, Hangzhou Dongcheng Electronics Co., …) provides units with payment terminals, allowing on site payment for C2C capabilities (Deutsche Post DHL, …).

Printer – In order to enable C2C business models, printers can be added to the Smart Lockers Terminals, issuing barcodes and receipt for parcel shipping. Even if not required for this purpose in the digital world, printers can also be used to issue receipt in B2C models to deal with returns.

Connectivity – Manufacturers all provide complete solutions when delivering Smart Lockers Terminals, from physical computer capacity to connectivity to a management system. This is aligned with the development of Hyperconnected Logistics Systems through the Internet of Things, tracking the goods all over the physical logistics network.

Modularity – Finally, Smart Lockers Terminals are modular, meaning that there is a set of configuration options that enables the terminals to be arranged in a way they will fit perfectly with the location where they are deployed, both in terms of capacity and layout. This modularity also eventually allows to increase or decrease the capacity by adding/connecting or removing/disconnecting entire modules dynamically to adapt to the demand.

SUPPLY CHAIN STRUCTURE

Finally, we analyze the way Smart Locker Terminals are integrated in e-commerce supply chains. Among the set of companies studied, we identify two main different structures: one where Smart Locker Terminals are tied to one or a set of Logistics Providers, and one where they are ted to one or a set of Retailers (Figure 3 shows the 2 structures).
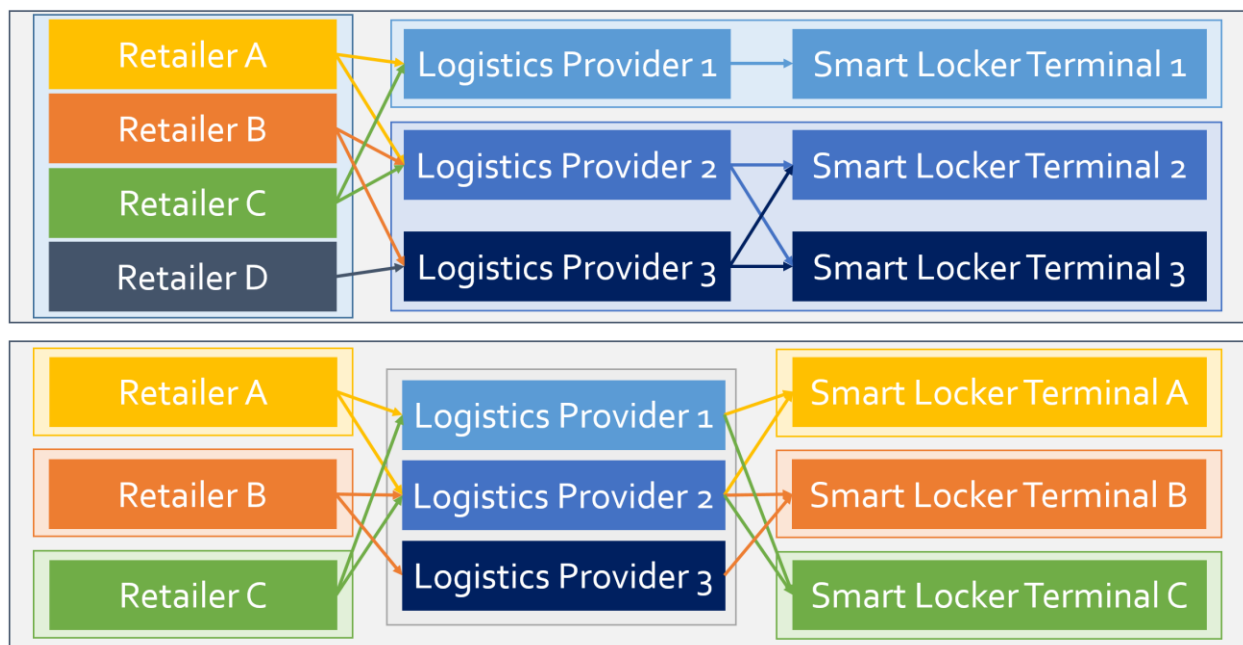

Figure 3: E-commerce Supply Chain Structures Identified for Smart Locker Terminals

In the first case, a parcel carried by a logistics provider must be delivered to a Smart Locker Terminal that is tied to it. For instance, a parcel shipped by Retailer C through Logistics Provider 1 must be, if using this last mile delivery solution, delivered to Smart Locker Terminal 1. In this structure, the ownership of the Terminals is restrictive, limiting the use to the owner. Smart Locker Terminal 1 can only be operated by Logistics Provider 1. We note that as shown for Terminal 2 and 3, the ownership could be shared between a set of Logistics Providers.

In the second case, a parcel carried by a Logistics Provider must be delivered to a Smart Locker Terminal that is tied to a Retailer. The use of a specific Terminal is now not restricted to a specific set of Logistics Providers, but could be used by any of those carrying parcels originating from the corresponding Retailer. For example, a package shipped from Retailer A through either Logistics Provider 1 or 2 must be, if using this last mile delivery solution, delivered to Smart Locker Terminal A. But, although Logistics Providers 1 and 2 can access Smart Locker Terminal A, they can only deliver parcels originating from Retailer A.

At a large scale, following either of these two structures, we can imagine ending up having many Smart Locker Terminals in the same area to support the activities of all entities (one Terminal per Logistics Providers, or even one per Retailer). Obviously, this is not sustainable from a space perspective, but also from an investment and efficiency perspective.

