Deployment of an Operational Control Center in a Smart City

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Abstract: - The present article presents a bibliographic review about Operational Control Center, about the concepts of Smart Cities and the relational between them regarding the deployment of an integrated management and monitoring system in a city. On this bibliographic review, possible technical for a Control Center are identified, focusing on their deployment, infrastructure demands and possible applications. Furthermore in this bibliographic review, technologies for Smart Cities are addressed, as well as a collection of processes, systems and technologies compatible with the deployment of a Control Center, within the addressed concept.

Key-Words: - Operational Control Center, management and monitoring system, smart city

1 Introduction

Operational Control Centers are not a novelty in Brazil and worldwide. The application of this resource for cities management and, more specifically, in public resources management is, in fact, the great innovation on this subject.

The performance of big events in Brazil, such as the Soccer World Cup in 2014 and the Olympic Games in 2016 arouse public authorities for the need of integrating efforts, as in offering a security compatible to these events at the same time that the technological infrastructure, mainly communication, measures up to it. Up until that, the centers were used exclusively for a specific operation, such as railway lines management in a transportation system.

Much has been discussed about the quality of public services offered by State agencies, on their many levels (municipal, state and federal) and powers (legislative, executive and judicial). In most cases, the citizens feel left out by public authorities and, many times, even damaged by it, in the sense that they do not see return of services in exchange for the quantity of taxes that are collected.

On other hand, public authorities have many difficulties in integrating and offering an effective service, since there is a complex legislation for acquiring and maintaining technologies, and their activities are developed under very strict hierarchical models, that hamper the integration and coordination of different forces.

In this sense, Operational Control Centers with their advanced identification, operation and management technologies can bring more easiness to this system, as long as it is well deployed and well operated.

2 Operational Control Centers

According to Hay (1961), operational control is the exercise of finding an effective use of available equipment.

Therefore, an Operational Control Centers is about a site where information from different operational control points, are consolidated, allowing for a more comprehensive assessment of a situation and, therefore, a strategic decision-making that aims to solve an ongoing issue, effectively using the available resources.

It must allow an organization to operate as it has been projected, to execute everyday operations, regardless of what is happening around it, in such a way that no one notices it is there, but everybody knows who is the responsible when there are issues at hand.

Thereby, emerges an emphasis on the use of technological tools that allow identification, control and response, in short time, of situations that require intervention, besides the essential need to developed standard operating processes and procedures (SOP) for using information and performing action commands.

Processes, according to Davenport (1997), are the ordination of activity within defined time and space, with start and end, as well as well-defined inputs and outputs. Fernandes (2001) states that it is the operational process of a systemic model to do things, where managers take part of inter-related activities, independently of their abilities and skills, in order to achieve the organization's goals.

For Araujo (2001, page 65), "the objective of studying the process in to assure the flow of this movement and keep decision boundaries within principles that do not allow inefficiency and ineffectiveness for the entire process".

In an Operational Control Center, processes must the strictly managed at the risk of becoming obsolete and do not meet the required demand. According to De Sordi (2003), process management goes through eight stages in the form of a management cycle, as illustrated by Figure 1:

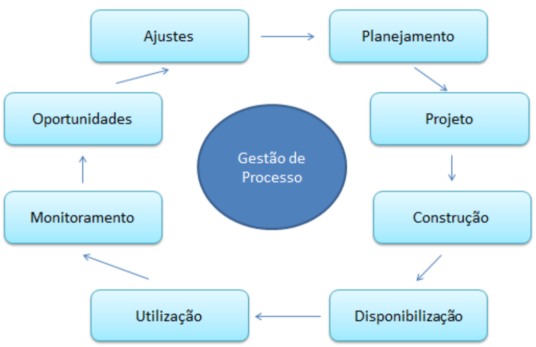

Figure 1: Process Management Cycle (De Sordi, 2003)

In order to systemize the knowledge of the processes by all actors involved in it, it is important to create manuals to "allow the gathering of information arranged in a systemized, careful and segmented way to act as a facilitating instrument of the organization's functioning" (ARAÚJO, 2001, page 107).

