Assistive systems for special mobility needs in the Coastal Smart City

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Abstract. The Smart City is an important evolution for cities of different sizes and contexts. Multifaceted proposals are made all around the world. Mobility support and its evolution is an important part of this issue. In this paper we propose to study a particular context, which is devoted to showing how a Coastal city can become a Coastal Smart City. We present our study and proposals based mainly on special mobility configurations, the role and functionalities of corresponding assistive systems, and the HCIs implemented in practice. Finally, we integrate all these aspects in the architecture of the assistive system managing them.

Keywords: Smart City, mobility of people and goods, assistive systems for mobility, special needs, tourism, on the beach, on the sea, boat mobilities.

1 Introduction

The Smart city originated in the media sector, which refers to integration of urban systems and services by using various information technologies or innovative concepts to improve the efficiency of resource utilization, optimize urban management, and improve the quality of life of citizens.

Today, countries world-wide realize in varying degrees the idea of smart cities and the different implementation efforts. However, there is no denying that in the 21st century, the age of smart is here.

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. A variety of classifications try to clarify this huge domain. One of these proposes six dimensions: environment, economy, living, mobility, people, and government with the following orientations: wireless city, smart home, smart transportation, smart public service and social management, smart urban management, smart medical treatment, green city and smart tourism [1].

It is also possible to examine whom these evolutions concern. By avoiding the generic “to everybody”, we classify the answers by age: kids, teenagers, adults, seniors; by implication in the city: citizen, neighbor, student, worker, administrator, governor; without avoiding important orientation to all persons with deficiencies.

We can also try to draw up a list of reasons for: better common welfare and neighborhood, energy, transportation of goods and passengers, information dissemination on culture, sports, social services, tourism, etc.

The Smart City is an area where all ICT possibilities can be used: data accessibility, data processing, information access exchange and manipulation in static and mobility situations, using wired or wireless networks, mainly in contextual situations. Multiple ICT technologies are used to solve these problems such as Internet, Internet of Things (IoT), Location-Based Services (LBS), Big Data and Open Data, as well as Artificial Intelligence with Machine and Deep Learning.

The presentation at this conference is steered towards mobility in the city, as well as towards HCI devices allowing propagation and collection of appropriate information to the users concerned.

The next sections of this paper are organized as follows. After a short state-of-the art in section 2, we identify in section 3 multiple aspects of our field of study which is a coastal city. We try to identify characteristic situations to consider, as well as corresponding activities and/or applications in order to manage them. Data collection, management, and evolution are studied in section 4. The architecture of an assistive system and its role in the field are studied in section 5 based on data exchanges with the ground and with users. Appropriate HCI supports and devices are presented and discussed at appropriate places in the paper.

2 State-of-the-art

To carry out a complete state-of-the-art for the Smart City would appear to be totally impossible as the amount and diversity of work is large and diversified. It would be hard enough to establish a common definition and classification, and indeed this has not yet been achieved, while listing 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]. The Japanese view seems interesting [4], as is also Singapore’s perception of emerging technologies [5]. The questions on the effectiveness of smart cities make for instructive reading [6], as does also the view presented to CIOs [7]. [8] directly relates to our approach. From the coastal city point of view, we shall now suggest two references [9, 10].

3 Coastal city characterization and how it becomes smart

To show how a city evolves into a smart city, specifically in the case of a coastal city, we need first to characterize what a Coastal city is. Then, we identify progressively different dimensions of its evolution into a Smart City. We limit our work to the dimension of management of mobility and the assistive system, the role of which is to manage corresponding behaviors.

