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# Fresh and Frozen Food Box/Lockers as part of Market, e-Market and Collaborative Economy Smart City Environment:

Systemic & logistic point of view

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**Abstract**— In the Smart City environment several distribution modes are proposed, ranging from physical & virtual shopping to goods transportation and distribution. Use of the classical B2C schema can be upgraded to that of the B2B2C one and its variations. We study the use of a new approach based on lockers supporting fresh and frozen food storage, together with a new distribution system able to take collaborative economy into account. This allows these lockers to be used by several providers, thereby shortening distribution circuits. We describe and discuss a systemic and logistic point of view.

**Keywords**— lockers; fresh and frozen foods; Collaborative economy; systemic approach; logistic; smart city.

## I. INTRODUCTION

In the Smart City approach [1, 2, 3] of in-city life, old and new distribution techniques are used for different products (documents, goods and foods) [4]. A number of new constraints are progressively taken into account such as rapidity (distribution time), security (during transportation and delivery), thermal conditions, as well as ecological conditions (traffic, noise, environmental pollution), to name but a few. Generally, it is useful to distinguish between B2B relationships in which provider and receiver are professional and B2C relationships when the receiver is not available all the time at his/her address. This situation can considerably influence the delivery process and performance. For receivers available all the time, the distribution process is easier, as it is limited to only one delivery. For sporadically available receivers several solutions are conceivable: knowing the receiver's availability, requiring presence to avoid several deliveries, or finding an external solution such as a delivery point or locker.

From performance and ecological points of view, individual delivery of parcels, by different delivery trips and vehicles, contributes to the creation of traffic jams and harmful particle emission. More appropriate solutions are emerging called “massification” (grouping all parcels for the day or week for a receiver) aimed at minimizing the number of trips, and “mutualization” (giving one delivery firm an area of

distribution). The delivery area reservation process is another solution for increasing delivery performance [5].

If we analyze clients' shopping behaviors, we can identify four situations:

- **Classical physical shopping:** go to the shop, choose, collect, pay and transport corresponding goods to home;
- **Physical choice and home delivery:** go to the shop, choose, collect, pay and ask for delivery at home;
- **Drive:** choose and order by Internet and go to collect the goods at the delivery place (often shop drive platform);
- **eShopping:** choose and order by Internet and receive ordered goods at home (or other address) by the shop delivery service.

## II. BOX/LOCKER BASED DISTRIBUTION

### A. Classical box/lockers

A new type of solution emerged recently. Its goal is to provide a location for storing parcels outside the final destination. This avoids non-delivery if the receiver is absent, leading to a new delivery trip at another moment of the day or the next day. In this way, an asynchronous behavior between transporter and receiver is created.



Fig. 1. Box/Lockers used by French (a,b) and Chinese (c,d) Posts

The Box/Locker is generally located in a public area. This method is commonly used for postal parcels and letters, i.e. the French Post uses it (Fig. 1a, 1b), as well as the Chinese Post (Fig. 1c, 1d) for B2B and B2C distribution schemas.

Today, this solution is also used for distribution of different goods such as foods, mainly in the B2C schema. It has been implemented recently by a number of supermarkets such as Casino, which provide in front of their stores this kind of box/lockers (Fig. 2). One of the main providers of this solution is InPost, a Polish company providing its solution worldwide (Canada, France, etc.) [6].



Fig. 2. Box/Locker used by a store for ambient temperature and dry goods

The advantage of this kind of Box/Locker is its availability in multiple areas of the city or town, as well as in pedestrian areas: it is also called “pedestrian drive”, in reference to super and hypermarket drives for vehicles. Its main advantage is its accessibility 24 hours a day 7/7 days a week. The location is carefully chosen to optimize proximity for pedestrians and accessibility for loading.

The standard physical structure is a big cupboard with, at the user-oriented face, a large number of slots each receiving a letter or parcel. An interactive screen is used to manage control and access commands for providers (loaders) and receivers (retrievers) based on access codes for both parties. The user interface is either based on tactile interaction on a Box/Locker screen or can be deported to the user’s smartphone.



Fig. 3. BingoBox & WeChat

Bingobox [7], managed by the WeChat social network, is another concept of a “fresh food” 100% automated shop without staff allowing the client to choose freely the goods he/she purchases. This is a Canadian “depanneur” store, which can be moved to different locations in the city. Amazon Go [7]

has the same characteristics. This concept is totally different from the box/locker concept.

