Assistive systems for special needs in mobility in the Smart City

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Abstract. The Smart City is a multifaceted objective aiming at increasing viability of the city for its inhabitants. Mobility in the city is an important dimension of the Smart City for humans and goods, which can either move without assistance or may need special assistance. The objective of this paper is to investigate the role of assistive systems for the mobility of humans and goods in order to take into account special needs. We discuss and classify different situations for assistance of humans and goods either by means of technology or humans (and technology) and present different assistive system behaviors already used or to be implemented in the future.

Keywords: Smart City, mobility of humans and goods, Assistive systems for mobility, special needs.

1 Introduction

1.1 Mobility in the Smart City

The Smart City is a very hot and important application field of ICT (Information and Communication Technologies), able to receive a wide variety of contributions and using multiple declinations of ICT aspects (data management, data processing, Human-Computer Interaction, collaboration, information accessibility in mobility, automated or on-demand information access, IoT, AI contribution, etc.). This area is so large that it is not easy or possible to find a commonly accepted definition. However, to clarify our view we decided to take into account the following definition: “The Concept of “Smart Cities” describes how investments in human and social capital and modern Information and Communication Technologies (ICT) infrastructure and e-services fuel sustainable growth and quality of life, enabled by a wise management of natural resources and through participative government" [1].

At present, the Smart City is still a concept undergoing evolution and experimentation. It aims at highlighting the role of ICT in a modern city, as well as integrating and optimizing the resources of a city, to make city life more efficient, energy-economic and intelligent. The Smart City is not only the application of new information technologies, but also concerns the participation of citizens in the various activities of the city with the intelligence of humans, combined with Artificial Intelligence in different forms. Different classifications try to clarify this huge domain. One of them proposes six dimensions: environment, economy, living, mobility, people and government. It is also possible to ask several questions and try to use the relevant answers to clarify this domain.

Smart City to whom: there are many answers, from a generic one "to all", to more specialized and precise ones (by age: kids, teenagers, adults, seniors), by city status, by implication in the city (citizen, neighbor, student, worker, administrator, governor); and also "to all" from the point of view of deficiencies.

Smart City by what: better common being and neighborhood, energy, transportation of goods and passengers, information dissemination on culture, sports, social services, etc.

The Smart City as an area of use for all ICT possibilities: data accessibility, data processing, information access exchange and manipulation in static and mobility situations, using wired or wireless networks, in appropriate applications taking into account contextual situations.

The context of the different contributions presented in this paper consists of transportation of passengers and freight in the city, as well as the associated services, which can be naturally added to this field. In these applications, we mainly base our contributions on the use of Internet, Internet of Things (IoT), Location-Based Services (LBS) and Big Data and Artificial Intelligence with Deep Learning.

1.2 State-of-the-art

To carry out a complete state-of-the-art for the Smart City would appear a totally impossible goal as the amount and diversity of work are large and diversified. Merely to establish a common definition and classification is hard and has not yet been achieved, while to list all approaches and contributions seems totally impossible. We thus propose that the reader consults our paper [2]. In relation to transportation aspects a relevant reference is [3].

2 Mobility characterization

Different kinds of mobility can be identified in the Smart City: (1) Human individual mobility, in which the human decides, organizes and does (executes) his or her mobility; (2) Good mobility based on standard shipping procedures. These two classical cases are out of the scope of our study. We will only mention these cases and indicate the assistive tools or systems used.

Table 1. Identified situations and characteristics taken into account.

Case #	Situations	Nature of mobility			Humans: Children, Elderly, Disabled	Assistance		Goods	Collab.		Selection in			Security/safety	Rewards
		Pedestrian	Private Transportation	Public Transportation		Human-based	Technology-based		Synchronous Collab.	Asynchronous Collab.	Personal diary	Limited list	Large list		
0a	Classical Human mobility	Or	Or	Or			X								
0b	Classical Goods delivery	Or	Or				X	X			Or	Or		Tr	
1	Indoor Navigation**	Or	Or	Or	Or		X		X						N
2	School Walk-bus	X			X	X			X			X		SS	N
3	Dynamic Lane Allocation**		&	&			X		X					Tr	N
4	Delivery Area Reservation**		X			Or	Or	X	Or	Or	Or	Or		Tr	N
5	Carbon-free goods transportation*			X		Or	Or	X	Or	Or			X	Tr	Y
6	Store client based distribution*	Or	Or	Or			X	X					X	Tr	Y
7	Goods transportation for colleagues*	Or	Or	Or		Or	Or	X		X	X			Tr	Y
8	Goods transportation for neighbors*	Or	Or	Or		Or	Or	X		X		X		Tr	Y
9	Escorted Children*	Or	Or	Or	X	Or	Or		X		Or	Or		SS	Y
10	Escorted Elderly persons*	Or	Or	Or	X				Or	Or	Or	Or	Or	Se	Y
11	Escorted Disabled*	Or	Or	Or	X				Or	Or	Or	Or	Or	Se	Y

*Human- & Technology-assisted

**Technology-based only

Or - Possible diversity & – Mix between public & private transportation X - Concerned Y – Yes N – No	SS – Security/Safety Se – Security Sa – Safety Tr – Traceability

We are concerned with assisted mobility of humans and goods characterized by specific needs. This mobility can be walk-based or use different kinds of vehicles (car, train, subway, tram, bicycle, scooter, etc.), and assistance can either be fully technological or human- and technology-based. We try to elaborate a classification allowing us to identify main elements and associated solutions. The following characteristics are taken into account (Table 1):

- **Nature of mobility:** pedestrian, by personal vehicle, and by public transportation.
- **Who is moving: humans** (children, adults or elderly persons) possibly with different kinds of disabilities,... or **goods** (parcels, letters, shopping (books, clothes, food), construction supplies)
- **Nature of assistance:** human- and/or technology-based
- **Nature of the escort:** from start to end, by segment (with or without continuity)
- **Nature of collaboration:** synchronous or asynchronous escorting
- **Selection process** of the escorting person (identified, pre-recorded, known as colleague or neighbor) in small, medium or large lists.
- **Level of security** to ensure (traceability, security, safety)
- **Kind of reward** …

In Table 1 we indicate the cases studied, which are explained in this paper in relation with identified characteristics.

