A KNOWLEDGE-BASED CONCEPTUAL VISION OF THE SMART CITY

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Abstract

The term smart city is a fuzzy concept, not well defined in theoretical researches nor in empirical projects. Several definitions, different from each other, have been proposed. However, all agree on the fact that a Smart City is an urban space that tends to improve the daily life (work, school,...) of its citizens (broadly defined). This is an improvement from different points of view: social, political, economic, governmental,... This paper goes beyond this definition and proposes a knowledge-based conceptual vision of the smart city, centered on people's information and knowledge of people, in order to improve decision-making processes and enhance the value-added of business processes of the modern city.

1. Introduction

Over the past few decades, the challenges faced by municipal administrations, such as urban growth or migration, have become increasingly complex and interrelated. In addition to the traditional land-use regulation, urban maintenance, production, and management of services, governments are required to meet new demands from different actors regarding water supply, natural resources' sustainability, education, safety, or transportation (Gascó et al, 2014). Innovation, and technological innovation in particular, can help city governments to meet the challenges of urban governance, to improve urban environments, to become more competitive and to address sustainability concerns.

Since the early 90s, the development of Internet and communication technologies has facilitated the generation of initiatives to create opportunities for communication and information sharing by local authorities. This phenomenon appeared in the United States then moved to Europe and Asia. Indeed, in our everyday life, we are more and more invaded by data and information. This flow of data and information is often the result of Information and Communication Technologies (ICT). Moreover, potentialities of ICT, that have almost exponentially increased, have given rise to a huge mass of data to treat (Batty, 2013). The world is becoming increasingly digital and people are affected by these changes. Also, the digital infrastructure infers an information environment that is "as imperceptible to us as water is to a fish" (McLuhan & Gordon, 2011).

There exists a kind of parallelism between technologies and humans. On one hand, people use technologies more and more and are hyper-connected, and, on the other hand, (numeric) systems are more and more user-centered (Viitanen & Kingston, 2014). Thus, within cities, systems have to adapt to hyper-connected citizens, in a very particular environment, the one of cities in constant evolution where systems and humans are nested.

The advent of new technologies also confronts the city to a large influx of data (Big Data) from heterogeneous sources, including social networks. It is also important to note that much information and / or knowledge flow between different people (with different uses and backgrounds) and between different stakeholders (Kennedy, 2012). In this respect, the city sees that numerous data circulate via the internet, wireless communication, mobile phones,…

Finally, smart cities are exposed to technological issues tied to the huge mass of data which pass within them. These data can carry knowledge and, by the way, the smart city, and de facto, the smart city, aware of the existence and of the potential of this knowledge, can exploit and use them.
Note that, for a city, all citizens become knowledge-citizens, especially those whose knowledge is the crucial factor enabling them to improve their

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decision-making processes. In this respect, knowledge is fundamentally valuable to make better decisions and to act accordingly.

Given this context, this paper focuses on knowledge in the smart city. The paper discusses both explicit knowledge (knowledge extracted from data which flows within the city) and tacit knowledge (that is, citizen's knowledge). Our argument is two-fold: on one hand, we believe that, due to the importance for the city management of tacit knowledge, the city should be closer to its citizens (Bettencourt, 2013). On the other, a city can become smarter by improving its decision-making process and, therefore, by making better decisions. ICT can help in this respect: more data and better-managed data result in, not only more information, but also more knowledge. More knowledge gives rise to better decisions (Grundstein et al, 2003; Simon, 1969).

The remainder of this paper is organized as follows. Next, we present some literature on smart cities and knowledge. Subsequently, we describe the opportunities and challenges smart cities offer for cities development and growth. The City's Information and Knowledge System is then introduced. Finally, we bring to a close, drawing some conclusions on what a knowledge-based smart city is.

2. Related Work

2.1. On smart cities

The origins of the smart city concept are related to the European Union's energetic efficiency programs that aimed at making cities sustainable (AMETIC, 2013). However, important conceptual trends have also contributed to the emergence of this term. In particular, the influence of open innovation has been key. Chesbrough (2006 & 2003) defines open innovation as a strategy by which firms commercialize external (as well as internal) ideas by deploying outside (as well as in-house) pathways to the market. In addition, "ideas can also originate outside the firm's own labs and be brought inside for commercialization. In other words, the boundary between a firm and its surrounding environment is more porous, enabling innovation to move easily between the two" (Chesbrough, 2003: 37).