The main objective of an Operational Control Center is to allow quick and effective decision-making by the system's operators. For such, it is necessary to strengthen the decision-making power of individuals. According to Araújo (2001), this process can be named "empowerment". Castro (1994, apud Araújo, 2000) states that the term synthetizes the transformation process, minimizing hierarchy and distance between the organization segments, adding value to those are at the organization's front.

According to Chinelato Fº (2004), on the new organizational paradigms, bureaucracy will be replaced by adhocracy. Adhocracy is word derived from "ad hoc", which means "for this case". In comparison, bureaucracy is an attempt to anticipated all possible alternatives of an action and define possible action alternatives. The Standard Operating Procedures (SOP) work on this model and are defined by the aforementioned organizational manuals. However, undefined situations required that the operator, empowered by decision-making, defines new action paths. In this model, adhocracy designates the authority of a person who has in mind the operation standards as guidelines and not law (CHINELATO, 2004, page 246).

Technologies that support procedures inside an Operation Control Center are diverse. However, the functioning core of an OCC is called Information System for Control and Dispatch.

An Information System has the objective to present information flows and to establish links to the decision-making process (ARAÚJO, 2001). Some features of these systems are essential for its proper functioning, given specific sensibility issues regarding the information contained and transacted within an OCC. Perhaps the most important feature is Data Integrity and Security.

The use of technologies inside an Operation Control Center is integrated in three levels: Operational, Tactical and Strategical.

According to Laudon & Laudon (2010), organizations are composed by three hierarchical levels: Senior Management, Middle Management and Operational Management. All can be managed by information systems. Figure 2 illustrates the organization of management hierarchies.

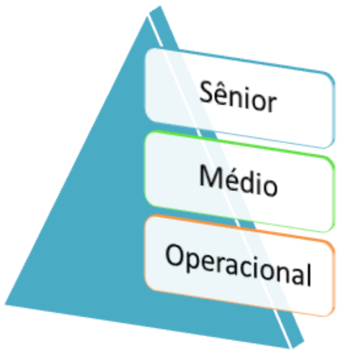

Figure 2: Management levels of an organization (Laudon & Laudon, 2010, page 40)

Getting back to the application of these concepts in Operational Control Centers, at the Operational level, it is possible to classify an entire technological base for the purposes of video monitoring and analysis, sensing and alarms.

2.1 Technologies and Organizational Levels

2.1.1 Video Monitoring and Analysis

The most part of investments in Control Centers are concentrated on this subject. Smart Video Analysis Technologies, based on sturdy monitoring systems, compose the technology highlights of Control Centers.

Smart Video Analysis technologies allow to proactively identify based on artificial intelligence situations outside the operation standard, enabling the controllers to act swiftly in many situations.

As an example, we can use the monitoring image shown on Figure 3. The scene presented in a turn on a specific street of a city. It is a one-way street. If a vehicle traffics on the opposite way, the system can identify it. Or in case there is an object left on the grass, or a person crossing the street on a not-allowed place, or jumping over the wall, or walking the street at an unexpected time. However the movement, be it unexpected, uncommon or not-allowed, the system is able to identify, alert or even trigger alarms for field vehicles, remote operators or partner organizations. Figure 3 illustrates a video monitoring scene available online at the site of Santos city, state of São Paulo, Brazil (SANTOS, 2016).

Figure 3: Video Monitoring Image (SANTOS, 2016)

2.1.2 Sensing and Alarms

Sensing is also a commonly used technology in Operational Control Centers. Weather, motion, presence and many others kind of sensors can be used so that emergency situations can be rapidly identified and allow a reaction from operating procedures defined inside the Control Center.

Sensors are widely used, from domestic use to more sophisticated use. In an interview published on the G1 website (G1, 2016) it is possible to assess the use of sensors for identifying natural disasters. According to the interviewee, David Gasgón, “Basically, almost any kind of natural disaster can be prevented or, at least, have its damages minimized. In Mariana, at least two interesting parameters could have been measured to alert the possibility of landslide”, he stated, referring to the accident occurred in the city of Mariana, in the state of Minas Gerais, Brazil, in November 2005. According to the news article, “beside barrier breakings and landslides, sensors can also be used to prevent and mitigate damages caused by other natural threats, such as flooding, avalanche, earthquake, volcanos and forest fires.”

These information, centralized and combined with other field information, can also enable an early reaction or, even if late, in time to minimize the occurrence’s impacts.