3 Assistive system role and functions

To provide appropriate services organized in an assistive system, it seems important to identify the main aspects of this system. Globally, ITS (Information & Communication Systems) systems are responsible for taking into account data collection, storage and management, appropriate manipulations in different working situations, providing communication over short and large distances by wireless and wired networks, in mobility, and interacting with the environment in which active and passive things are organized in IoT (Internet of Things).

Two important aspects are HCI (Human-Computer Interaction) and new services based on AI (Artificial Intelligence). The main HCI objectives are related to multimodal and multi-channel communication with various devices and interaction styles as touch-based and speech-based interactions, as well as AR (Augmented Reality) approaches. These interactions can occur either on desktop computer or with mobile devices allowing individual and collaborative situations. The Mashup approach for implementation of appropriate services is proposed.

From the AI point of view, Big Data and Deep Learning are mainly used to procure appropriate information from the huge amount of data available and to synthetize observed behaviors in typical data. An interesting summarization is proposed in Fig. 1 [4].

To organize all these aspects, it seems appropriate to create an **Intermediation platform.** This is an assistive system, the objective of which is the Vitalization of data [5]. Its architecture is summarized in Fig. 2a.

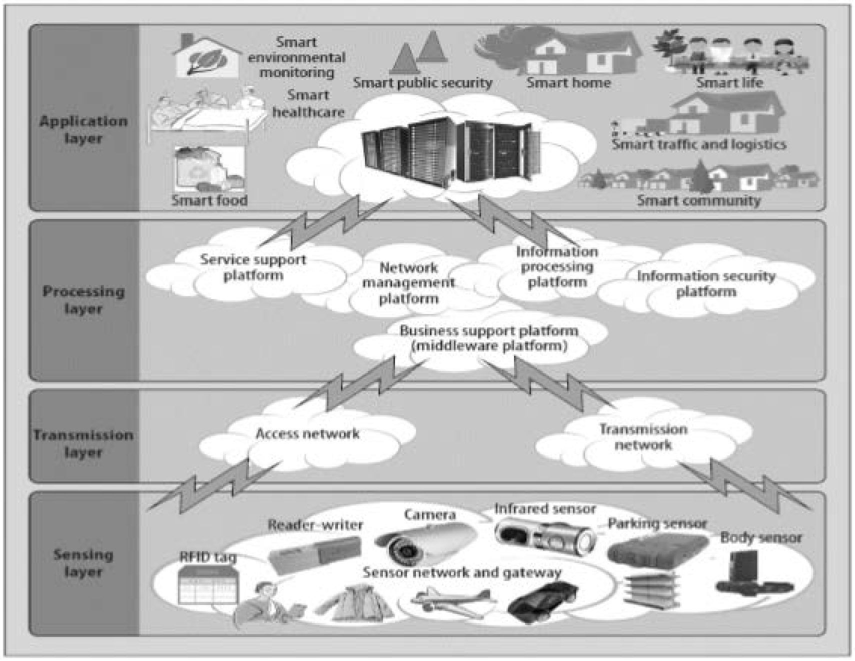

Fig. 1. Smart city architecture summarized by Liu and Peng [4].

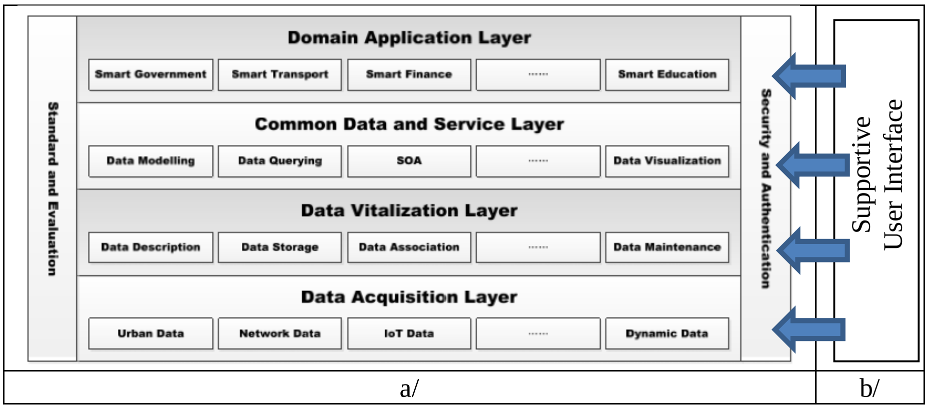

Fig. 2. a/ Architecture of an Intermediation platform with Data Vitalization [5], b/ Supportive User Interface [6].

3.1 Intermediation platforms

Intermediation platforms connect people, services and even things in ways that have been unthinkable until now. Search engines provide relevant references for people searching for information. Social networks connect users in their environment. Car-pooling systems link drivers and passengers whose goal is to take the same routes. Intermediation platforms use big data to fuel the services they offer. All these services are evolving extremely quickly but are almost unnoticed.

