Towards a Smart City Security Model

Exploring Smart Cities Elements Based on Nowadays Solutions

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Abstract— **Even though concepts related to smart cities are well established and spread, those concepts are still very thin when related to Information Security. This paper will present some studies on smart cities, and will show that those studies are based on three macro concepts, System Interoperability, Applications and Frameworks/Platforms. Solutions and tools focusing on Information Security are still far from the common and typical scenario of urban systems. Based on that assumption, we propose a solution, based on a self-contained information security model, that aims to relate several items from urban system sand solutions for problems like, privacy and information integrity. This paper presents the first stage of this model that is based on elements found on nowadays solutions form Smart Cities.**

Keywords-smart city; security; privacy; information.

I. INTRODUCTION

The term City, in general, means a place or an urban area demographically closed, running under economical and political understanding [1]. These assumptions are also related to the idea that a City is a trading and commercial center that offers different services and products to a region. Those images are directly influenced by the industrial age when the production of services and products had their transformation [1].

Today, urbanization have reached an unprecedented level; different from other ages, large cities have now most part of world population and an increasingly share of the world's most skilled, educated, creative and entrepreneurial minds [2]. More than 50 percent of people on the planet now live in large cities [4]. According to United Nations, this number will increase to 70 percent in less than 50 fifty years [3]-[5]. This so-called *city growth* or emerging of urban life is driving the city infrastructure into a stress level never seen before as the demand for basic services are both increased and overloaded [6].

According to a research called *Smarter Cities and Their Innovation Challenges*, there is an urgent need for urban scenarios and cities to be smarter in the management of their infrastructure resources and interactions [3]. The urban performance must not depend only on its hardware infrastructure, or the physical concepts of infrastructure, but it must start taking into account social interactions and a faster deployment of information and services.

Cities are becoming increasingly empowered technologically as their core systems, i.e., Education, Public Safety, Transportation, Energy and Water, Healthcare and Services, are instrumented and interconnected, enabling new ways to deal with massive, parallel and concurrent usage.

In this paper, we aim to present a Security Model for Smart Cities, based on the assumption that this field has few works focusing on Information Security and its consequences. To that, this paper will present works related to security, it will depict Smart City initiatives and will present the Security Model based on urban system, data type and their interaction. This work is divided as follows:

In Section II, we present a difference between information security in cloud computing areas and smart cities. In Section III, there is going to be a detailed model basis. Section IV presents model's entities explanation; Section V presents the conclusion and future works.

II. INFORMATION SECURITY, CLOUD COMPUTING SECURITY AND SMART CITIES

Typically, cities or urban areas will begin to increase the demand for a better and more spread network connectivity, which will serve as a base for a group of different and more powerful features and services. Along with that, potential threats against those systems will increase, going beyond security network aspects. Hence, security measures will be needed within system scope. According to Bartoli et al. [7] and to Li et al. [8], for an effective protection of a Smart City system or its environment in the correct way, a number of problems related to security have to be addressed following a specific plan, definition or architecture. Those plans cover different types of systems and threats, but still do not address specific environmental situations and entities of a Smart City.

Although systems information security, within the scope of smart city, is not a well-established concept, another area presents several advances in this security field; for instance, CERT presents a hierarchical graphic where it presents potential vulnerabilities and/or exploits to be studied as challenges in Cloud Computing area [9]. G-Cloud Information [10], on the other hand, presents a series of

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minimum requirement needed by Cloud Computer Service Provides (CCSP).

Finally, in Security Architectures for Cloud Computing [11], international trends in security requirements for Cloud computing, along with security architectures proposed by Fujitsu such as access protocol, authentication and identity (ID) management, and security visualization, is presented and discussed.

Different from the smart city needs, Cloud Computing studies on security focus on specific problems for this area, among those problems we can mention topics like virtualization, PaaS (Platform as a Service) or IaaS (Infrastructure as a Service) or SaaS (Software as a Service) failures, legal responsibility, scalability to ensure availability. Even though smart city systems rely on Cloud Computing as a host and service provider for its services, it is still a scenario where security concerns supersedes far beyond the structure it uses.

As a basic situation, we can explore an application that helps citizen to report crimes; this typical application is deployed within a cloud computer structure to guarantee scalability and availability among others. Still, even a secure cloud solution does not create the guarantee for the citizen, or user, that its identity will be kept private in case of a complaint; nevertheless it also does not answer the question *"Is this accusation, reliable? Should the system trust this complaint? Should it relay on historical denounces to trust this one?*"

This situation summarizes a common concern with privacy within the use of a Smart City system. Many more can be presented, like a patient who does not want his/hers medical history reviled, but still, they must be accessible to the medical entities. Another situation is of a driver that would not want his physical location broadcasted but has to have its location ready available for the traffic authorities in case of a traffic transgression or does NOT need its location just to inform cases of traffic violation. Whatever the situation, the smart city system(s) presents different needs from a Cloud Computing system, for instance, because it needs to deal with a higher, and therefore different, level of concern.