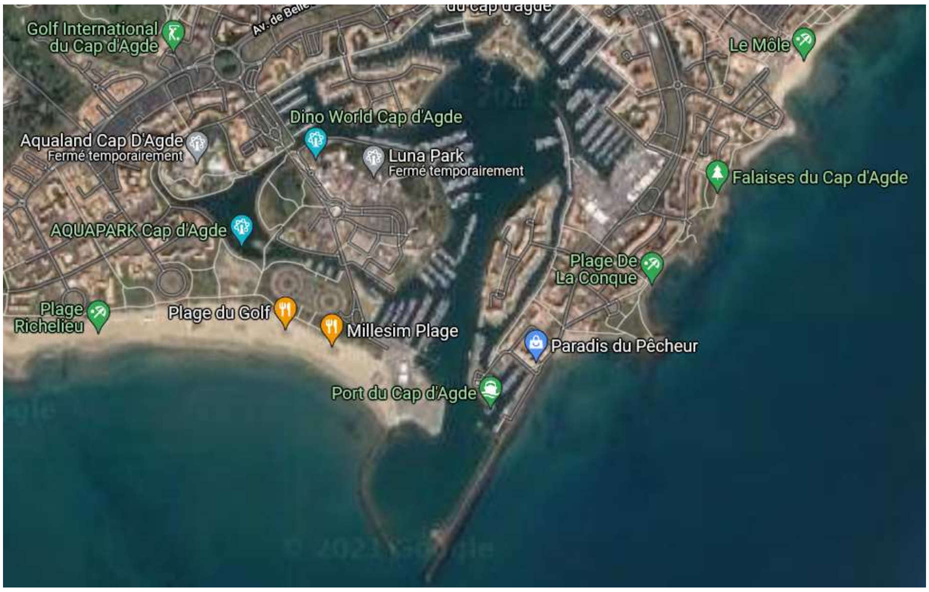

Fig. 1. Coastal city with downtown, harbor, port, beaches, and boating industrial zone.

We start with the definition of a Coastal City: A Coastal City is a city that is located by the sea or the ocean. Its activities are related to the sea, i.e. fishing, boat transportation, boat and ship repairs, as well as possibly boat and ship construction. A large majority of coastal cities in France also have important tourist activities related to the proximity of more or less popular beaches. Swimming, diving, snorkeling, yachting, kitesurfing, and fishing are common practices.

This aspect of welcoming tourists is dominant in the organization of City life. It introduces the notion of the high and low seasons, mainly by the number of inhabitants that can vary considerably between these seasons (their number can be multiplied by 10 or more in summer). As such, the requirements of life organization are totally different. In the low season, a few inhabitants can live quietly without stress, noise or traffic jams. However, economically speaking, this period is a "waiting" period for a large majority of inhabitants who rely on their tourist businesses to live (retired people excluded), whether in the form of restaurants, shops, accommodation or recreation activities.

It seems natural to study the evolution of this kind of city into a smart city in the context of high season city life, while only later showing that in the low season it is possible to propose appropriate limited behaviors and city services adapted to this season and its inhabitants.

We begin our study with the general problem of circulation in a city with a large population density. We can inherit classical smart city solutions for different kinds of mobility: pedestrian, bike, scooter, motorbike, car, truck, and public transportation (bus and, for large cities, tram and subway). The solutions implemented are traffic reorganization with pedestrian zones, one-way streets and roads, prioritized lanes for public transportation, emergency services, and taxis, pedestrian and bike lanes. In coastal cities two evolutions can be considered: (1) organization of circulation between specific zones, i.e. park-and-ride and downtown, downtown and recreation areas and beaches, etc. and (2) new transportation modes such as boat taxis and individual boats, pedaloboats. New protected lanes can also be created for automated shuttles between these zones.

It is also important to consider the dynamicity of these reorganizations, which can be permanent (available all the time) or evolve according to the time scale (each month, week, day, weekdays, weekend, morning, afternoon, evening, night, per hour or in unpredictable exceptions). As we will see later, signaling must be appropriate (static or with appropriate dynamicity), as must also be propagation of applicable rules to different users. The goal is evolution of the circulation map during the high season in order to optimize fluidity and preferential transportation. Creation of park-and-ride can be associated with public automated transport to the city, the harbor (port) and the beaches. Management of priority for several kinds of vehicles such as buses, delivery trucks, emergency vehicles, and vehicles for disabled people can also be considered.

3.1 Management of circulation in the city, in the harbor/port, and on the sea

Let us now recall an approach to mobility devoted to **dynamic lane management** on which we worked [11]. Its objective was to create these lanes dynamically only when buses are present and to leave all lanes open to general traffic when buses are not present. This allows management of general traffic speed. 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 on selected situations (Fig. 0). From the HCI point of view, it is important to indicate the present situation on in-the-field indicators, as well as on the screen in the vehicle.