All intermediation platforms essentially rely on the same structure. To begin with, they collect huge amounts of data, which can derive from the outside world (e.g., web pages for search engines) or are hosted by the platform (e.g., social networks). However, they are never produced by the platform itself but rather by the people, services or things around it. These primary data are then indexed and transformed to extract information that fuels the primary services offered.

Users' activities on the platform generate secondary data. These secondary data mainly consist of traces that the platform generally has exclusive rights to use, as well as to create secondary services. A key example of this is the precise profiling of users, which permits personalized and customized services: personal assistants trace users as they go about their day-to-day activities, not only on-line but also in the physical world through the use of geo-localization or quantified-self means.

3.2 Mashup approach for Intermediation platform adaptation

A generic intermediation platform needs to be adapted to different working situations (as for our cases noted in Table 1 and described later). The objective is to provide appropriate collection of data, services and acquisition sensors and valuators, which are able to work together in a vitalization approach and create adapted User Interfaces allowing appropriate interactions. The Mashup approach is an interesting way to support these adaptations. Mashups are defined as "the perspective of software engineering. A Mashup is constructed by the assembly and combination of several existing functions integrated into a new application" [7].

The term "mashup" was defined initially in the field of music, where it consists in remixing two (or more) sounds in order to obtain a new one. Mashup is primarily and usually performed for the so-called "drag&drop" applications from different sources. The Mashup architecture is made up of three elements according to Merrill [8]: Data, Services and User Interface. Mashup aims at the composition of a three-tier application: (1) Data (data integration), (2) Application logic (process integration), and (3) User interface (presentation integration). Integration of heterogeneous data sources uses two main technologies: web services and Mashup. Integration implies that all relevant data for a particular bounded and closed set of business processes are processed in the same software application.

Moreover, updates in one application module or component are reflected throughout the business process logic, with no complex external interfacing. Data are stored once, and are instantaneously shared by different business processes enabled by the software application [9]. In the Mashup, every user can compose his/her own service with other services in order to create a new service. Mashup is a “Consumer Centric Application”. It describes web 2.0 sites combining functions of one site with another site. Different pieces of UIs (User Interfaces) are integrated into a new web application. This approach requires composition and orchestration of web services.

Application mashuping in the context of intermediation platforms is a much appreciated approach for creating appropriate applications based on reuse of existing ones. It is based on a four-layer structure (Fig. 2a). To update or adapt data and services, a particular user interface called Supportive UI is used to introduce appropriate adaptations concerning data, services, IoT exchanges and HCI. This supportive user interface, which is also Mashup application creation- or evolution-oriented, proposes a programming interface for experienced developers and a visual programming-oriented approach for experienced users (Fig. 2b). A typical example of mashuping is visual selection of actors as we will see later in this paper.

By mashuping between OpenStreetMap with subway stations and potential actor locations, we create an application in which the choice of the accompanying escort can be manually selected directly on an interactive map. For example, Fig. 3 shows a journey from the Croix-Paquet to Masséna subway stations in Lyon to be completed between 4.30 and 6pm. All nearby actors around the Croix-Paquet station are shown, and the user can select the right person by checking that her/his starting time and final destination are compatible with the journey.

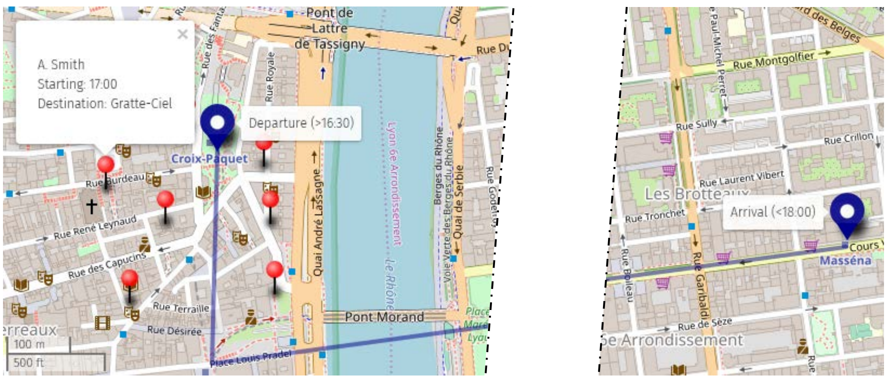

Fig. 3. Mashup between OpenStreetMap and actors’ locations.

3.3 Focus on two important services

The first service we wish to explain is the **Collaboration between humans participating in transportation of parcels or escorting situations:** In human- and technology-based assistive systems it is important to determine collaboration organization between participating humans. We identified two main collaboration situations: synchronous and asynchronous.

As we will explain later (sections 5 and 6), we studied with students parcel distribution and human escorting based on public city transportation in Beijing, in which we expected to use the subway. The main idea is to use subway users as transporters of parcels or as escorts of people who cannot travel alone. We identified two solutions. The first is based on **synchronous collaboration** (Fig. 4). At the starting station, the "sender" (person who needs to send a parcel or who has a person to escort in the subway) gives responsibility for the parcel or person to the "transporter" and, at the final station, the "transporter" hands over responsibility of the parcel or person to the "receiver". In this case, the process is fully human-oriented without need of technological infrastructure related to public city transportation.

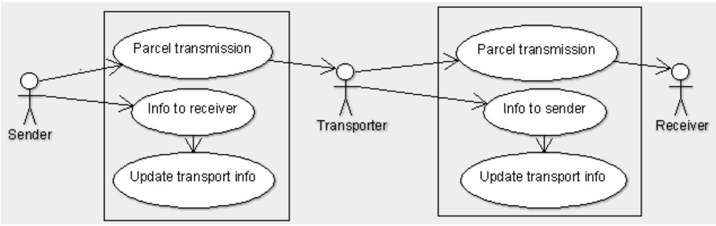

Fig. 4. UML Use-Case Diagram of the synchronous solution

The second solution is based on **asynchronous collaboration** (Fig. 5).