ByBox [8, 9] is a more directly related proposal, hailing from the Silicon Valley and created in February 2000. The original mission was to build technology to increase the efficiency of online shopping delivery. The first product was an electronic lockerbank connected to the Internet. Today, ByBox continues to lead the global market for locker-based solutions to difficult supply chain problems. Online shopping remains a core market for ByBox with a range of automated Click & Collect solutions. Today, the three pillars of ByBox are software, technology and infrastructure. A ByBox proprietary software platform was designed to re-wire field service supply chains to operate with less inventory and minimal distribution, with the mantra “move the data, not the part”. For field service, the latest product is an app-controlled smart box, which takes the form of temperature controlled units for the grocery market. The ByBox is used in the UK and South Africa.

### B. Box/Lockers for fresh and frozen foods

We designed and developed in a consortium of several companies and academic institutions, a new Box/Locker concept, the aim of which is to store and deliver foods at the appropriate temperature. This physical structure is different in order to avoid temperature loss by coolness (Fig. 4).



Fig. 4. Box/Lockers for fresh and frozen foods

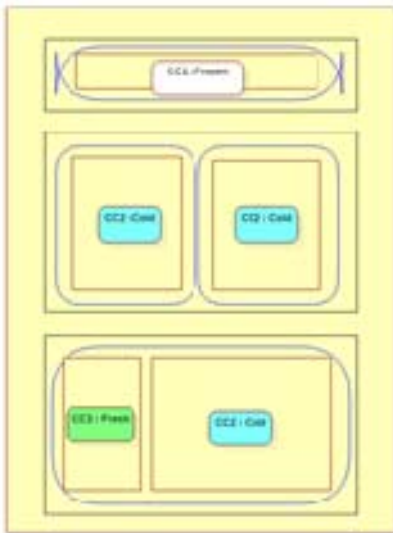
We replaced multiple slots and their associated doors by a single door able to open to match with vertical location of baskets containing parcels. In other words, the parcels are not statically located in slots but in baskets with several slots. The vertical position of the slot is related to the corresponding temperature (ambient, fresh or frozen – Fig. 5). The baskets move circularly in the Box/Locker to be positioned in front of the door during storage (by the provider) or retrieval (by the receiver – client).

Usually three kinds of physical location can be used for these Box/Lockers:

- In front of a store,
- In a shopping gallery or railroad station,
- Outside in the town or city.

24 hours and 7/7 days availability for clients-receivers is the main characteristic. The first statistics collected by InPost are very interesting. 30% of goods are retrieved during the weekend and 32 % at night (between 8pm and 9am).

Another advantage concerns the providing / loading process, which can take place according to provider working and transportation conditions, independently from the retrieving process (asynchronously).



The box/locker consists of Columns (12 currently):

1 column consists of baskets (3 currently)

1 basket can be divided into lockers (1, 2)

There are as many doors as lockers (4 currently)

1 locker can be divided into areas with different Cold Categories (CC):  
 -20°C (Frozen)  
 +2°C (Cold)  
 +8°C (Fresh)

Fig. 5. Overview of a Box/Locker column

In the first case (in front of the store), the providing process can be continuous during store opening hours. For distant locations (galleries or outside towns/cities) the decision to provide depends on the distance and the amount of parcels to transfer. Optimization is necessary between a high degree of reactivity (often demanded by clients) and the transportation cost / quantity of parcels to provide. This aspect needs appropriate data analytics to discover behaviors in the field and take them into account for Box/Locker functioning.

### C. Box/Lockers for fresh and frozen foods and software architecture

Our main goal is to study the role of the Box/Locker in different working situations of the market. For this purpose, we present, first, generic software and then its adaptation to different market environment configurations.

This kind of locker is generally used in the following scenario. The user (shopper) connects to the website of his/her preferred shop – super or hyper market, selects and orders appropriate goods and dry, frozen or fresh foods (needing temperature controlled storage). He or she also selects the location of the preferred Box/Locker and the required date and time of availability.