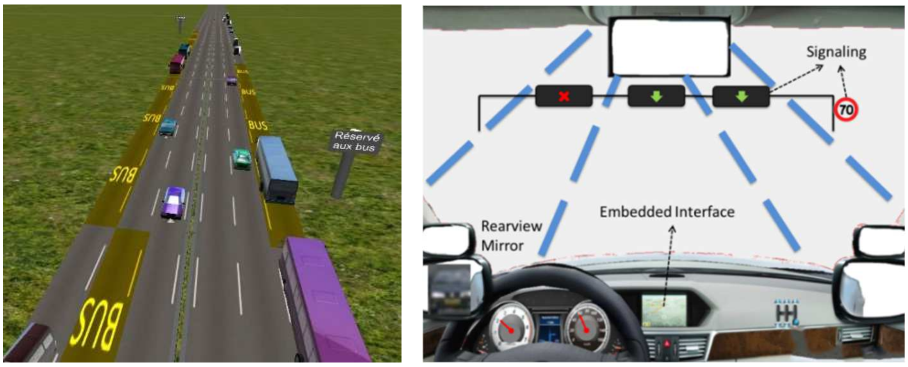

Fig. 2. Dynamic lane management [11].

Another non-coastal specific service is devoted to **better and easier parcel delivery to inhabitants or stores.** In this case, we proposed to create delivery areas which can be reserved as priority by delivery vehicles, in order to shorten delivery times [12]. In this context, the main data are: delivery addresses of parcels to be distributed and the geographical location of delivery areas to be reserved. An algorithm or interactive tool is used to create a delivery trip integrating the schedule of use delivery areas allowing transported parcels to be delivered to destination addresses. A mobile interaction tablet-based tool allows the driver to modify the trip if a traffic jam problem or other problems occur (Fig. 0).

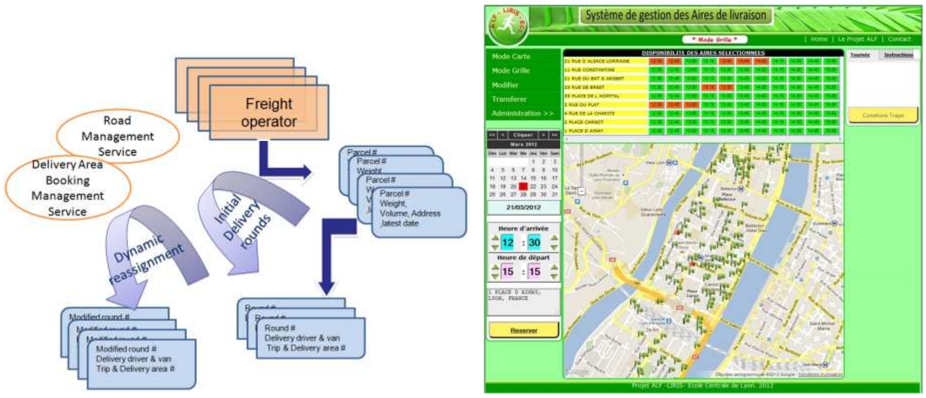

Fig. 3. Parcel distribution based on delivery area reservation [12].

Management of circulation in the commercial port/harbor is totally specific and has no relation to the touristic part of the city, in order to preserve appropriate working conditions in this part of the city and on the sea (Fig. 4).

In the context of the coastal city, a specific service is devoted to **management of circulation in the port,** taking into account weather conditions and the state of the sea, as well as access to different parts of the port (industrial, professional, sailing, and yachting). In this context, not only local mobility can be managed, but also all the activities of fishing boats and cruising boats (as we will see later). From the HCI point of view, integrated screens and mobile tablets will be used by the crew.

Fig. 4. Industrial coast and navigation zones.

This service can be generalized to the overall management and supervision of boats in the harbor and on the sea. The ecosystems for fishing and cruising boats (Fig. 5) are schematized in Figures 6 & 7. The principle is to identify all concerned actors and situations and to indicate their behaviors, their interrelations and contributions to appropriate trip and work conditions. In the past we studied this kind of ecosystem for buses (e-bus) and trucks (e-truck) [13] and adapted them to these situations.

Fig. 5. Cruising and Fishing boats.