Despite open innovation was born in relation to the industry and the business world, several authors think this theory can be easily implemented in different fields. In this respect, while historically the public sector has lagged on the innovation curve, today information technology is opening up new opportunities to transform governance and redefine government-citizen interactions, particularly within cities (Chan, 2013; Pyrozhenko, 2011; Almirall & Wareham, 2008). In this context, a smart city can be understood as an environment of open and user-driven innovation for experimenting and validating ICT-enabled services (Schaffers et al., 2011).

A second relevant stream of theory that has contributed to the development of smart cities is urban planning and urban development (Trivellato et al., 2013). Ferro et al. (2013) state that the term smart city probably finds its roots in the late nineties with the smart growth movement calling for smart policies in urban planning. According to Anthopoulos & Vakali (2011), urban planning controls the development and the organization of a city by determining, among other, the urbanization zones and the land uses, the location of various public networks and communal spaces, the anticipation of the residential areas, and the rules for buildings constructions. Traditionally, urban planners have been concerned with designing the physical infrastructure of communities, such as transportation systems, business districts, parks and, housing development (Fernback, 2010). Currently, in doing so, urban planners find in technology an enormous opportunity to shape the future of a city (Townsend, 2013), particularly for urban planning is a complex task requiring multidimensional urban information, which needs to be shared and integrated (Wang et al. 2007).

Regardless of its origins, various attempts have been made to academically define and conceptually describe a smart city. AlAwadhi & Scholl (2013) state that, actually, these definitions depend on different types and groups of practitioners think about what a smart city is. In this respect, although no generally accepted academic definition has emerged so far, several works have identified certain urban attributes that may characterize what a smart city is.

To start with, Giffinger et al. (2007) rank 70 European cities using six dimensions: smart economy (competitiveness), smart people (human and social capital), smart governance (participation), smart mobility (transport and ICT), smart environment (natural resources), and smart living (quality of life). As a result, they define a smart city as "a city well performing in a forward-looking way in these six

characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens" (p. 11).

Moreover, Nam & Pardo (2011) suggest three conceptual dimensions of a smart city: technology, people, and community. For them, technology is key because of the use of ICT to transform life and work within a city in significant and fundamental ways. However, a smart city cannot be built simply through the use of technology. That is why the role of human infrastructure, human capital and education, on one hand, and the support of government and policy, on the other, also become important factors. These three variables considered, the authors conclude that "a city is smart when investments in human/social capital and IT infrastructure fuel sustainable growth and enhance a quality of life, through participatory governance" (p. 286).

In turn, Leydesdorff & Deakin (2011) introduce a triple helix model of smart cities. They argue that cities can be considered as densities in networks among three relevant dynamics: the intellectual capital of universities, the wealth creation of industries, and the democratic government of civil society. Lombardi et al. (2011) build on this model and refer to the involvement of the civil society as one of the key actors, alongside the university, the industry and the government. In Lombardi's words (2011): "this advanced model presupposes that the four helices operate in a complex urban environment, where civic involvement, along with cultural and social capital endowments, shape the relationships between the traditional helices of university, industry and government. The interplay between these actors and forces determines the success of a city in moving on a smart development path" (p. 8).

Yet, so far, one of the most comprehensive and integrative framework for analyzing smart city projects has been presented by Chourabi et al. (2012). The authors present a set of eight dimensions, both internal and external, that affect the design, implementation, and use of smart cities initiatives:

1) Management and organization: Organizational and managerial factors such as project size, leadership or change management.
2) Technology: Technological challenges such as lack of IT skills.
3) Governance: Factors related to the implementation of processes with constituents who exchange information according to rules and standards in order to achieve goals and objectives.
4) Policy context: Political and institutional components that represent various political elements and external pressures.
5) People and communities: Factors related to the individuals and communities, which are part of the so-called smart city, such as the digital divide or the level of education.
6) Economy: Factors around economic variables such as competitiveness, innovation, entrepreneurship, productivity or flexibility.
7) Built infrastructure: Availability and quality of the ICT infrastructure.
8) Natural environment: Factors related to sustainability and better management of natural resources.