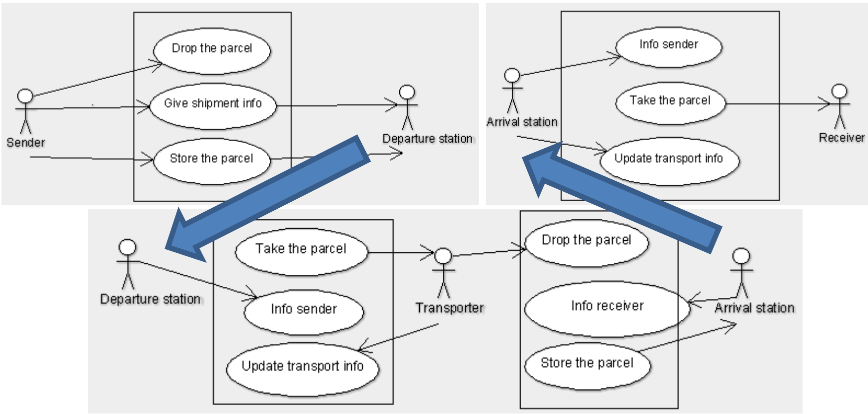

Fig. 5. UML Use-Case Diagram of the asynchronous solution

In this case, the "sender", "transporter" and "receiver" move independently. To coordinate their collaboration, a subway infrastructure in each subway station is provided. For parcels, a box-locker is provided to act as a support of the asynchronous buffer between sender & transporter and transporter & receiver. For human escorting in each subway station, a location called a "meeting point" is provided. At this location, the escorted human can wait for the new accompanying escort, either transporter or receiver. Fig. 5 shows the UML Case Diagram of the asynchronous solution based on box-lockers.

Fig. 6 shows the Sequence Diagram of the synchronous solution with the parcel transportation and confirmation message exchanges, while Fig. 7 gives the UML Sequence Diagram of the asynchronous solution also in the parcel context. Transposition to human escorting is relatively easy, consisting in replacing lockers with meeting points. Confirmation messages are the same but with semantic changes.

The second service to be explained relates to **Participant selection from a list of potential actors.** In the approach of parcel distribution or human escorting based on public transportation clients, it is mandatory to discover potential travelers ("transporters") who could evolve in this activity. These people must explicitly declare to be interested and must take out a collaboration agreement. As such they can be tracked by the system, based either on smartphone tracking or public transportation ticket tracking. The data collected are used to find a subset of potential transporters, compatible with start and finish subway stations and offering temporal compatibility with sender and receiver timing. This compatibility must be strict in the case of the synchronous solution (physical exchange between actors) but is less so for the asynchronous solution using the box-locker buffer or the waiting at meeting points.

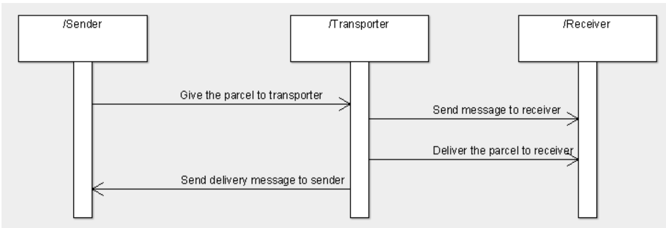

Fig. 6. UML Sequence Diagram of the synchronous solution

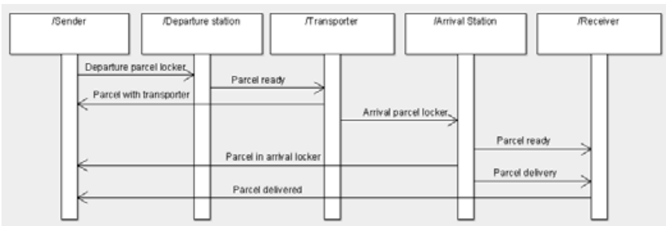

Fig. 7. UML Sequence Diagram of the asynchronous solution

This research of appropriate escorting / transporting persons varies in complexity according to the size of the list in which the selection occurs. Selection in a personal diary or a short list is easy, for example by scrolling. It can be proposed in a visual way (as mentioned earlier and shown in Fig. 3).

The selection process in a large list can become more complicated, and appropriate algorithms must be provided for this intermediation process.

Intermediation between individuals and services is also considered as a **recommendation problem**, that is to say, correct services or items are recommended as a ordered list to users by the intermediation platform. Many algorithms can be applied in intermediation platforms, of which Collaboration Filtering is the earliest and most famous algorithm. It can find users' preferences by mining their historical behavior data, divide users into groups based on different preferences, and recommend products with similar preferences. User-based collaborative filtering algorithms and item-based collaborative filtering algorithms are two principal categories of algorithms.

Both algorithms have the same main idea: calculate the similarities between users (or items), then recommend similar items to similar users. Calculation of similarities is often based on distance calculation or clustering methods. We studied in [10] several matching or clustering algorithms (GN, CNM, LCV, EACH, etc.) and proposed a general clustering algorithm, CDHC (Community Detection based on Hierarchical Clustering). The CDHC Algorithm first creates initial communities from global central vertices, and then expands the initial communities layer by layer according to the link strength of vertices and communities, before finally merging some very small communities into larger communities.