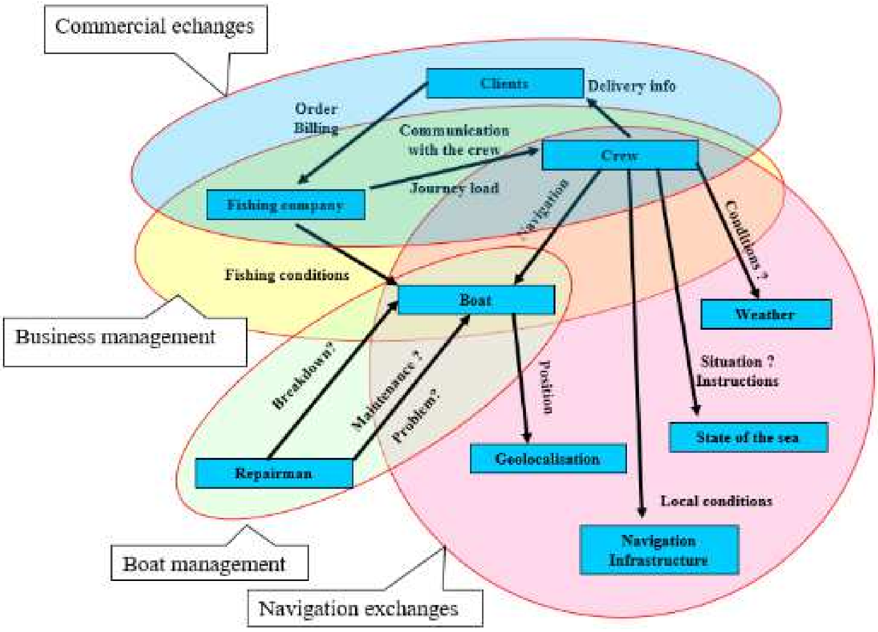

Fig. 6. Fishing boat information ecosystem.

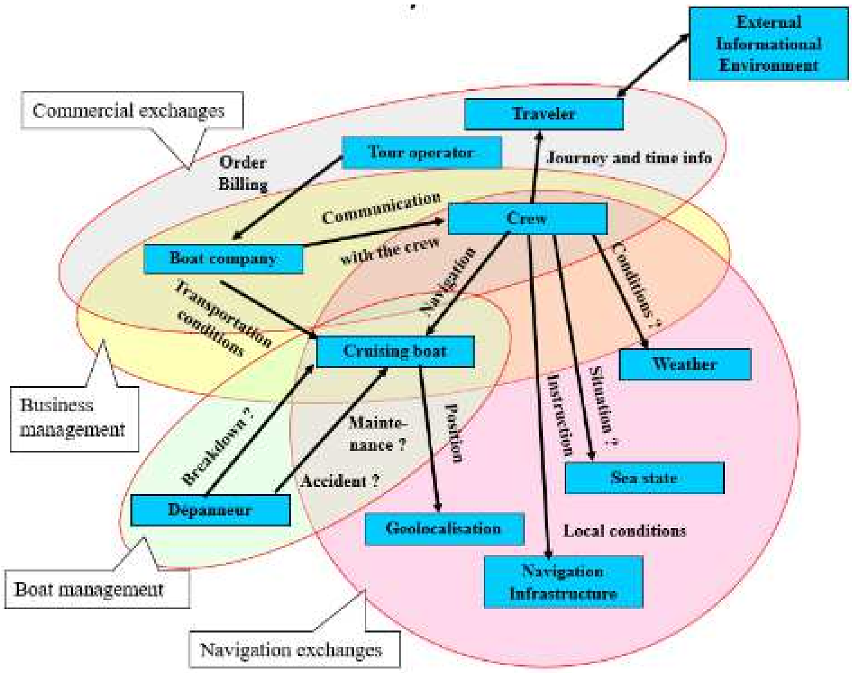

Fig. 7. Cruising Boat information ecosystem.

3.2 Beaches and sea

Another important aspect for coastal cities is management of mobility on the beaches and on the sea. On the beach several activities are possible, more or less dynamic: sunbathing, walking along the seashore, carrying out various sports or family activities. In all cases, it is important to look out for other beach users, to avoid accidents and ensure you do not disturb them. In the recent COVID period, on many French beaches, city mayors at local level or, more globally, government authorities have determined several categories of rules: prohibit access to beaches, authorize only "dynamic use of the beach" (no sitting or sunbathing, only walking and running), respect of distances between groups of users, either natural or physically materialized zones, with the possibility of reserving them (Fig.8 & 9).

Fig. 8. COVID on the beach [14].

Fig. 9. COVID location management on the beach

On the sea (Fig. 10), the creation of activity zones is a common approach resulting in the creation of specific zones with supervised swimming, diving, and snorkeling activities, as well as sailing, yachting, surfing, kitesurfing, with either visual supervision, or more instrumented electronic monitoring. In this case, each actor (swimmer, sailor, kite surfer has at his/her disposal a connected watch, or more sophisticated devices able to communicate his/her position and related situation (OK, emergency call, etc.). On the beach, life guards are equipped with a receiver allowing them to monitor the situation and trigger the appropriate rescue actions.