The website registers this command and payment and transfers the order to the logistic department, which is in charge of preparing it and organizing its transportation to the Box/Locker. As soon as possible, an email or SMS is sent to the client to give him/her the availability date and time of the command in the chosen Box/Locker. A logistician/provider is in charge of transferring the goods to the Box/Locker and inserting them in it. To this end, the Box/Locker manager gives him/her appropriate slots to be used. The goods (foods) needing different temperatures are located in the appropriate slots. When the process is completed, a confirmation is sent to the client indicating that the command is available in the expected Box/Locker.

The main modules used to manage this process are [10, 11]:

- Web command management, payment and command transfer to the logistician,
- Command preparation and packaging, transportation scheduling and transportation,
- Box/Locker local management with the loading (storage) and retrieving process, as well as the security, maintenance and cleaning actions,
- Multi Box/Locker manager allowing more efficient scheduling of goods allocation if authorized by the user.

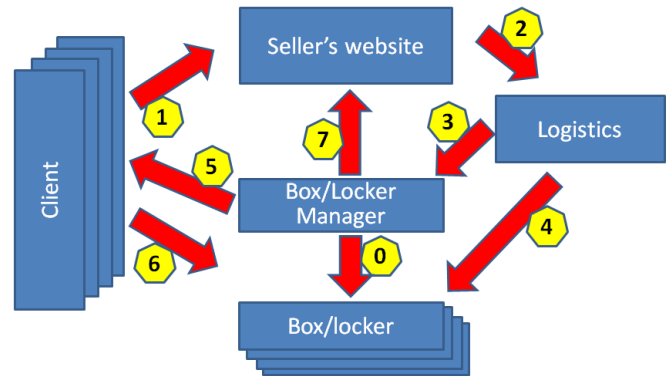


Fig. 6. Software architecture with main modules and exchanges.

The main exchanges between modules are (Figure 6):

- 0 – Management of multiple Box/Lockers: To know the current occupancy of each Box/Locker, basket and slot in order to allow the logistician to distribute appropriately the goods/foods on a command list. Management of forgotten items is also necessary.
- 1 – Client command list elaboration process via seller(s) website(s).
- 2 – Transmission to the logistician of the command list in order to allow him/her to prepare the corresponding delivery.
- 3 – Asking the Box/Locker manager to receive the box/locker identifier and baskets and slots for goods/food ordering.
- 4 – Transportation to and loading in the chosen Box/Locker of ordered goods, with the provider access code.
- 5 – Client information on goods availability (Box/Locker identifier, date and time of availability, and access code).
- 6 – Retrieval operation process based on the access code and the list of goods provided and their location in one or more baskets and slots used in ordering door opening and internal motion of baskets.
- 7 – Acknowledgement of completion of the loading or delivery operation, with, if necessary, a retrieval report sent to the seller.

The data manipulated by the different parties are as follows:

- Client – Customer data: Client contact; Purchasing: product - volume / gauge, weight, category; Box/Locker

required (1 precise one or perimeter related to an address and distance); Required release date (and duration)

- Box/Locker data: Occupancy: dry, temperate, cold, icy - occupied / free and by addressing; Assignment operation: as soon as possible (as soon as the order is processed), at the latest (at the time of loading), overbooking; Loading operation: loading code, load list; Retrieval operation: client code, retrieval list; Observation of the state of the Box/Locker (hygienic situation, broken baskets and slots, etc.); Technician intervention operations (maintenance, recovery, etc.)

In more detail, categorized by stakeholders involved in the information system, we list:

- Customer purchases: Identification of the customer, date of availability, location; List of products (nature, weight, volume, price)
- Logistician: Shopping list; Separation by nature (packing): determined number and types of baskets to be provided;
- Manager of the Box/Locker: Availability of baskets in each Box/Locker; Updating by exchange of information between manager and Box/Locker, Static reservation (on actual availability) or dynamic (overbooking)
- Delivery man: List of deliveries by Box/Locker; List of customers and their slots; Inform the merchant site or the Box/Locker manager about implementation of the sales order, the latter informs the customer
- Client retrieval: Access code, location, availability period, number of slots; Incident management
- Maintenance technician: List of problems; Actions to be carried out; Report to the manager of the Box/Locker: baskets out of order, etc.

This textual (semantic) presentation could be completed by the UML class diagram (not present due to lack of space). Nevertheless, we give, in the Appendix, the overall UML sequence diagram showing the dynamicity of the process.