In more detail, in the intermediation process, the platform proposes to use the collaborative filtering method and the CDHC algorithm [10]. Once the public transportation users' data have been collected, we can try to build a complex network of transporters. The problem is then transformed into the detection of communities in which transporters have similar properties.

A city has one or more centers and is expanded layer by layer around the centers. The closer to the center the layer is, the denser the connections to the layer are. Inspired by the hierarchical structure of cities, a community of transporters should have one or more global central nodes, and be expanded layer by layer around the global central nodes. The nodes in layer n are mainly connected by nodes in layer n+1 and layer n-1. The connection number of one node with other nodes is known as its degree. Community detection consists in initializing communities, expanding communities, merging small communities and choosing the best result.

In the first step of initializing communities, we first sort all the nodes by degree in descending order, before choosing k nodes with maximal degree as global central nodes. The node with the maximal degree is then assigned to the first community and marked as the first community's central node. For each node of the remaining k-1 global central nodes, its similarity with each initialized community's central node is calculated. If there is a similarity greater than a given threshold, the node is assigned to the community maximizing the similarity. Otherwise, a new community is initialized, assigned to the new community, and marked as the new community's central node.

After finishing the process of initializing communities, we need to expand these communities. The process of expanding communities consists in marking node level and calculating link strength. All the global central nodes are marked as first level. If a node is connected to the first level and is not yet marked, its level is marked as two. By repeating this we can mark all the node levels, if we assume that the network is connected. Starting from each level-two node, the link strength between the node and each community is calculated. The node is then assigned to the community with the maximal link strength, until the nodes of each level have been assigned to communities.

The communities, in which nodes have strong connections and good similarities, have now been detected. The final step is to merge some small communities into large ones. Different community detection solutions with similarity thresholds could be evaluated by extensive modularity, and the best solution found. Some experiments on peoples' network datasets were conducted, and the result showed that the algorithm is effective [10].

CDHC can help us find compatible transporter groups for trajectory similarity, based on their daily traffic tracked data. During the searching process, if the historical transporters cease to be available, similar transporters are recommended first. They will get the information before the others and have priority to accept the order.

4 Mobility with and without specific needs

As we mentioned earlier, our objective was to study and characterize mobility of humans and goods in the city, distinguishing between classical and new ones. We examine in-depth the role played by assistive tools and systems in both situations, as well as for humans and goods.

4.1 Classical mobility situations (Cases #0a, #0b)

Human movement in the city (Case #0a) can use different kinds of transport such as walking, individual transportation such as bike, scooter **or** car and their e-versions. People can also use public transportation. In these situations, they can either move without assistance, in the case of well-known trajectories (everyday paths) or can use multiple tools to prepare, assist and consolidate the path. Tourist websites can be used to prepare the trip, GPS for guidance, mobile websites to find out and follow path trajectories, etc. Mono and multimodal transport trajectory guidance systems are also very interesting tools. Movement using taxi or Uber is also possible. For the latter, assistive tools are used by the driver.

Standard movement of goods (parcels) (Case #0b) is carried out by official transporters such as the Post Office, UPS, etc. services. The senders are exempted to use assistive tools unless for location of Post or UPS office. They can use tracking tools to know at any time where their goods are located during the delivery process. Guarantee of professional delivery can be also assisted by tools or systems, either standard as mentioned earlier (GPS) or more specific.

4.2 New mobility situations with assistive functions (Cases #1, #2, #3 and #4)

Navigation assistance for the blind in indoor situations (Case #1). Assistive technology for indoor navigation is very important for blind people, especially when they have to go to new or rarely visited places. Navigation technologies rely primarily on the precise location of the person in order to provide the right navigation instructions at the right time.

Outdoor localization is easy to obtain throughout the planet by using global navigation satellite systems (GNSS) like GPS or Galileo, although this may be imprecise. However, for indoor localization, GNSS signals are too weak or absent and thus many alternatives are proposed. If the location has WiFi coverage, the signal emitted by the access points can be used for location, but generally accuracy is insufficient for navigation. Alternatively, RFID tags can be incorporated into the soil and a blind man's cane equipped with a RFID reader can get the unique identifier associated with the tag. A similar approach is to use BLE beacons such as iBeacon, which are placed on walls, and to use an application on a mobile phone equipped with a Bluetooth device to retrieve the identifiers. In all cases, it is necessary to establish a precise cartography of the place with the exact locations of the access points, tags or beacons and their identifiers, which will allow localization by the navigation application [11].

A concrete application, Wayfindr [12] proposed by the Royal London Society for Blind People (RLSB's), was successfully tested in the London Underground. When the smartphone application retrieves a signal from a specific beacon, it triggers the playback of an audio message through a bone conduction headphone, to give the user turn-by-turn directions.

Alternatively, Okeena developed a solution called Naviguo+Hifi [13] which is currently being deployed throughout the Parisian metro network. Audio beacons are installed at strategic locations in the subway corridors; these beacons broadcast audio messages when activated on-demand by remote control or smartphone app. The remote control uses the same standard already used by blind people to activate French pedestrian traffic lights.

Walk-bus – escorting groups of children to school (Case #2) is another assistive system application, aimed at creating journeys between a distant starting point and a school, the goal of which is to collect children at well identified stops allowing parents to limit their implication in their children escorting over short distances instead of full trajectories between their home and the school (and back). The walk-bus is managed by identified persons (mainly parents), who are in charge of respecting the journey schedule and collecting new children at identified stops and taking them to the school. The traceability procedure is clearly defined between parents and walk-bus "driver" in relation with organizers (usually school – parents associations). One of the possible solutions is use of a QRCode for each child, which is scanned when the child joins or leaves the Walk-bus. This enables child transportation to be recorded long-term, with precise information on conditions of use (boarding and unboarding locations, dates and times), which can be used for security reasons. These data can also be used for more general studies, such as journey schedules, or for modifying journey profiles.