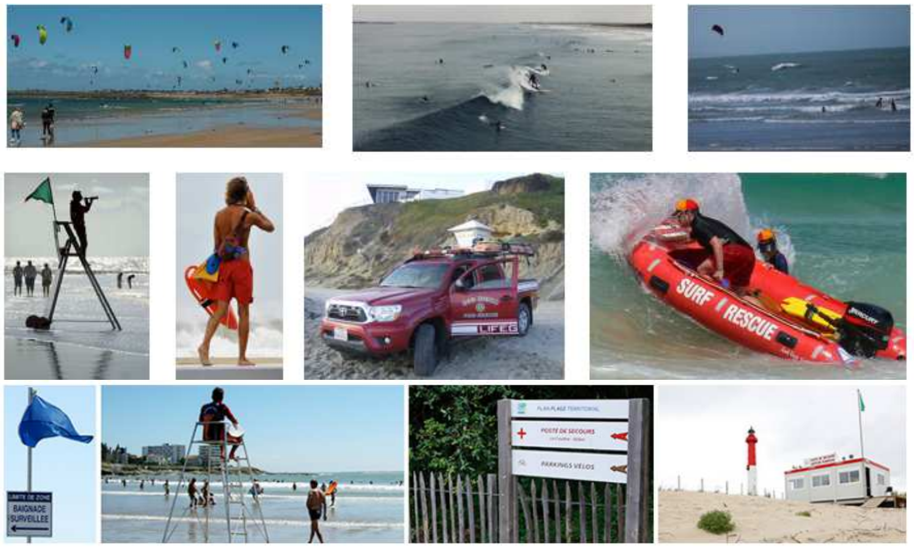

Fig. 10. Beach and sea zone management, supervision and rescue organization.

Another service that can be used in downtown, near the parking area, on the harbor and near the beaches, is an information shelter. Its objective is to provide potential passengers and visitors with appropriate information on transportation lines and their schedules, using appropriate screens, as well as providing local, cultural and sports programs, commercial advertising, etc. (Fig. 11).

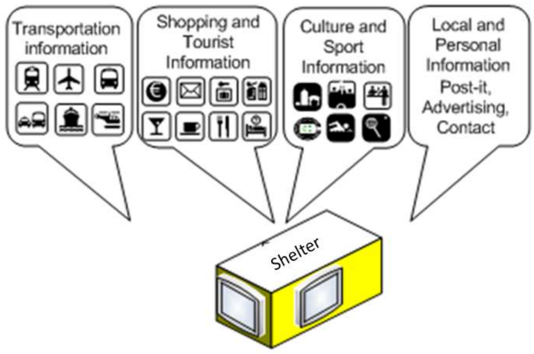

Fig. 11. Bus or Boat shelter for inhabitants' information.

Last but not least, a service we would like to mention is the **Pedestrian Drive,** the aim of which is to provide fresh food distribution based on box-lockers [15]. The idea is to convey fresh food to the beach instead of asking clients to go to a supermarket. The pedestrian drive is a variant of the concept of the supermarket drive, specially designed for pedestrians. Located as near as possible to client locations (beaches, sports arenas, etc.) 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 logistics process of the firm or can be managed independently. This case offers an interesting support system for the 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. This makes it possible to support the circular economy as a short circuit of agricultural goods (Fig. 12).

Fig. 12. Box/Lockers for fresh and frozen food [16].

For all these identified activities, it is fundamental to define how to collect the data on which they are based and to determine their management and evolution. The following section 4 is devoted to this issue.

Of course, this list is not complete and has been voluntarily limited to mobility aspects. We could continue to add other aspects and, in particular, reexamine our propositions from the view of special adjustment to disabled people, as we have already done in our previous papers [17, 18].

4 Data identification and their management - dynamicity

For all identified activities and applications, it is important to identify the data needed and to determine their evolution, i.e. dynamicity. We identified several levels and providers of data dynamicity.

4.1 Data dynamicity

The first, basic, level, is totally static, which means not smart, but useful for a large majority of city users (on the whole or by category): physical panels, boards and signs, as well as circulation signs. A contextual example can be seen in Fig.13.