These technologies applied at the operational level have its efficacy amplified when, on the middle level (also known as tactical level); the data gathered on it are consolidated, allowing a better planning and control.

Other possible use of the information is the planning for attending the citizen’s demands. A service order of asphalt resurfacing, tree pruning, street lighting repair, among others, can be assessed in their current conditions and planned on its entire execution. Definition of team, material, vehicle, possible traffic intervention requirements can be made early and a start date, as well as an end date prevision, can be offered to the citizens, aiming for operational efficiency and result efficacy results.

Such planning can be executed with the support of simulation and scheduling technologies integrated to the operational data, which allows data gathering, attendance programming and action monitoring.

To finalize, the structure of the support technologies; there are solutions focused on the strategic level. Analytical dashboards enable support in situations that require non-structured or semi-structured decision-making.

According to Baltzan & Phillips (2012), a decision-making support system models information in order to assist managers to make decisions. According to the authors, the systems usually have three analysis models for making information available to the users:

- Sensitivity Analysis: study of the impact that changes in part of the model have on other parts. The system allows users to change a variable and understand the impact of such change on other variables.
- What If Analysis: checks the impact of a change in an assumption of the proposed solution. Users can repeat the analysis to understand the effect of various situations.

- Goal Analysis: finds the data inputs required to achieve a goal with a desired output level. It sets a target value for a variable and, from the inputs recorded in the collection systems (operational level), calculates the missing requirements to achieve the defined target (goal).

2.2 Control Centers and Cities Management

The use of Operational Control Centers on the management of cities, in Brazil, has been more widely reported. The perhaps most famous example is from the Rio de Janeiro City Hall, already mentioned in this chapter.

According to information in the website launched in 2010, there are currently more than 30 bodies that monitor the city's daily routine. On the website, it is possible to verify services regarding traffic and weather. According to information available on the website, "beside real-time information from concessionaires and public agencies, the Operational Center capture images from 560 cameras installed all over the city. All data is interconnected to visualization, monitoring and analysis at the Control Room, on an 80 square meters screen" (RIO DE JANEIRO, 2016).

Another widely reported example in Brazil is the deployment of the Integrated Command and Control Centers (ICCC) for FIFA's Soccer World Cup, performed in 2014 in Brazil, in 12 game host cities in the country. These Centers had, as their main feature, to assure the security of the stadiums and its surrounding areas.

In terms of physical infrastructure, Control Centers are mostly the same and basically have the same installation features: Control Room, Emergency Room, ICT (Information and Communication Technology) Management, Press Room, Living Area (which is important, considering it is an activity that takes place 24 hours per day, seven days per week) and utility area.

A Control Center has many resources, technological and human, integrated for attending a specific demand. On the present cases, the objectives were very different, which results in the use of also different technologies. On the first case, focused on weather accident management, sensing and alarms systems are the highlight. On the second case, focused on public security, monitoring images and integrated communication systems that allow centralized command and control of multidisciplinary actions receives the great attention.

3 Smart cities

In the literature, there are several definitions of the concept of Smart Cities. It is possible to mention the concept where smart cities monitor and integrate the operational conditions of all critical city infrastructures, acting preventively for the continuity of its core activities (Hall, 2000).

Whatever the used definition, we can assume that Smart Cities use ICT resources to act proactively to attend the citizen's requirements. They use the data collected by technological devices in an integrated, smart manner for the continuous improvement of city's services and infrastructure and, thus, improve life quality.

For Diniz, Silva & Gama (2015), the term describes cities that, on the one hand, are more and more composed and monitored by pervasive and ubiquitous computing and, on the other hand, has its economy and government boosted up by innovation, creativity and entrepreneurship.

Pervasive computing is understood as "imperceptible computing, that it, the use of computing resources embedded in a non-visible form to the user, but still present" (OLIVEIRA, 2012). Ubiquitous computing, in its turn, is "the union of two or more important concepts: mobile computing and pervasive computing" (WEISER, 1991).

The action scope of smart cities, according to wordings by Gama, Álvaro & Peixoto (2012) are diverse. According to the author, the European model of smart cities include, on their scopes, the economic, mobility, government, environment, life quality and human capital areas. In Brazil, the scope of these cities includes transportation, education, communication, health, water and security.