Finally, according to Dameri (2013), within the European Union, the concept of smart city is based on four basic elements that composed the city:

1) Land: The territorial dimension is not limited to the administrative boundaries of the city but may extend to the region. Sometimes, cities group together and form a network to share knowledge and best practices to tackle urban problems. The city is subjected to influences and regulations of the nation, which itself is affected by more global prerogatives.
2) Infrastructures: Buildings, streets, traffic and public transports impact the quality of urban life and urban environment.
3) People: All the stakeholders who are linked to the city (students, workers, neighbors, friends, tourists, …).
4) Government: Urban policies are defined at the local level, and also at the central level, or even at a more global level, such as the European level, depending on the topic, the action, the project, …

However, a definition of a smart city is indispensable to define its perimeter and to understand which initiatives can be considered smart and which cannot. Moreover, a standard definition is also the first step for each city to specify its own vision of a smart city strategy. The definition and the comprehensive smart city framework (threats, opportunities,…) are the necessary basis on which to build the smart city goals system. That is why, in this paper, we agree with the Chourabi, et al's framework (2012) and the Caragliu, et al.'s definition (2009) and consider that cities are smart when investments in

human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

2.2. On knowledge

As mentioned in the introduction, the smart city must be able to exploit knowledge that result from data management. This knowledge will result in better decisions in order for the 21st century city to address its main challenges (Negre & Rosenthal-Sabroux, 2014).

We suggest an approach to digital information systems centered on people's information and knowledge of people, in order to improve decision-making processes and enhance the value-added of business processes of the city.

ICT allow people located outside a city to communicate with other people and to exchange knowledge. These observations concerning knowledge in the city context highlight the importance of tacit knowledge. It points out the interest of creating a favorable climate for both the exchange and sharing of tacit knowledge and its transformation into explicit knowledge and therefore extending the field of knowledge which will come under the rules and regulations governing industrial property (Negre & Rosenthal-Sabroux, 2014). Moreover, we should emphasize the fact that capitalizing on city's knowledge is an ongoing issue, omnipresent in everyone's activities, which specifically should have an increasing impact on management functions of the city.

Polanyi (1967) classifies the human knowledge into two categories: tacit knowledge and explicit knowledge. He says: "tacit knowledge is personal, context-specific, and therefore hard to formalize and communicate. Explicit or 'codified' knowledge, on the other hand, refers to knowledge that is transmittable in formal, systematic language" (p. 301). Our point of view can be found in the work of Nonaka & Takeuchi (1995), with reference to Polanyi (1967), considering that "tacit knowledge and explicit knowledge are not totally separated but mutually complementary entities" (Nonaka & Takeuchi, 1995: 61). For Nonaka & Takeuchi (1995), explicit knowledge can be easily expressed in written documents but is less likely to result in major decisions than tacit knowledge, which is to say that the decision process stems from knowledge acquired through experience, albeit difficult to express in words.

Tangible elements are "explicit knowledge". Heterogeneous, incomplete or redundant, they are often marked by the circumstances under which knowledge was created. They do not express the unwritten rules of those who formalized knowledge, the "unspoken words". They are stored and disseminated in archives, cabinets, and databases, ... (Polanyi, 1967).

Intangible elements are "tacit knowledge". Acquired through practice, they are adaptable to the situations. Explicitly or non-explicitly, they are often transmitted by implicit collective apprenticeship or by a master-apprentice relationship. They are located in people's minds (Polanyi, 1967).

By analogy with the works of Polanyi (1967), Nelson and Winter (1982), Davenport & Prusak (1998) and Grundstein et al. (2003), the city's knowledge consists of tangible elements (databases, procedures, drawings, models, documents used for analyzing and synthesizing data, …) and intangible elements (people's needs, unwritten rules of individual and collective behavior patterns, knowledge of the city's history and decision-making contexts, knowledge of the city environment (citizens, tourists, companies, technologies, influential socio-economic factors, …). All these elements characterize the city's capability to innovate, produce, sell, and support its services. They are representative of the city's experience and culture. They constitute and produce the added-value of the city.

These observations concerning knowledge in the city context highlight the importance of tacit knowledge. They point out the interest in taking into account tacit knowledge in decision processes. As a reminder, we believe that the decision in the context of smart cities, where data and knowledge flow, is permanent and important.

3. Opportunities and challenges of the smart cities

Cities are confronted to a continuous improvement process and have to become smarter and smarter (Negre & Rosenthal-Sabroux, 2014). In doing so, they are confronted with threats and opportunities.