### III. COLLABORATIVE AND SHARED ECONOMY: UBERIZATION

The term "uberization" is a neologism popularized by Maurice Lévy after an interview with the Financial Times in December 2014 [12,13,14]. The term originates from the Uber Company that has globally popularized passenger cars with driver, thus competing directly with taxis. The features of this service are almost real time, pooling of resources, and the small percentage of heavy infrastructure (offices, support services, etc.) in the cost of service. This term "uberization" is generally used to refer to the phenomenon whereby a start-up or a new economic model related to the digital economy threatens to replace an old economic model. Some of the services mentioned the following examples: Airbnb, Booking.com and Amazon. After the two models, Uber and Uber Pop, which are currently challenging traditional Cab activity, the car share

BlaBlaCar Company, initially created in France, is another uberized model for transportation sharing.

The collaborative/shared economy is understood in a broad sense [15, 16], including collaborative consumption (couch surfing, carpooling etc.) but also shared lifestyles (co-working, colocation, collective housing), shared finance (crowdfunding, ready to silver peer-to-peer, alternative currencies), contributory output (digital manufacturing, DIY, Fablabs, 3D printers, maker spaces) and free culture.

It assumes different forms (sharing economy, service economy including circular economy, economy of solutions, peer-to-peer economy according to the types of goods and services concerned or proposed (consumer empowerment, eco-effectiveness). This kind of economy is placed in a context of mistrust of institutional actors in the traditional capitalist system and in an economic crisis context, as well as in an ethical and environmental context.

Its rise is due to the use of new technologies to improve collective/shared creativity and productivity. It also responds to the desire for green practices and more friendly social relations.

### IV. BOX/LOCKER SUPPORTED COLLABORATIVE ECONOMY

#### A. Classical configuration: one provider for multiple users

The first configuration is a classical one with several clients, one seller, one logistic provider, several Box/Lockers, one Box/Locker manager and one final client (receiver) as shown on Fig. 5. We can formalize it by the code  $N:1:1:N:1:1$ . In this configuration, there is service fusion between the seller and its logistic service in a classical B2C schema. On the contrary, another possibility would be several logistic services in charge of preparing and loading goods in the Box/Locker, coming directly from the seller's providers. In this case we have a B2B2C schema.

#### B. Different configurations for collaborative economy

The goal of collaborative economy is to offer the possibility for several providers to use the set of Box/Lockers. For this approach we identified 3 solutions, namely:

$N:N:1:N:1:1$  - several clients, several sellers, one common logistician, several Box/Lockers with one Box/Locker manager and one final client;

$N:N:N:N:1:1$  - instead of one logistician, several offer their services. A more complex management schema is: B2B2B2C;

$N:1*:N:N:1:1$  - a common website for several sellers is proposed by an independent party, who is able to organize and dispatch collected demands and commands to appropriate logisticians each working for one seller.

From a theoretical point of view we are not far from "uberization", in which we have two categories of people: clients and providers. The goal is to connect in an individual way the first (the client) with the second in order to find a product proposed by a provider (seller). This can be organized in different ways: either each person has his/her own website and the client knows how to connect to it or someone has elaborated a common website. In the first case, each seller is

responsible for his/her website, while in the second case someone has elaborated this common website.

For logistic aspects, there are also several solutions: a close relationship between seller and logistician, complete separation between these two activities with one or more logisticians working for one seller.

Intermediation is a very important service that must be provided to support this collaborative economy: it allows creation of short distance circuits between providers and consumers, mainly clients and farmers, to shorten fruit, vegetable and meat distribution times.

We can synthesize these situations in the Fig. 7.