According to Vilaca, et al. (2014), the object of deployment solutions focused on the smart cities concept has, as the main advantage, to enable the possibility of providing quick answers to different kinds of requirements from citizens, be it from their daily routine, environmental, regarding security or even for economic activities.

The concern of public managers in order to deploy smart cities solutions has grown, mainly because of the growth of the importance of the urban society in the world and the consequent concern on maintaining a high standard life quality in the cities. According to Falcão, Baptista & Menezes (2012), the estimative is that 50% of the current world population lives in urban areas. These estimative points out that until 2050, this number may reach 70%.

For other authors, the impact of this growth is clear: increasingly dense cities, with traffic jams, poor access to basic resources, increased marginalization and high crime rates. Further in relation to impact, the author points out the enlarging of deforestation and pollution rates, indiscriminate use of natural resources and consequent change in regular weather conditions.

For the full deployment of these solutions, it is necessary a better management and monitoring of resources, as well as more adequate estimative for the local reality, such as deployment and operation costs, and identification of the most adequate technological solutions for the demands (VILACA et al., 2014).

Considering that city managements continuously seek to reduce costs and are obliged to offer basic resources to the population (access to potable water, electricity, transportation, health, education and security), planning, design, search for financing, construction, governing, service operation and urban infrastructure deployment are big challenges that must be considered when choosing the solutions (FALCÃO, BAPTISTA e MENEZES, 2012).

These projects can contemplate many different or integrated focuses, which include (VILACA et al., 2014):

- integration of information networks and systems;
- sensing of buildings to improve electricity performance;
- improvement of urban lighting systems;
- urban mobility;
- support to public security;
- water resources management;
- among others.

Different technologies can and must be combined in order to attend the purposes of a smart city. Use of concepts that involve Internet of Things, diverse Sensors, Geographic Information Systems, Cloud Computing, Mobile Computing, Business Intelligence (Data Mining, Big Data, Decision Support, etc.) (LEMOS, 2013).

According to Gama, Álvaro & Peixoto (2012), it is necessary to the create systems capable of dealing with the entire mass of data created by the technological devices. The author mentions the possibility of creating a maturity model in order to assess the current level and the level aimed by the city, in order to create a gradual project towards the construction of a smart city. For the authors, maturity levels can be classified as:

“0. Chaotic: Phase where most of the cities begin in. On this phase, the cities do not have ICTs to assist the process of city management. They can even have some data on the little information obtained from basic services provided to the population, however it is not used.

1. Initial. Planning and modeling phase of information systems that will assist in a certain domain, as well as the identification of existing systems that may potentially be integrated to the smart city solution.

2. Management. Collected data (i.e. traffic data, electricity consumption data, water quality, etc.) and accessible through information systems. For example, GIS can be used on this level in order to visualize data per region; data can be used to generation information of high added value; sensors can be used on river and dam beds in order to notice the population, via text message, when a flood may happen, among other possibilities.

3. Integration. Smart city with systems using the cloud computing model, integrated and available as service, both for citizens and as third-party applications. Citizens have an active role as users of cloud services, as data feeders, through their mobile devices that can communicate with the cloud.

4. Optimization. An efficient city, seeking to innovate and be pioneer on ICT solutions. Support to decision-making using data obtained from diverse domains of the city; use of information for event forecast systems, be it weather-related or not; support to decision-making both for the population and to governments, in other others, information to enable both citizen and governors to make decisions. (GAMA, ÁLVARO E PEIXOTO, 2012)”

3.1 Applied Technologies

Considering the high volume of data that these solutions tend to create, suggest that the best solution for this kind of project is a combination of diverse technologies, as already mentioned. Besides that, public policies of Open Data – opening of public data by governmental institutions – generate high data traffic, conciliated by cloud computing, internet of things and others, generating great necessity of good space dimensioning, processing capacity and transmission bandwidth.

It is important the support of technologies so the public power can recognize their problems in real-time, as well as the citizen can produce information.

This combination can generation a good mapping, informed discussions, and integrated and jointed addressing of difficulties (LEMOS, 2013).

During the 90s, cities aimed the deployment of technologies for Digital Cities. Efforts focused on deploying policies for computer access and making internet available in public spaces (LEMOS, 2013).