Dynamic lane management (Case #3) on which we worked [14] aims at creating dynamically lanes reserved for buses in order to accelerate transportation time for public transportation in traffic jam situations. The objective is to create these lanes dynamically only when buses are present and to leave all lanes open to general traffic when buses are not present. As such, general traffic speed is managed. The main technologies used are: A Location-Based Service integrating bus detection sensors; an intermediation platform collecting sensor information and determining dynamic bus section activation and deactivation; in-the-field infrastructure and/or embedded vehicle interface receiving instantaneous information of selected situations (Fig. 8).

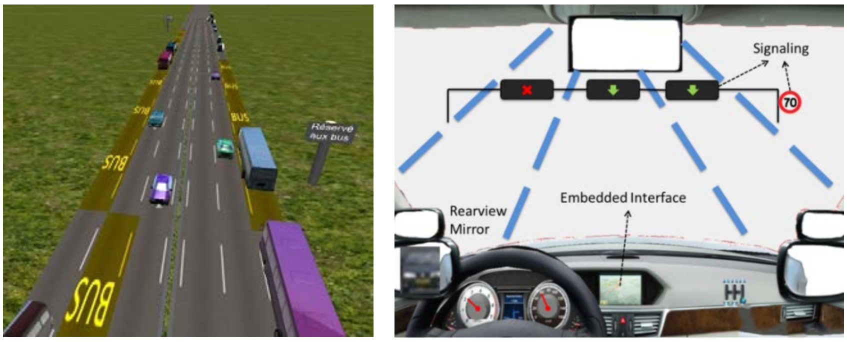

Fig. 8. Dynamic lane management [14].

Better and easier parcel delivery to inhabitants or stores (Case #4) is another supportive system on which we worked [15]. The main idea was to propose a reservation system of delivery areas in the city in order to shorten delivery time by better management of delivery stops based on delivery area reservation [15]. In this context, the main technologies used are: Address delivery based on a list of parcels to be distributed, geographical location of delivery areas to be reserved. A trip elaboration algorithm or HCI based tool creating a time integration schedule description with stop delivery locations and delivery addresses. A mobile interaction tablet-based tool allows the driver to modify the trip if a traffic jam problem or other problems occur (Fig. 9).

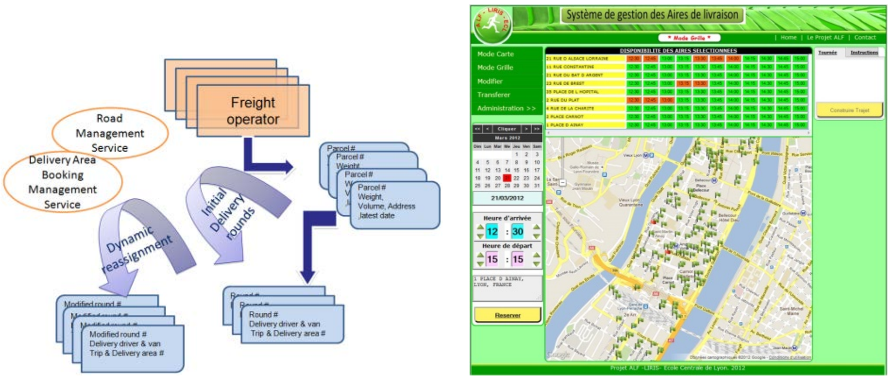

Fig. 9. Parcel distribution based on Delivery area reservation [15].

5 Case studies for parcel distribution

Parcel distribution is a very important activity, time-consuming, and a source of pollution and traffic jams, mainly in large cities. In relation with the last application we continued to work in this field. Large distribution companies very often subcontract to small companies to perform this unprofitable activity. Several reasons account for this non-profitability: access to downtown is complicated by circulation constraints, traffic jam problems, lack of parking availability, as well as the limited presence of receivers at destinations. This problem is increased by the number of distributors with a relatively small number of parcels to distribute, thus generating increased traffic problems in the same district. A variety of solutions were tested in several cities: identification of distributors for each district, thus reducing the number of vehicles entering each district and increasing the volume of distributed parcels. From a collaborative economy point of view, a more original and effective approach, which is carbon-free, is based on the use of existing movements of persons and vehicles to take advantage of these existing trips to have them transport parcels. We propose to examine three of the different working situations that we have identified: the first is based on public city transportation users, the second relies on supermarket clients, while the third is based on a closed network of small craftsmen. The latter situation is based on pedestrian box-lockers to which pedestrians go to collect the goods they have ordered.

5.1 Public city transportation based parcel distribution (Carbon-free parcel distribution case [16]) – (Case #5)

In a large city like Paris, Lyon or Beijing, it is possible to imagine high-speed transportation of letters and small parcels by users of this public transportation (buses, trams and subway). The process is based on identification of segments defined by start and destination public transportation stations, identification of start date and time (availability of the parcel at the start station) and expected destination time (availability of the parcel at the destination station). The next step is to find a transporter, a city transportation user, who is "interested" in carrying out this transportation. This requires an available list of potential transporters with their history of movement on the city transportation network. An algorithm can determine potential transporters with appropriate profiles (segment used, in the proposed time interval and transportation conditions such as parcel weight and transportation remuneration). A preliminary contact with this identified transporter is established via the intermediation platform in order to validate this transaction.