The second level, with very low dynamicity, is based on boards with QR codes. In this case, in the field (city), the information indicator is static, and dynamicity is provided by the information sent to the user's smartphone from the website address encoded in the QR code. This approach is appropriate for optional information, which is accessed only by interested users and known only to them, in the form of historical information for example, but also for commercial and advertising purposes.

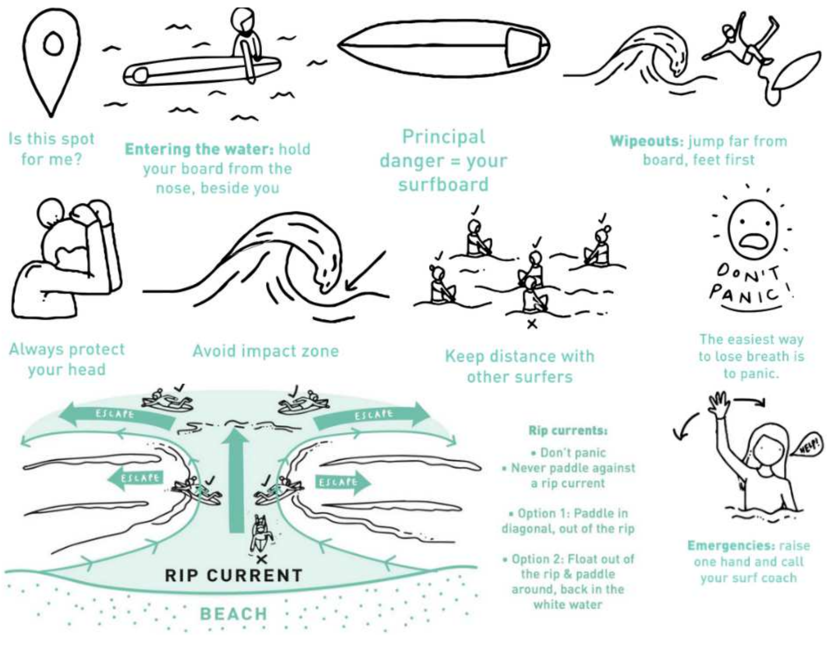

Fig. 13. Surf safety physical panel [19].

The third level of dynamicity is characterized by the need to propagate information that is of general interest and needs to be commonly known. The solution is to propagate it directly on users' smartphones or on GPS vehicle screens. Another solution is to use public active screens and information boards. This is the case for circulation information for dynamically managed circulation lanes such as we described earlier. This kind of dynamicity is usually determined by external decision centers working on collected or predefined data.

The fourth level of dynamicity is a contextual one, i.e. it is related to particular cases or situations that can be produced by an action on a local device, manually or automatically. A classic example is a sender located on a bus, which activates the opening of a barrier accessing a restricted portion of the road. This kind of sender (or remote control) can be either integrated on the vehicle (bike, car, bus, boat, etc.) or used manually by the user, often in emergency situations. These devices are attributed by the relevant authority. The actuator associated with the remote control can be either mono-located and mono-answer acting on a single door, barrier, etc. or integrated in a system assisting more sophisticated behaviors. Management of this dynamicity requires appropriate association between sender(s) and receiver(s) in order to organize the corresponding behaviors.

4.2 Emergency and rescue management

The highest level of dynamicity concerns emergency and rescue situations, mainly related to weather and environmental situations, such as floods, landslides, tsunamis, ecological and industrial problems, and fires. In these situations, the objective is to collect appropriate information and transmit it to the relevant organizations in charge of determining appropriate actions and informing those concerned (both those having to take action and those impacted).

From the data collection point of view, it is important to dispose of appropriately distributed sensors in water, air, and elsewhere for fire detection, which are able to transmit the appropriate data to the rescue center. The synthesis of these data is then elaborated, and an emergency signal is propagated to all information media, both individual and collective, in the city with vocal and/or visual announcements indicating the actions to take (leave the sea, put on a mask, move to an appropriate location, etc.).

4.3 Data for beach mobility

As we explained earlier, concerning management of mobility on beaches and on the sea in recreation areas, static information is available, mainly to indicate authorized and banned zones and expected users' behaviors. In this case, security observations and rescue actions are based on visual observations.

In a more dynamic and secure approach, swimmers and kite surfers are equipped with appropriate transceivers indicating their geographical positions (Fig.14). These devices are able to activate emergency demands. Life guards are fitted with a receiver designed to observe the movements of everyone in the beach zones and beyond in order to observe users' behaviors and contact each one in order to clarify their situation. They can indicate inappropriate behaviors, such as use of an inappropriate zone or ask the swimmer for the reason for his/her emergency signal and trigger appropriate action.