On the current scenery, these efforts migrated to Smart Cities and technologies expanded in a way to make everything sensible to environment and to produce, consume and allocate a high number of information in real-time.

Besides that, the author further highlights the importance of using social networks as a boosting factor for communication and social articulation. There are a number of examples of the utilization of this media by city administration for collecting data and disclosing information relevant to citizens.

Regarding the integration of all these sources, a middleware architecture is capable of facilitating the communication between many technological devices is necessary. Gama et al. (2012, apud BORJA & GAMA, 2014) proposed an middleware architecture based on service-centered computing with modular architecture and low coupling, allowing the integration of several heterogeneous devices and technologies without the need to stop or reconfigure the systems. Its architecture allows news modules and devices to develop and be added in an independent manner.

3.2 Possibilities

It is possible to mention some examples of projects developed around the world related to the Intelligent Cities' focus.

There are several possibilities of applying Information and Communication Technologies (ITC) in the Intelligent Cities project. As already mentioned, the most famous project on Brazil is on the City of Rio de Janeiro.

According to the Document “Rio Resiliente” (Rio de Janeiro [2], 2016), COR (Centro de Operações Rio – Rio Operating Center) was projected with the meteorological control as main focus. In this document, the Mayor Eduardo Paes states that the City of Rio de Janeiro faced a tragedy: “Heavy summer rains caused landslides and inundations that destroyed Rio. So many lives were lost and so many houses were destroyed: this cannot happen again.” (Eduardo Paes, Mayor of the City of Rio de Janeiro). From his point of view, this fact developed the need of transforming Rio de Janeiro in a resilient city. To achieve that, the management culture of the city should be changed. According to the document:

“That was how Centro de Operações Rio (Rio Operational Center – COR) was created: a situation and coordination room to monitor the daily life and face the problems in an articulated manner. This kind of event does not have a scheduled time to happen. COR is the “brain” of the city that works 24/7 and gathers the coordination of more than thirty departments, high technology and the capacity of processing information. It even has new meteorological radar implemented on 2010 that allows a more accurate predictability when detecting adverse climatic events.”

Although COR was initially focused on meteorological matters, nowadays it also comprehends the traffic and security areas.

One of the most commented projects for Intelligent Cities on Europe was held on Malaga, Spain. According to the website “Consciência Ampla” (2011), “the goal of the pilot project of 31million Euro is reducing the energy consumption in the city in 20% and avoiding the emission of more than 6 thousand tons of CO_2 per year in the atmosphere. That created a new sustainability standard in the energy industry”.

The mayor of Presidente Prudente, in an official visit to the city held on October, 2014, verified that Malaga has a call Center which receives all calls and requests of services made by the citizen, whether by phone or by internet (PRESIDENTE PRUDENTE, 2014). This Center works with the concept of managing and monitoring all incidents, from the beginning to the end, besides monitoring the main roads of the city with an average of 120 cameras distributed in several points.

“If anybody calls to complain about a broken traffic light or about a hole in the sidewalk, for example, the request generates a protocol which is accompanied until the central executes the procedures and makes the photographic record. The street lighting is also outsourced. Thus, the company must record not only the repairs, but also the images from before. After repairing, the city hall pays according to these releases”.

Thus, the initial focus, which was centered in the Smart Grid concept, has been amplified to the deployment of controls in the monitoring and caring fields. The mayor of Presidente Prudente, in an official visit to the city held on October, 2014, verified that Malaga has a call Center which receives all calls and requests of services made by the citizen, whether by phone or by internet (PRESIDENTE PRUDENTE, 2014). This Center works with the concept of managing and monitoring all incidents, from the beginning to the end, besides monitoring the main roads of the city with an average of 120 cameras distributed in several points.

According to the website "La Informacion" (2014), the city reduced its CO2 emission levels in 4,500 tons, an approximate energy efficiency of 20%.

The Intelligent City Project on Amsterdam, which was held in the same time, had a different focus. According to the website "Cidades Sustentáveis" (2016), the project aimed at creating a more sustainable and energetically efficient city. In order to do that, the project was divided in four categories: housing, mobility, work and public spaces.