In this case, two different solutions can be used for the exchange of parcels at the start and destination stations (see section 3.3). The first (synchronous approach) is based on physical exchange between the persons involved in transportation, between sender and transporter first, then between transporter and recipient. The second solution is based on an asynchronous approach using technological support for parcel exchange based on box-lockers located at each city transportation station and electronic key access, which is shared, respectively, between sender and transporter and transporter and recipient. In this case, there may be a delay between deposit and withdrawal at each extremity of the segment. This solution is efficient and flexible (no need for synchronous presence of two actors at each segment point). This is also important from a security point of view, as it integrates delivery traceability. In the first case, scanning of the parcel by each actor must be introduced to allow its follow-up. In the second case, box-locker handling is charged with scanning the parcel in both cases (In & Out).

These two approaches (synchronous and asynchronous) can either be based on start to end transportation or on splitting the trip into several segments working separately. This is possible if no direct transportation is found.

The asynchronous approach box-locker solution, which may be considered to be expensive and space-consuming, can be replaced by a cheaper solution based on special bags with electronically controlled opening and handling, allowing the bag to be attached to an exchange post located in each station.

5.2 Market client based parcel distribution (Case #6)

Another possible approach for carbon-free distribution is based on market clients who are neighbors of the client waiting for his/her parcel at home. The starting point is the internet site of the shop. The goods are ordered and purchased by a distant person who is the client and receiver of the corresponding parcels. The internet purchase is connected to the delivery service in the market shop. The process of discovering a transporter who is a neighbor of the ordering client (receiver) can be based on different situations. The first is a totally open situation in which the goal is to find and create dynamically an association by checking the proximity of geographical locations between ordering persons and potential transporting persons. The presence of potential transporting persons can be discovered either by explicit declaration (signaling of presence in the shop or shopping mall) or by contextual location detection (by smartphone localization or other implicit identification). In this case, the intermediation algorithm must be able to take into account a huge amount of data.

In a more collaborative situation, parcel transportation can be an interesting functionality of a neighbor association collaborative system or an intergeneration collaborative system in which interpersonal help, information and cooperation are supported. Through this system, its members have access to a list of members and can either pre-establish potential relationships between the ordering person and the transporting person (one or more) or have access to less accurate information providing a list of potential transporting persons. These data can be supplied to the delivery service of the shop or mall. In this case, the intermediation algorithm works on a limited set of data.
Tracking of goods carriage is important in order to check that delivery is complete. Traceability is also required by scanning at departure and arrival (delivery to receiver), often by smartphone apps.

Assessment of all actors is also essential for managing their participation in subsequent actions. Naturally, unappreciated transporters will be excluded from future matching processes. This also applies to clients whose requirements are considered to be excessive (deadline, weight, etc.).

5.3 Supply distribution between members of a network of small craftsmen (Case #7)

Small craftsmen work on different sites. Their activities mainly consist in studying the work to be performed (discussion with the client), in choosing and purchasing the appropriate items (supplies) in DIY stores, and, when necessary, in transporting them to the work site, where the work can be performed. This intermediate activity of choosing, supplying and transporting is a time-consuming activity which could be reduced by a more appropriate organization. If the craftsman knows exactly what he needs, he can order by Internet and, when necessary, ask a colleague from the network of craftsmen, who is working near their current work site, to transport the objects to them.

In this case, it is also important to find a colleague who is in contact with the same DIY store and who is currently working near their work site.

This situation occurs in closed environments, in most cases a club or an association of local craftsmen. They are interested in a relationship allowing collaboration in large construction or reconstruction projects and mutual assistance in problematic situations. A collaborative system is then naturally used to support these activities. Its extension to shared transportation is a logical step.

In this case the set of potential transporters is more limited, and the potential intermediation algorithm may be less sophisticated and less efficient.

Of course, appropriate authorizations must be established between actors and the relevant DIY store so as to trace all purchases and deliveries.

In all cases, compensation must be decided: reciprocity in carrying, financial compensation (free subway tickets, etc.) or inter-generation assistance association action, etc.

5.4 Pedestrian Drive: Fresh box-locker based food distribution [17] (Case #8)

We are currently studying another shared economy support system by transforming a well-known supermarket drive for pedestrians. The supermarket drive allows consumers to order their shopping on-line and then go to the supermarket only to collect the ordered items. The supermarket drive is usually located near the supermarket and is organized to minimize loading time.

The pedestrian drive is a variant of this concept, specially designed for pedestrians. Located in the city and accessible 24 hours a day, it allows ordered goods to be collected at any time. It is able to store not only ambient temperature products but also fresh and frozen goods.

This fresh product box-locker can be either owned by a supermarket firm and totally integrated into the ordering, management and logistic process of the firm, or can be managed independently. This case is an interesting support system for shared economy, as the role of the pedestrian drive manager is to manage such use for multiple providers. His/her role is to ensure Internet access for all provider offers and to organize the global supply chain with consumer information on availability of ordered goods in the box-locker. In this way, circular economy as a short circuit of agricultural goods can be supported.

In this case, the intermediation platform is more open than in association-based situations (such as craftsmen associations and intergeneration associations), while not as large as the Airbnb or the BlaBlaCar breeding ground.

6 Case studies for mobility of persons with special needs

6.1 Escorting children in public transportation (Case #9)

The case of parcel and letter transportation by public transportation users (Case #5) can be adapted to human escorting of children, elderly and disabled persons.