Opportunities in cities are given by innovation, education, culture, companies, public organizations and public spaces where people can exchange, make sport, share experiences, meet each other, …

On the other side, difficulties related to urbanization, environment protection, pollution, inefficient public transports, traffic, lack of green spaces, social differences, … are threats to city.

To deal with these threats and opportunities, questions regarding knowledge in the city arise: How should we link knowledge management to the smart city strategy? What activities should be developed and promoted? What organizational structures should be put in place? How should we go about creating them? How can we implement enabling conditions for knowledge management initiatives? What impact and benefit evaluation methods should be installed? How can we go about provoking cultural change towards a more knowledge-sharing attitude? Within this perspective, we must keep in mind that cities need to evolve through their own efforts, by intensifying diversity and creating new foundations for thought and behavior.

A knowledge-based city requires that each citizen takes responsibility for objectives, contributions to the city and, indeed, for behavior as well. This implies that all citizens are stakeholders of the city.

This vision places strong emphasis on the ultimate goal of the digital information system which is providing knowledge-citizens, engaged in a daily related decision process, with all the information needed to understand situations they will encounter to make choices - which is to say, to make decisions – to carry out their activities, capitalizing the knowledge produced in the course of performing these tasks.

The use of high technology help to improve a better way of life in the city because citizens are more informed, connected and linked. Moreover, using Information and Communication Technology (ICT) is essential to create social inclusion, social communication, civil participation, higher education and information quality.

Finally, it is important to note that if smart cities are too connected/linked, they can become ICT-addicts (Viitanen & Kingston, 2014). In that case, it is possible that, one day, some smart cities will be confronted to problems of cyber-security and/or resilience, such as in the new video game "Watch Dogs" (Ubisoft) in which the player is at the heart of a smart and hyper-connected city in which his smartphone gives him/her control of all infrastructures of the CTOs (Central Operating System - high performance system that connects infrastructures and facilities of public security of the city to a centralized exchange pole). The player can handle the traffic lights to create a huge pile or stop a train to board and escape the forces ... Everything that is connected to the network can become a weapon.

Opportunities and challenges should be more related to knowledge in the smart city. Therefore, in the next section, we propose to adapt the concept of Enterprise's Information and Knowledge System (EIKS) introduced by Grundstein & Rosenthal-Sabroux (2009) to smart cities to address challenges related to knowledge in the smart city.

4. The Smart City's Information and Knowledge System

In general, an information system "is a set of elements interconnected which collect (or recover), process, store and disseminate information in order to support decision and process control" (Laudon & Laudon 2006). Grundstein & Rosenthal-Sabroux (2009) introduced the notion of knowledge into the information system and proposed the concept of Enterprise's Information and Knowledge System (EIKS). In this section, by analogy, we propose our Smart City's Information and Knowledge System (CIKS) where data and knowledge flow within.

Under the influence of globalization and the impact of Information and Communication Technologies (ICT) that modify radically our relationship with space and time, the city increasingly develops its activities in a planetary space with three dimensions:

- A global space covering the set of cities (the nation).
- A local space corresponding to the city located in a given geographic area.
- An area of influence that covers the field of interaction of the city with the other cities.

The city locked up on its local borders is transformed into an extended city, without borders, opened and adaptable. The land is the territorial dimension of a city, with different levels. These

levels range from the local dimension, to regional, network, national and finally the global dimension.

Furthermore, this city is placed under the ascendancy of the unforeseeable environment that leads towards uncertainty and doubt.

The city meets fundamental problems of information exchange and knowledge sharing among, on the one hand, its formal entities distributed in the world and on the other hand, the city's people (nomadic or sedentary), bearers of diversified values and cultures according to the origin.

Two networks of information overlap:

- A formal information network between the internal or external entities, in which data and explicit knowledge circulate. This network is implemented by means of intranet and extranet technologies.
- An informal information network between nomadic or sedentary peoples. This network favors information exchange and tacit knowledge sharing. It is implemented through converging Information and Communication Technologies (for example the new IPOD with Web 2.0).

The problems occur when nomadic people (tourists or students for example) placed in new, unknown or unexpected situations, need to get "active information", that is, information and knowledge they need immediately to understand the situation, solve a problem, take a decision, and act.