1) Housing: provide renewable energy to 8,000 houses, mainly based at wind energy generating.

2) Mobility: preference to the bike and low-carbon public transportation, aside from a project of allocating filling stations for electric cars throughout the city, in order to boost the use of electric energy rather than the fossil fuel in the city vehicles.

3) Work: Communitarian activities are common in some densely populated areas in Netherlands. The projects aim at encouraging a collaborative consumption routine to reduce the environmental impacts originated from the daily activities of the citizens.

4) Public Spaces: kindergarten children learn about saving energy in a competition on energetic efficiency between schools. Another project uses a street of the city as an incubator and test space for innovations and climatic experiments, in order to share directly the developments with the whole city.

According to the MIT (Massachusetts Institute of Technology, 2014), the project has evolved to place more responsibility in the citizens.

"(...) the main idea is to allow Amsterdam people to gather data to measure the air quality, the traffic or the trash quantity in the street. The laboratory aims at helping to develop "not only intelligent cities, but also intelligent citizens" explained Sabine Niederer, director from CREATE-IT, a department of research of Applied Sciences, from Amsterdam University, which will house the new lab.

Those data will allow measuring the city traffic, the barriers for wheelchairs, garbage cans, and even smoking areas. These are a few examples of the data that will be available to assessment and planning for the municipal management. Amsterdam aims at more than only implementing infrastructure or collecting data. "It is also to create products and services that the citizen will deem as useful".

The most expressive example of intelligent city in the USA is on New York. The city was considered as the most violent city in the 80's and 90's, but now managed to reduce the murder rate in 82% and the car theft rate in 94%. (IG, 2012). One of the reasons that led to this is the intensive use of technology. The technological tools enabled an expansion in the investigating and crime combating programs without changing the number of agents in the street. Handheld computers for field officers, security cameras in different points of the city, well-structured databases with available information and data traffic speed were some of the details which allowed the changes.

Although the main focus was on public security, in 2014 it was changed: the city announced its objective of making available free, high speed internet in the entire city until 2015(Hypeness, 2014). The idea was to replace the public phones for digital intelligent totems which would offer free, high speed internet and a tablet, from which it would be possible to make calls and check maps.

"This proposal for the broadest, fastest, accessible free internet of the world, for citizens and tourists, represents a great step for a more equal, open and connected city." Affirms Bill de Blasio, mayor of the city."

4 Operational Control Centers and Smart Cities

As mentioned, there are many possibilities to use the information technology and communication in the implementation of smart cities projects. However, all of the possibilities are intended to the need to assemble, organize and coordinate all captured data in one equipment, and then distribute, helpfully, the information generated.

The Operational Control Center is, as indicated on chapter Three, the place where the information, resulting of distinct operational control points, consolidates allowing an extensive evaluation of one situation and then, a strategic decision-making, aiming to solve one question in progress with efficient use of involved resources.

Multiple definitions of Smart Cities with the possibility to use the infiltration computing concept are contemplated in spread sensors through the city, or even available to the citizen, the Control Centers become a proper local to consolidate all this information and organize them in a way that enables an improvement in decision-making and the efficiency of citizen attendance needs.

One Operational Control Center may have distinct emphasis, isolated or integrated. The most common domains, as exemplified on chapter three, match with smart cities domains, as listed on chapter four. It is possible to talk about urban mobility (transport and traffic management is included); public security support (sensors and videos monitoring), and public service planning (with register and organization of municipal janitor occurrences or public services performed by concessionaires).

The model of mature proposed by Gama, Álvaro and Peixoto (2012), exposed on chapter Four, in relation with the Operational Control Center moment of deployment to a municipal management based in the smart city concept must be regarded. Some minimum technological infrastructure must be previously conceived in the city in order that the Control Center obtains success in its planning and attendance processes.

A successful deployment of an Operational Control Center is supported if it is between the Initial (1) and Managed (2) levels. So, its deployment initially raise the city to the Integrated (3) level and with its mature operation by means of well structured processes, the city reach the Optimum (4) level, purpose of every city in case it wants to receive the "Smart City" denomination.

After all this explanation, it is clear the need of planning the deployment of Operational Control Center. If the city wants a good deployment it must define the focus, minimums technologies and infrastructures, and processes that will be managed by the Control Center.

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