Fig. 14. The GPS wristband saving lives [20].

4.4 Data for traffic management

Organization of traffic is a very important aspect. Of course, in the low season, we can consider that static allocation of the circulation map is appropriate. However, in the high season, dynamicity aims at ensuring better traffic speed by introducing several restrictions during different periods of the day with authorized or prohibited vehicles. Circulation restrictions can vary frequently between buses, trucks, tourist vehicles, and so on. It is also important to take into account the main objective of each zone in the city. In tourist zones, such variation is natural. In industrial zones, mainly dedicated to boat construction and maintenance, priority must be given to the fluidity of this activity. Such dynamicity is either based on collected and preprocessed data (behavioral patterns) or on real-time data. This is then propagated to the assistive system and drivers in an appropriate manner, either by electronically driven signs and/or by propagation of corresponding information to the in-vehicle screens, smartphones, and GPS applications.

5 Data collection and elaboration

As analyzed in the previous section, data availability is the main problem in the provision of appropriate solutions. For the first levels of dynamicity, work can be elaborated progressively and be used relatively long-term. For greater levels of dynamicity, three different approaches can be used.

The first is totally related to the local context. The aim of local senders addressing local receivers is to obtain local and appropriate answers, such as opening of a read section that is managed.

A more general solution is to be able to share available data that are collected by communicating devices, namely senders and receivers, on site in the field, the city, and its neighborhood. This approach, which is called Open Data, constitutes major progress in general utilization of available data.

Another interesting approach is based on evolution of collected data by the acquisition of new, more recent data and their integration in the elaborated behavior model.

This approach is based on a very active research field called Machine and Deep Learning. We decided to devote the next two sections to these last two approaches.

5.1 Open data

One of the possible sources of information is access to open data published by different operators, such as municipalities, road operators, etc. These data can be either old data that are synthetized and give general trends or real-time data, indicating what is happening now or a few minutes ago.

Open Data [21] is the idea that some data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control [22]. The goals of the open-source data movement are similar to those of other "open(-source)" movements such as open-source software, hardware, open content, open specifications, open education, open educational resources, open government, open knowledge, open access, open science, and the open web. Paradoxically, the growth of the open data movement is paralleled by a rise in intellectual property rights [23]. The philosophy behind open data has been long established (for example in the Mertonian tradition of science), but the term "open data" itself is recent, gaining popularity with the rise of the Internet and World Wide Web and, especially, with the launch of open data government initiatives such as Data.gov, Data.gov.uk and Data.gov.in. INSPIRE (Infrastructure for Spatial Information in the European Community) is an EU initiative to establish an infrastructure for spatial information in Europe that is geared to help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development.

One of the most important forms of open data is open government data (OGD), which is a form of open data created by ruling government institutions. The importance of open government data is that it is a part of citizens' everyday lives, down to the most routine/mundane tasks that are seemingly far removed from government.

We give the following example [24]: Since January 1, 2015, the Metropolis of Lyon has grouped the missions of the Lyon Urban Community and the Rhône department into the 59 municipalities that make up the territory of Greater Lyon. The Metropolis of Lyon builds and preserves a pleasant living environment for its 1.3 million inhabitants by acting in broad areas: travel, mobility, knowledge, culture, environment, energy, solidarity, public health, childhood, family, city politics, habitat, housing, cleanliness, water, sanitation. It is in charge of major urban facilities and infrastructure, economic development, the attractiveness and influence of the territory. The Metropolis of Lyon is committed to opening up data to strengthen the innovation capacities of stakeholders on its territory and to invent the services and uses of the city of tomorrow.

5.2 Machine learning and deep learning

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 [25].

In some situations, it seems that deep learning can be used to analyze existing data and lead to interesting solutions. We can take intelligent navigation and travel planning as examples. For intelligent navigation, the intermediation platform considers the starting position and the destination position, combines the time information, meteorological information and other interfering factors, and finally provides the most appropriate one or more recommended paths. As for travel planning, the focus is to intelligently analyze the user's intention his/her behavior and finally make travel recommendations based on the tags that he/she is interested in and his/her browsing history.

Concerning the automated buses between park-and-ride and the main destinations (downtown, several beaches), it would be interesting to study the evolution of the trip trajectories, day-time periods, and the type of passengers. The objective is to determine the appropriate trip trajectory and timetable.