In the case of escorting children (**Case #9**), the main characteristics are:

- Escorting the full trip (from starting station to final station)
- Synchronous escort, i.e. entire trip
- Choice of escort from a list of carefully selected and identified persons
- Security and safety of the child is mandatory

6.2 Escorting elderly persons in public transportation (Case #10)

In the case of escorting elderly persons (**Case #10**), the main characteristics are:

- Escorting can be either for the entire trip (from starting station to final station) or by section, i.e. with exchange of escorting person if it is not easy to find someone to escort the entire trip
- Synchronous or asynchronous escort, i.e. exchange of escorting persons in real time or with a waiting period when the elderly person is alone. This is provided, of course, that psychological conditions allow this
- Choice of escort from a list of selected and identified persons is mandatory
- Security of the elderly is mandatory

6.3 Escorting disabled persons in public transportation (Cases #11)

In the case of disabled persons (**Case #11**), the nature of the disability is taken into account, and the main characteristics are modified, namely:

- Escorting can be either for the entire trip (from starting station to final station) or by section, i.e. with exchange of accompanying person if it is not easy to find someone to escort the entire trip
- Synchronous or asynchronous escort, i.e. exchange of escorting persons in real time or with a waiting period when the disabled person is able to remain alone. This is provided, of course, that psychological conditions allow this.
- Choice of escort from a list of selected and identified persons is mandatory
- Security of the disabled is mandatory

We have not yet discussed **reward conditions**. It is not easy to enact general rules. In each situation, for goods and humans alike, it is important to define clearly what seems appropriate. Financial rewards can be possible, either rewards in kind such as transportation tickets or other compensation. Reciprocity can also be an appropriate solution for transportation of goods between colleagues or neighbors.

7 Application of Deep Learning to mobility

In several cases it seems appropriate to work on accumulated data and use them for Deep Learning in order to obtain interesting solutions. We can take as examples Walk-bus (Case #2) and Carbon-free goods transportation (Case #5). This treatment can also apply to other cases.

For the Walk-bus, it seems interesting to study the evolution of trip trajectories, taking into account schoolchildren, including the schedule and home addresses of the transported children. The objective is to determine the appropriate trip trajectory and timetable.

For goods transportation by public transportation users, it is important to start with a case-by-case study, before going on to progressively capitalize these data in order to find main transportation trajectories and propose them more quickly.

Deep learning is hugely popular today. The past few decades have witnessed its tremendous success in many applications. Academia and industry alike have competed to apply deep learning to a wider range of applications due to its capability to solve many complex tasks while providing state-of-the-art results [18]. Recently, deep learning has also revolutionized intermediation architectures, providing more opportunities to improve matching performance. Recent advances in deep learning-based intermediation platforms have gained significant attention by overcoming obstacles of conventional models and achieving high recommendation quality. Deep learning catches the intricate relationships within actual data, from abundant accessible data sources such as contextual, textual and visual information.

In most cases, intermediation is deemed to be a two-way interaction between user preferences and service features. For example, matrix factorization decomposes the rating matrix into low-dimensional user / service latent factors. It is natural to construct a dual neural network to model the two-way interaction between users and services. Neural Network Matrix Factorization (NNMF) [19] and Neural Collaborative Filtering (NCF) [20] are two representative works.

The Deep Structured Semantic Model (DSSM) [21] is a deep neural network for learning semantic representations of entities in a common continuous semantic space and measuring their semantic similarities. It is widely used in information retrieval areas and is supremely suitable for service intermediation and recommendation. DSSM projects different entities into a common low-dimensional space, and computes their similarities with a cosine function.

Autoencoder is a very effective deep learning method. Autoencoder can be applied to intermediation platforms in two general ways: (1) using it to learn lower-dimensional feature representations at the bottleneck layer; or (2) filling the blanks of the interaction matrix directly in the reconstruction layer. Almost all the Autoencoder variants, such as denoising autoencoder, variational autoencoder, contractive autoencoder and marginalized autoencoder, can be applied to the recommendation task. AutoRec [22] takes user partial vectors r (u) or service partial vectors r (i) as input, and aims to reconstruct them in the output layer.

Convolution Neural Networks are very powerful processors of unstructured multimedia data with convolution and pool operations. Most CNN based intermediation models utilize CNNs for feature extraction. CNNs can be used for feature representation learning from multiple sources such as image, text, audio, video, etc.

CNN-based collaborative filtering may prove very useful in intermediation. Directly applying CNNs to vanilla collaborative filtering is also viable. For example, He et al. [23] proposed using CNNs to improve NCF, and presented ConvNCF. This uses the outer product instead of the dot product to model user-item interaction patterns. CNNs are applied over the result of the outer product and could capture high-order correlations among embedding dimensions.

Deep learning-based intermediation has proved very effective. However, the key problem for deep learning in different application scenarios is always data. Once data have been sufficiently collected and tagged, some deep learning-based solutions could be studied and applied.

8 Conclusion

In this paper we studied the mobility aspect of the Smart City, which is one of the main issues raised here. After a general introduction, we listed different approaches of mobility for humans and goods, and split them into groups: mobility with and without special needs. We limited our observation of non-assisted mobility to two significant examples for humans and goods, and focused our paper on assisted mobility with special needs. We identified eleven situations (summarized in Table 1), and characterized them by a series of characteristics. We also identified the main services needed, and organized them into an intermediation platform architecture.

Finally, we described the finality of eleven situations identified and gave potential applications of different selection algorithms from simple scrolling to more sophisticated approaches. This was based on graphical selection on transportation maps and Big Data selection in a huge collection of data taken from the general public transportation system. A proposal for the Deep Learning approach is also briefly described, taking into account evolution of walk-bus routes for picking up and returning schoolchildren from / to their homes and schools. We also show how to synthetize all used transportation paths and discover those most frequently used in order to propose them first and foremost.

This work is open to multiple extensions, not only for in-city mobility but also for intercity mobility, which has equally emerged as an interesting area of research.

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