An approach to a reference model for a sentient smart city

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Abstract

The interest about Smart City concept has increased in recent years. In fact, Smart Cities is expected to improve cityzens life experience by driving the next digital revolution, moving from the personal area (mobile computing, smart home) to the urban area (collective computing and collective intelligence). But the development of Smart Cities is not being as fast as expected. Several problems need to be undertaken in order to achieve the objectives of the paradigm. This paper presents an approach to address one of these problems: to orchestrate the platform that is required for gathering information about city, store it in a model and enable it for exploitation. The heterogeneity of the potential data sources available and the complexity of the information nature and structure, make it a non-trivial task that have to be solved before commercial solutions appear and provide specific and non-interoperable solutions.

1. Introduction

According to Unied Nations, more than 50 percent of all people, 3.3 billion lived in urban areas. By 2030 this number is expeted to be increased until 5.5 billion. This urban growth rate impulse goverments to look for solutions and smarter ways to manage and organize cities.

At the same time, evolution of electronics is increasing its capabilities and changing the way in which humans interact with technology. Computing devices are becoming part of our daily life.

But now, these devices jump from personal environment to the city area, improving the way in which humans and city interact, and creating smart cities.

Several definitions of smart city can be found in bibliography:

- The use of smart computing technologies to make the cirtical infrastrcuture componets and service of a city more intelligent, interconnected, and efficient.
- A city well performing in a formard-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens.
- A city striving to make intself “smarter” (more efficient, sustainable, equitable, and livable).
- A city that monitors and integrates conditions of all of its critical infrastructures, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.
- An instrumented, interconnected and intelligent city. Instrumentation enables the caputre and integration of live real-world data through the use of sensors and other devices. Interconnected means the integration of those data into a computing platform and the communication of such information among the city services. Intelligent refers to the inclusion of complex analytics, modeling, optimization and vistualization to the operational business processes to make better operational decisions.
- A city where the ICT strengthen the freedom of speech and the accessibility to public information and services.

From these definitions, can be emphasized some key concepts related to smart cities: infrastructure, communications, computing, information, technology, services, efficience, citizens, sustainability, livable, quality of life, integration, resources, optimization and accesibility.

Smart Cities have been identified as one of the central topics in European Research Program because of its potential, and its decisive contribution to quality of life in coming years. The evolution of the paradigm will create also an emerging market around it, and provide an important impulse for economy.

European Commission affirms that there is a need to reach a high level of agreement at an industrial level to overcome the increasing market fragmentation caused by isolated partial or specific solutions (vertical), commercial oriented, that already exists in the smart city initiatives.

Smart City concept is expected to be an important economic engine in coming years, because of the implications that its development has for people, bussiness and administrations. In fact, the paradigm implies a joint effort between them.

The project *European Smart Cities* identifies six smartness dimensions for smart evaluation: economy, people, governance, mobility, environment and living.

The paradigm will improve cities in each one of these dimensions.

- Information and communicatinos networks
- Engineering
- Energy and cooling networks
- Responsible mobility
- Distribution of drinking water
- Smart building management
- Waste collection and recovery
- Public lighting networks
- Garden city
- Wastewater recovery
- Energy management

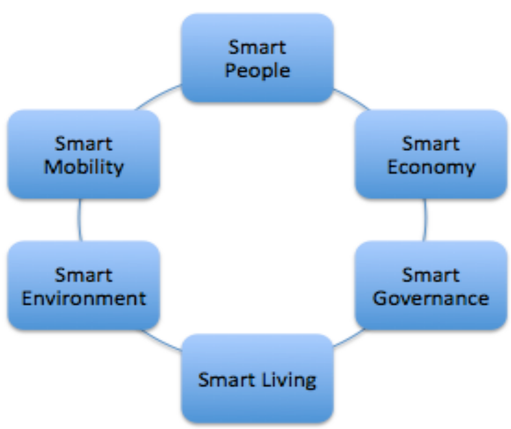

Figure 1 - Smart Cities dimensions

These dimensional developments will be translated in more concrete benefits for society as are the following facts:

- Reducing resource consuption: energy, water, hence CO_2 emissions
- Optimizing infrastructure utilization, and so improving quality of life
- Developing new services for citizens (collective, real-time city information, forecasting, health monitoring, bussines opportunities)
- Improving commercial relationships for providers and consumers

According to Gartner, in 2012 there were 143 smart city projects ongoing along the world. Distributed as follow: North America (35), South America (11), Europe (47), Asia (40) and the Middle East & Africa (10). But the number is growing.

Research programs are driving this trend and spend large amounts on this issue to encourage the creation of a market to strengthen business involvement and smart cities development.

Nevertheless, because of the early stage in which Smart Cities are, the challenges for a smart city are very general [Batty, 2012]:

- A new understanding of urban problems
- Effective and feasible ways to coodinate urban technologies
- Models and methods for using urban data across saptial and temporal scales
- Developing new technologies for communicatinos and dissemination
- New forms of urban governance and organisation
- Defining critical problmes relating to cities, transport, and energy
- Risk, uncertainty and hazard in the smart city

But not only exist challenge in smart city design, yet also about research in smart city:

- To relate the infrastructure of smart cities to ther operational functioning and planning through managemente, control and optimization
- To explore the notion of the city as a laboratory for innovation
- To provide portfolios of urban simulation which inform future designs
- To develop technologies that ensure equity, fairness and realise a better quality of city life
- To develop technologies that ensure widespread participation

The objective of this paper is to describe a reference model for the architecture of a smart city that develops interoperability (service composition thinking) and infrastructure integration (multiple-device platform, networks and integrated data center). This is, to orchestrate the information gathering, processing, publication and use.