That means that ICT provide the information needed by people who are the heart of the city. By extension, our reflection is: ICT bear potentialities, they bring new uses, they induce a new organization, and they induce a new vision of city, what we call a "smart city". And, ICT are the heart of the smart city.

Building on this, a city can be seen as an information system and because of its hyper-connected nature, smart city can be seen as more than an information system: an information and knowledge system. In fact, the City's Information and Knowledge System (CIKS) consists mainly in a set of individuals (people) and digital information systems. CIKS rests on a socio technical context, which consists of individuals (people) in interaction among them, with machines, and with the very CIKS. It includes:

- Digital Information Systems (DIS), which are artificial systems, the artefacts designed by ICT.
- An information system constituted by individuals who, in a given context, are processors of data to which they give a sense under the shape of information. This information, depending of the case, is passed on, remembered, treated, and diffused by them or by the DIS.
- A knowledge system, consisting of tacit knowledge embodied by the individuals, and of explicit knowledge formalized and codified on any shape of supports (documents, video, photo, digitized or not). Under certain conditions, digitized knowledge is susceptible to be memorized, processed and spread with the DIS.

We must identify information and knowledge to a city's activities and for individual and collective decision-making processes. The objective could be to design a Digital Information System (DIS) which would allow the city's stakeholders to receive, to gain access to, and to share the greatest variety of information and knowledge they deem necessary, as rapidly as possible, in order to accelerate decision-making processes and to make them as reliable as possible.

5. Conclusion

The city has evolved over time: it started with scattered houses, then these houses were grouped into cities, which were industrialized and mechanically connected to other cities and, now, we have hyper connected cities (with citizens who are connected, who need access to different information, and with cities that are connected to the rest of the world) (Kennedy, 2012).

In this paper, we propose a conceptual vision of the smart city, based on knowledge. Knowledge can be: explicit knowledge (knowledge extracted from data which flows within the city) and/or tacit knowledge (that is, citizen's knowledge). According to the previous works on the area of smart cities and knowledge management and the study of threats and opportunities of cities, one specific challenge appears (among some): knowledge must be integrated into the city. Thus, we introduce our Smart City's

Information and Knowledge System (CIKS) where data and knowledge flow within.

The smart city is more than Information and Communication Technologies (ICT), and more than people. It also has to do with knowledge (Kennedy, 2012; Negre & Rosenthal-Sabroux, 2014).

Our vision is an approach that takes into account people, information, knowledge and ICT. From our point of view, knowledge is a factor of competence in order to improve the "smartness" of the city and to handle the complexity of the cities (du, in part, to ICT).

The multidisciplinary of a smart city program requires defining a set of objectives to be reached. Citizens should be involved, both in the plan phase and in the smart city implementation stage. Communication is at the center of a shared process of defining smart city goals and of spreading awareness about the smart city role and their benefits for people (Viitanen & Kingston, 2014).

Our viewpoint is situated very much in the acceptance of the term "knowledge" that does not dissociate people, the actors placed at the heart of the city's processes, from the actions that they perform, the decisions that they make, and the relations that they have with their city environment. What is essential in our approach is this strongly creative relation between people and their actions, taking into account their motivation, the end purpose of their action, and their orientation of knowledge toward an objective.

In today's new economy, cities must be aware of the value of non-material capital, and especially of knowledge capital. The decision-making process should be accelerated and its bases improved:

- Citizen carrying out their activities should become more efficient.
- Citizens should be given increased autonomy and mobility in their activities, enabling them to deal more effectively with fluctuations engendered by new constraints.

Citizens with a window open on to the city and its environment should be able to receive information and knowledge specific to their activities, to have access to data, information and knowledge and to transmit and share their own tacit knowledge.

From our point of view, the smartness of a city can be improved with (i) a more global view of the city (multicriteria, multi-views, context,…), (ii) both a technological and human -centered approach, and (iii) by taking into account knowledge in the smart city concept.

The expression smart city covers all the managerial actions aiming to answer the problem of the city's smartness: it is necessary (i) to align the management of the city with strategic orientations of the city; (ii) to make people sensitive; (iii) to train and motivate all the city's stakeholders; (iv) to organize and to pilot activities and specific processes addressed to become smarter; (v) to promote the implementation of favorable conditions to the cooperative work and to encourage the sharing of knowledge (Bettencourt, 2013; Negre & Rosenthal-Sabroux, 2014).

In sum, cities must evolve, otherwise they will die!

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