For goods transportation, it is important to start with a case-by-case study of the different destinations. We can then work progressively on these data that we capitalize in order to find main transportation trajectories and propose their evolution if necessary.

In practice, we can use the RNN (Recurrent Neural Network) structure in path planning, including intelligent navigation, travel for the disabled, parcel post and so on. The CNN (Convolutional Neural Network) model can be used for vehicle recognition to assist smart parking. For some scenarios with recommendation tasks, such as goods transportation and travel planning, we can use multilayer perceptron, LSTM (Long Short Term Memory networks), and other models [26].

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.

6 Mobility assistive system and its relationship with the field

As we explained in the previous sections, the process consisting in transforming a city into a smart city usually starts by identifying the actors concerned, as well as the necessary services and associated data.

In practice, in order to organize and manage these aspects, we need a system that groups the different services and their applications, the data on which they work, and the relationship, if needed, between the field and the system. We call this system an Assistive System, the aim of which is to manage contextually all smart city applications. Its architecture is organized in 4 layers (Fig. 15) where:

Layer number 1 is devoted to applications, while layer number 2 is geared towards management of common data and proposing general services. The aim of the third layer is to work on what is called “Data Vitalization”. The idea is to work on data and elaborate new constructions on them that can be used in new applications. An example of this need is to be able to collect and associate data in order to manage situations that were not predictable, such as several cases of rescue for not necessarily easily predictable situations.

The last (fourth) layer aims at acquiring and distributing the data needed for appropriate working of all applications concerning the coastal smart city. In order to take into account the evolution of this assistive system, an appropriate user interface, called the Supportive User Interface, is provided, allowing maintenance staff to provide the modifications requested easily.

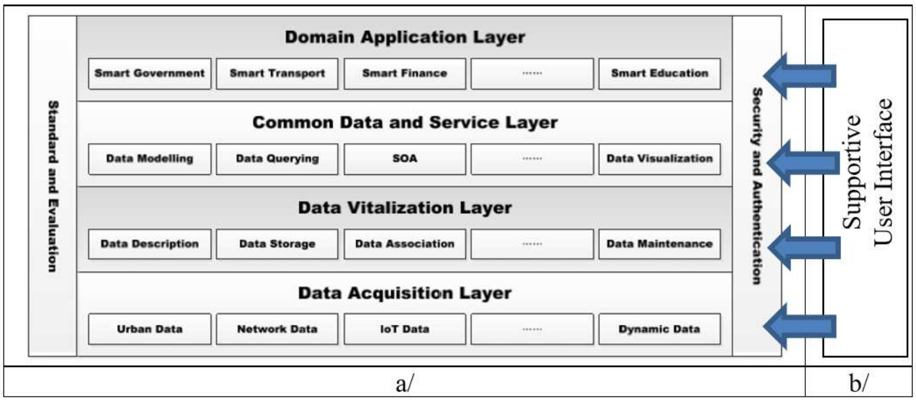

Fig. 15. a/ Architecture of an Intermediation platform with Data Vitalization [27], b/ Supportive User Interface [28].

Appropriate user interfaces, called Supportive User Interfaces, are provided to facilitate these evolutions. The "mashup" technique can be used for this purpose [29].

7 Conclusion

In this paper we studied how a coastal city evolved to become a Smart Coastal City. The process was mainly based on the study of the actors concerned (inhabitants, tourists, workers, government authorities, etc.) and the corresponding services for each of them and globally. The specificity of a coastal city with activities related to the sea, industry, and tourism were the main instigators of this study. Our reasoning was based on the existence of two seasons (the high season – tourism-oriented - and the low season – inhabitant-oriented).

We proposed what we consider to be major transformations, either specific to the coastal city or adapted from the smart city in general. We identified expected services, associated data, corresponding user interfaces, individual or more common, and we described the links (passive or active) with the field (part of the city concerned) and the need for in-the-field indicators, senders and receivers. The dynamicity of the functional periods was also studied. We only briefly presented technological aspects (assistive system as an intermediation platform, open data use, and Machine and Deep Learning techniques), which we consider out of scope of this conference.

We also avoided the problem of assistance to disabled people, which we studied in our previous publications [17, 18], in which we presented several solutions applicable in Smart Cities and that can be transposed easily to this context. Of course, new solutions, specific to the coastal context (beaches, sea, harbor, boats) can be proposed. This is our objective in the near future, together with the discovery of other Coastal Smart City services and applications.

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