III. BACKGROUND

A century ago, city population would not exceed the size of a million people. Nowadays that scenario is known in more than 450 cities [4]. The connection from the services and structures of those cities has become a big connected information system in order to guarantee that the cities are becoming smarter and, from that, will endure as a Smart City, and not just a connected city.

Within these scenarios, Smart City environments, or solutions, we face three specific topics that are: System Interoperability, Platforms and Applications.

A. System Interoperability

In the last decades, major cities around the globe have emerged to a reality in which every major public and urban system are now represented in the form of a Computer System. Urban systems like the ones responsible for Education, Public Safety, Transportation, Energy and Water, Healthcare and Services are now present and vital to the continuity of those cities. Furthermore, those systems deal with a historical amount of data that would be impossible to manage in any different way.

One of the problems faced by those environments is that their solutions are isolated from each other, therefore it is impossible to gather information from one system and use it on another system so that it creates more valuable information [2]-[6], [12]. To face that, research studies show that is vital for cities, which want to have a smarter and healthier growth, to open their system to make possible for other entities to interact with as many system as possible to provide to the citizens, public and private institutions with more valuable information [3], [4], [6].

B. Platforms or Frameworks

Once it is understood that urban system face problems related to their interconnection, a second approach lays on the proposal or the creation of platforms or frameworks to connect different units, to interact through this platform. Those units are represented in the form of a set of specific profiles that are directly related to citizens, buildings or companies and Things [13]-[17].

In this option, there is a highly adopted concept of The Internet of Things [18]-[21] which create situations where sensors and different entities can and will interact with each other. Furthermore we have the concept of social sensors, which are presented by values provided directly by citizens through social networks like, Twitter or Facebook. Even though social networks are a well established concept representing an important step to reduce distances and connecting people, its importance to urban life lies upon the messages, or posts, created by the user (citizen) itself [18], [22], [23], which leads to a vision that one citizen, or its information, is equally important as any other citizen. This way, Platforms and Frameworks emerge as the infrastructure in which the concept of sensor information, which could be either physical or a social sensor, is used as input to instantiate specific solutions for different urban environment. For instance we have Cosm [19], former Pachube, a platform for Energy connection that uses a physical sensor to monitor energy consumption on Twitter profiles that tracks traffic problems, working as a social sensor.

C. Applications

The important difference between those two topics (Platform x Applications) is that a platform is built with the assumption that the power to decide how it is going to be used depends upon the choices made by the user that instantiate it. For instance, it is possible to see the same platform built to serve as a dynamic panel showing opinions or as a medical solution showing the status of all systems in a hospital [21]. Hence, we are dealing with an approach more abstract, which usually comes combined with an application as a solution.

On the other hand, solutions made for urban systems that are represented by applications appear as more dedicated, practical and less abstract. Some relevant examples are Waze

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[24] and Catch the Bus [25] which are applications that show problems related to traffic, Dwolla [26] that attacks scenarios of economical behavior and Crime Reports [27] for security measures, and even a Big Data based localization system called SkyBox [28] that aims to, through satellite photos, make easier and faster localization in different environments.

IV. SECURITY MODEL FOR SMART CITIES

To represent our security model, from a previous analysis on several platforms, applications and interoperable solutions focusing on smart city situations, we summarized entities that somehow are presented in every one of the analyzed subjects. Those entities are: System Type, Sensors, Actuators, Sensitivity Level and Grouping Value.

The following sections will explain one by one the selected entities and what they represent.

A. System Type

In a given system type we exhibit different types of system that are involved in Smart City areas. They are: Education, Public Safety, Transportation, Energy and Water, Healthcare and Government Services.

Education Systems: Represent every system that is, directly or indirectly, related to educational services.

Public Safety: Represent every system that aims to help public areas and citizens to guarantee city safety such as, but not only, vigilance systems or crime reports systems.

Transportation System: Represents every system that, in different way, drives citizens into a better movement around a city. The movement could be either with or without using automotive transportations.

Energy and Water System: Defines as any system that acts directly focusing on natural resources, more specifically on Energy or Water.

Healthcare System: Every system that seeks to improve the health and well-being of a patient.

Government Services: This term depicts every system that works within government scenarios. It can vary from a justice web system that expose legal issues of each citizen, to a platform that opens governmental data to the city itself. For example, we have the *Open Government Data* and British *Data.gov.uk*, both under this same idea [29], [30].