2. Background

Several Smart Cities projects are presented, analyzing especially how their functinonality is organized.

The smart city development pyramid [Al-Hader et al., 2009] is an example of functionality organization for smart city. The reference model proposed in this paper uses a similar approximation in the low layers, but is significantly different in top layers.

A service oriented architecture, in this case, of smart city geospatial management can be found in bibliography [Al-Hader et al., 2009a]. It seeks an efficient resource planning, management and quality of service.

Other proposal for an integrated service management planform, called ISMP [Jungwoo et al., 2011], divides it in thre layers: Infrastructure component (sensors and actuators), Middleware (Gateway service, Mobility manager, Ubiquitous information, Operation management and Integrated database) and Service.

A low level architecture for monitoring public spaces is proposed in SOFIA project [Filipponi et al., 2010]. It follows an event driven architechture, collected form wireless sensor networks, and use two main building blocks: Knowledge Processors and Semantic Information Brokers. It has an aggregation and correlation system to create event of a high level abstraction. This way, an Interoperability Open Platform manages heterogeneous data sources.

3. Reference Model

The reference model proposed (Figure 2) is organized in four levels, which divide responsibility of functionality implementation.

In the first layer, called *Infrastructure Level*, resides the complexity of to manage heterogeneous sensors, and other real world information sources, deployed in the urban spaces.

There is a core feature in this layer, which is Urban Communications Abstraction. In other words, how to connect the huge number of elements deployed along the city (sensors, actuators, gateways, etc). The specification for a WSN, in example, will reside in this level.

The second layer, called *Information Level*, aggregates and consolidates information gathered. Data is generated andcollected have to be orchestrated in order to build a sustain-

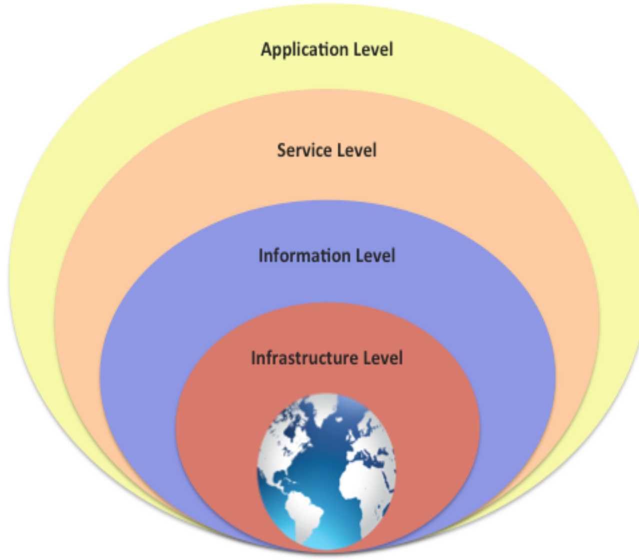

Figure 2 - Vision of the reference model proposed

able model that could be exploited by services and applications.

Basically in this level resides a real world model to store the data in a useful way and the procedures to transform plain information, gathered from sources, in data. The sources for the information of each dimension are heterogeneous, and complicated to aggregate. It is necessary a process to enrich with semantic information the data gathered. The Unified Urban Information Model will store the enormous quantity of information generated, to be exploited by services in the next level. This level should be able to measure, optimize, control and monitor complex systems from urban life.

Open Data philosophy encourage guvermental transparency and open innovation for smart cities, giving free access to data retrieved along the city. It empowers user driven innovation through open data platform strategy. This set of data would be at this level.

The third level, called *Service level,* by following SOA architecture, defines a suit of open and standardized enablers to facilitate the composition of interoperable smart city services. This ecosystem allows providing services to high-level applications. This is, an open urban service development, which supply interoperability between applications and service levels, and thus another key feature in the platform design.

In the top, *application level* is ubicated. These applications, use services provided in the previous layer, for implements complex task over city environment.

4. Conclussions

Smart Cities are on the track. The paradigm is not yet totally defined, but smart cities are starting to implement it and are going to be very much more in next years.

The succesful development of Smart Ctites paradigm will require a unified ICT infrastructure to allow a sustainable growth.

The evolution of the paradigm will create a bussiness opportunity in an emerging market. It will impulse the economy, and will constitute a research opportunity.

Information will be in the heart of the city. Data adquisition and sharing will play a crucial role in the game. Data management will be a complex task and the urban information model is one key aspect in the design.

Whole people implicated: researchers, enterpises, citizens, goverments, etc, have to row in the same direction, providing horizontal and interoperable solutions. In fact, service interoperability is essential for the good development of applications.

A reference model is necessary to orchestrate how the responsabilities and functions are divided among the solution in a more efficient, scalable and suitable way, that support new generations of services that have not been defined yet.

5. Future Work

The Reference Model has to increase the detail specification level, by explaining levels separately and defining the characteristics and singularities of them.

A demostration implementation is also needed in order to validate and show the utility of the reference model.

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