In line with the Physical Internet concepts of Open Facilities, we propose here an alternative structure of supply chain (figure 4), where Smart Locker Terminals use is not restricted to any entity anymore.
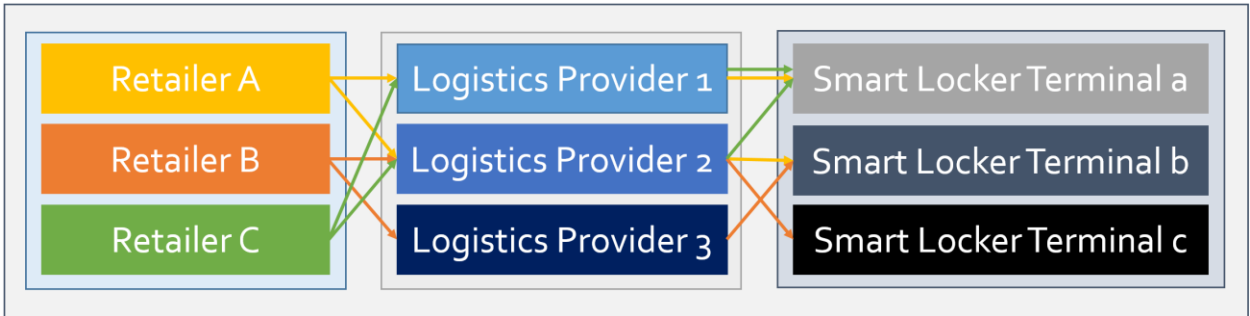

Figure 4: E-commerce Opened Supply Chain Structure for Smart Locker Terminals in line with the Physical Internet

As Smart Locker Terminals are now "opened", anyone could own them (Retailers, Logistics Providers, or even independent businesses), and immediate users (Logistics Providers) will for instance pay a per use fee, or subscribe to a flexible pricing plan. The intend here is not to propose a free to use structure, but a non-restricted use structure based on contracted pricing strategies to define.

In the example presented in figure 4, Logistics Provider 1 can use Smart Locker Terminal a to deliver parcels for Retailer A and C, and Logistics Provider 2 can deliver parcels to any of the Smart Locker Terminals a, b, or c.

As a result, it would limit the density of Smart Locker Terminals in a specific area, and Terminals' operators (or owners) of different sizes would cover certain areas. Moreover, since it is easier to manage demand variability globally rather than segmented, the sum of extra capacities necessary to

absorb demand variability of independent terminals is greater than the extra capacity required in one Open Terminal covering the same area and the same demand. It means that utilization rate in the Opened Supply Chain Structure proposed is potentially much higher than in the two previous restricted cases identified.

CONCLUSION

Over the last 5 years, Smart Lockers Terminals type of solutions have been popping up everywhere around the world to cope with last mile delivery in dense city areas. From pilots to large scale networks, companies are developing them on their own, trying out different business models and different logistics models to transform the last step of their supply chains.
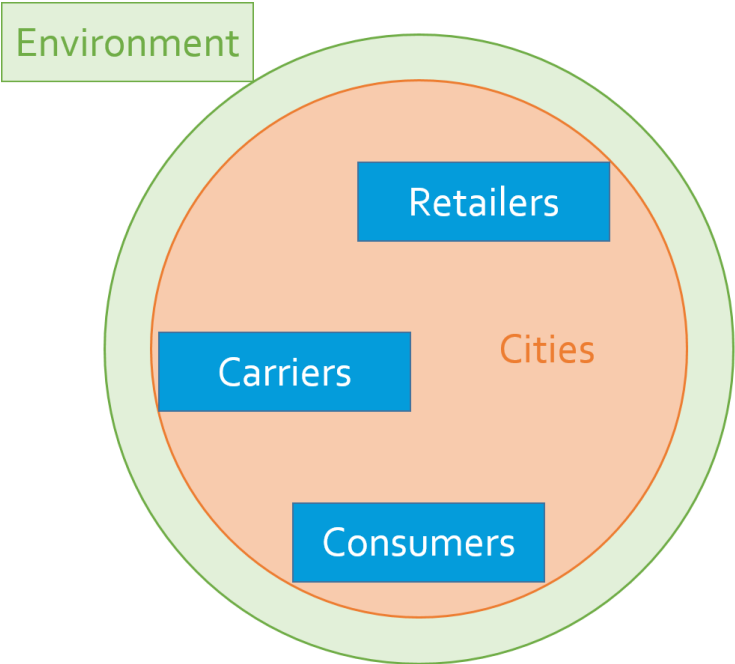
Figure 5: Stakeholders of E-commerce Supply Chains impacted by Last Mile Delivery

The implementation of such a solution impacts stakeholders at all levels (Figure 5). First of all, the consumer, although it requires to go to a public location to pick up a package, this solution eliminates the stress of not being at home when a package is being delivered. If chosen smartly, the location of the Smart Locker Terminal can make the pick up very convenient. For instance, if it is located on the consumer's commuting path, or at a gas station, or frequently visited grocery store.

For carriers (Logistics Providers), consolidated deliveries could limit the increasing need of assets (vehicles and drivers) induced by global urbanization, and eliminate multiple unsuccessful deliveries resulting in 2nd and 3rd attempts deliveries, or even returns to distribution center, due to absent consumers.

For retailers, the improvement on carriers' efficiency might be a trigger to reduce shipping cost, which tends to be critical in e-commerce. As a consumer, you are expecting your order to be delivered

tomorrow (as soon as possible), for no cost (since shipping cost doesn't add any value to your order from your perspective).

Finally, these stakeholders are evolving in cities, and the Smart Locker Terminal solution to e-commerce last mile delivery could result in more efficient flows thus limiting the impact of carriers' activities on congestion, helping to reduce the impact on the environment (gas emissions), and improving the quality of life in cities.

The different services studied in this paper are a good basis towards Hyperconnected City Logistics, at least at a first level. It helps us identify opportunities in further research areas such as Dynamic Capacity Allocation, Pricing Strategy and PI Container Applications for Smart Locker Terminals solutions.

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