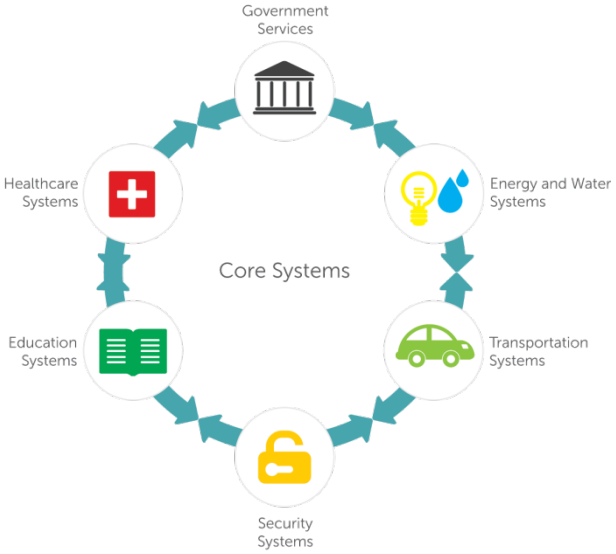

Figure 1. Core Systems Relations.

Figure 1 illustrates an environment that contains all systems mentioned above. Even though the image presents some relations between some systems, it is important to state that this is a common example and not the mandatory communication.

B. Sensors

In Sections A and B, we presented different types of sensors that are part of a Platform or Application. Both areas work with the same concept. In those areas we find entities responsible for gathering information. In our model, those entities express themselves as Physical Sensors and/or Social Sensors.

Sensors that generate an expected format of data and non-personal information represent a Physical Sensor i.e., Thermal Sensors, Presence Sensors, Magnetic Sensors, Radio Frequency Identification (RFID) tags and others.

A Social Sensor represents an entity whose data is created from a person and contains personal information, for example, a post on Twitter or any other social network.

C. Actuators

A sensor, Physical or Social, represents entities responsible for gathering information from the environment. Hence, an actuator represents the ways that the information gathered by the Sensor layer, processed or not, is sent back to the user. Take for example a system that collects information about traffic, combining twitter with physical traffic sensors, and sends back to the driver's Smartphone information about which part of city present more or less traffic. This way, both the application and the Smartphone are Actuators.

The actuators can be one of, Direct or Indirect; This classification will depend on the access to the information. The access can be direct, like on a Smartphone or indirect, like through a smart panel.

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D. Sensitivy Level

In this section, we present a situation on which information is gathered from different types of sensors and could be delivered back by different actuators. In this particular scenario, the collected data is used as grouped information. Grouping value will be the last entity we will approach, mainly because it needs more than just one value to represent a correct data. Once this requirement is fulfilled, it is necessary to take under consideration that this one value is a sensible value, and could not compromise the identity of the citizen that, through the sensor, sent its location and traffic info. Based on that, the information has to respect the Sensitive Level that can be private or public.

Private information cannot be exposed, even further, it cannot be associated with its creator. On the other hand, Public information can be associated, expose and even stored for future use.

E. Grouping value

The last aspect is grouping value and it represents one of three possible states any information represents. Those three states are, Information Grouped, Information Non-Grouped and Reversible Information Grouped.

Information Grouped represent a group of information that does not make sense if analyzed or stored individually, e.g., numbers, values or medians.

Non-Grouped Information represents all kinds of information that have value if analyzed or stored individually, e.g, Dates, Coordinates or social posts.

All information that represents a value when presented in a grouped fashion, but that can be traced back to its individual values, are called Reversible Grouped Information. An example of this concept would be List of values or Map Areas.

V CONCLUSION

The presented entities that compose the model are summarized in Table 1.

TABLE I: ENTITIES SUMMARIZED

Entity	Classification	Description
System type	Education Public Safety Transportation Energy and Water Healthcare Government	References to the systems type that is related to.
Sensors	Physical Social	Refers to the mechanims used to gather information from the citizen.
Actuators	Direct Indirect	Related to the way in which the information is returned to the user.
Sensitivity Level	Private Public	Depicts about the level that the information can be used.
Grouping Level	Grouped Non-Grouped Reversiable	Deals with the value degree that an information has according to its grouping need.

This paper has proposed a first stage of a Security Model that aims to add more Information Security to Smart Cities solutions. The elements presented in Table I are entities suggestion based on studies and analysis made on some of the solutions listed in this work. Furthermore as future works, we intend to develop the second stage of the presented model. It will present, a relation between the entities presented here with which aspect that is more critical in terms of information security. As a final work we suggest to present architectural solutions based on Security Pattern, those will guide city administration towards more secure urban systems.

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