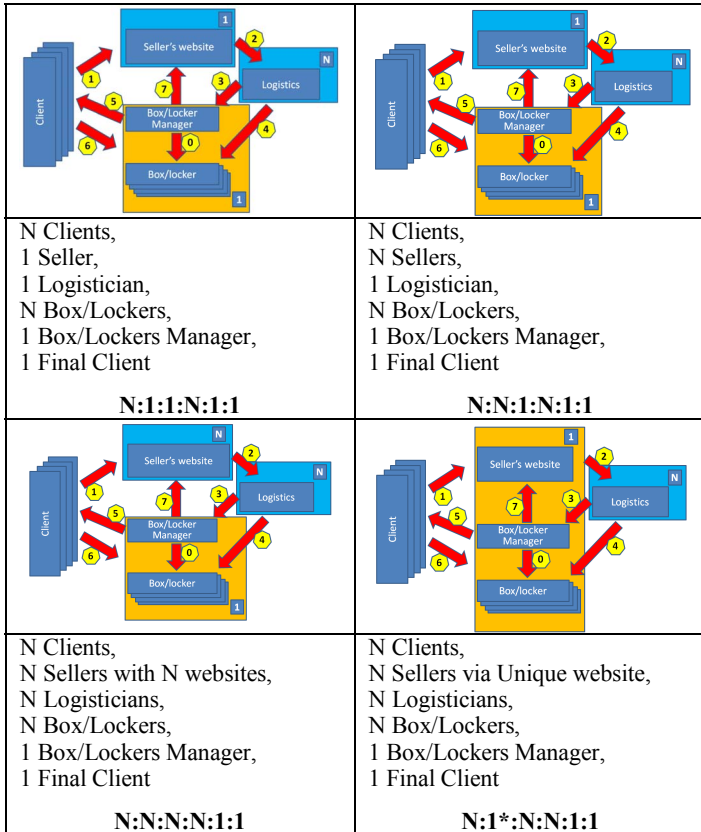


Fig. 7. Different working configurations.

## V. DATA ANALYTICS FOR DYNAMIC BEHAVIOR

While the generic architectural view is unique, its deployment must take into account the different working configurations discussed above. To determine appropriate functioning, we need to collect temporal aspects taking into account the observed behaviors of all parties involved, i.e. clients, sellers, logisticians and Box/Locker managers.

The main properties are:

- Client delivery time or the time required to deposit the goods/foods in the Box/Locker. Clients wish to shorten this time to 24h for parcels, as now proposed by Amazon Premium. For foods, this time could be shortened or adapted to clients' requests.

- Command & payment treatment delay is usually instantaneous.
- Logistics, transportation and loading in the selected Box/Locker is an important parameter with two contradictory characteristics: for the client, as mentioned above, this should be as soon as possible or in accordance with his/her request while, for the logistician, loading for several clients is more profitable. The main elements in the optimization procedure are the distance between logistician storage and the target Box/Locker and the number of parcels to load. Loading frequency is to be determined with regard to collected data: turnover of goods in the Box/Locker, average time of goods storage, loading frequency and evolution.
- Box/Locker occupancy is important information that must be collected and studied. It can provide us with current clients' behaviors, their promptness in retrieving their goods and the times they forget to retrieve them and contribute to the quantitative view and working strategies. This will allow us to appraise and increase Box/Locker profitability.

## VI. CONCLUSIONS

In this paper we presented a new kind of Box/Locker which is able to store foods according to their storage characteristics: ambient, fresh or frozen temperature. We dispose of a first prototype, which is a Proof of Concept of this Box/Locker. In-city tests can now start. We are not concerned only by classical use of the Box/Locker, i.e. used by one seller (shop, super or hyper market), but also and mainly by a new operational mode related to collaborative sharing economy. This means opening it up to several sellers – providers, who have or may not have their own website. We propose either to aggregate these websites or to elaborate them and integrate in the process logisticians issued from different sellers – providers. We can thus share our Box/Lockers with short circuit / distance actors, at city or town level.

Naturally, a number of important aspects need to be finalized. Top of the list is protection of the private information of each party in order to allow all concerned to maintain commercial advantages. Among other aspects we point out security (avoiding vandalism, theft, etc.), traceability of all operations (loading, retrieving, etc.) not to mention the hygienic aspect (cleaning, removing perished foods, etc.) and “return to provider” conditions, definition and application (if this can be considered as applicable). From the User Interface point of view, we are currently testing two options: a classical one based on a large multi-touch screen as on other Box/Lockers and a second one, which provides no Box/Locker interaction support and relies exclusively on the user's Smartphone screen for interaction. In this way user adaptability is more natural and access security is enhanced. Plus, vandalism is decreased.

## ACKNOWLEDGMENT

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## APPENDIX: UML SEQUENCE DIAGRAM OF THE OVERALL PROCESS

