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Cidades Inteligentes no Brasil: As Experiências em Curso de Búzios, Porto Alegre e Rio de Janeiro

Ciudades Inteligentes en Brasil: Las Experiencias en curso de Búzios, Porto Alegre y Rio de Janeiro

Smart Cities in Brazil: Experiences Under Way in Búzios, Porto Alegre and Rio de Janeiro

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Resumo

No Brasil, o fenômeno das smart cities ainda engatinha. Diferente de países mais agressivos dos BRICS, como a China ou a Índia. Neste artigo apresentamos a experiências de três cidades: Búzios, Porto Alegre e Rio de Janeiro. Além de descrever e analisar as três experiências brasileiras, o artigo propõe um modelo global para os projetos de "cidades inteligentes", baseado na "Concepção", "Organização" e "Ação" e utilizar o aporte da Teoria Ator-Rede (TAR) (LATOUR, 2005) como um corpus teórico pertinente para analisar esse fenômeno.

Palavras-Chaves: Cidades inteligentes; teoria ator-rede; comunicação

Resumen

En Brasil, el fenómeno de las smart cities aún empieza a andar, diferentemiente de países más agresivos de los BRICS como China o Índia. En este artículo presentamos las experiencias de tres ciudades: Búzios, Porto Alegre y Rio de Janeiro. Más allá de la descripción y análisis de las tres experiencias brasileras, el artículo propone un modelo global para los proyectos de "ciudades inteligentes" basado en "Concepción", "Organización" y "Acción" e utiliza el aporte de la Teoría Actor-Rede (TAR) (LATOUR, 2005) como corpus teórico pertinente para analisar el fenómeno.

Palabras-chaves: Ciudades inteligentes; teoría actor-rede; comunicación

Abstract

In contrast to the more aggressive BRICS countries, like China or India, the smart city phenomenon is still in its infancy in Brazil. In this article we present the experiences of three urban areas: Búzios, Porto Alegre and Rio de Janeiro. As well as describing and analysing these three Brazilian experiences, the article proposes a global model for smart city projects, based on "Conception," "Organisation" and "Action," and advocates the use of Actor-Network Theory (ANT) (LATOUR, 2005) as a useful theoretical framework for analysing this phenomenon.

Keywords: Smart cities; actor-network theory; communication

Introdução

Under the label "Smart Cities" (BURTE, 2014; GRAHAM, 2014; GREENFIELD, 2013; HAMBLETON, 2014; KITCHIN, 2014; NULL, DARDEM et al., 2014; RATTI, 2014; ROBINSON, 2013; THRIFT, 2014; TOWNSEND, 2013; ZEFERINO FERREIRA, 2012), proposals have emerged for reconfiguring social, political and management practices through the application of Information and Communication Technologies (ICTs), the production and processing of Big Data, the use of cloud computing services and the Internet of Things (IoT).

Projects are currently under way. France, Italy, Spain, China, the Arab Emirates, India, the United States and the United Kingdom are just some of the countries that have taken a lead in these projects. Urban centres have become closely associated with a new meaning of "intelligence." This meaning is primarily based on the creation of computerized processes, sensitive to context, capable of producing and distributing data and information in real time on all kinds of aspects of urban life.

In Brazil, this phenomenon is developing in its own singular form, responding to different local contexts that influence how each project is conceived and implemented. In this article we highlight three urban areas that present distinct models: Búzios (a *Living Lab*[1] for intelligent solutions to electrical power management), Porto Alegre (with a participatory model of urban management) and Rio de Janeiro (home to today's most advanced computerized urban 'command and control' centre - COR-RJ). In each of the cases selected, we identify the actors who influenced the format of the projects, exploring the complex sociotechnical networks that emerge through the action of human and non-human agents (devices, systems, interfaces and applications, as well as sets of rules, laws, climatic phenomena and so on).

The aim is to recognize the active role played by sociotechnical networks in organising the experiences. The main objectives are to: 1. Propose a global model for smart city projects, based on three main areas: "Conception," "Organisation" and "Action;" 2. Describe and analyse experiences now under way in Brazil (home to large cities and enormous urban problems, the country is one of the emergent nations that most deploys digital communication and information technologies); and 3. Propose Actor-Network Theory (ANT) (LATOUR, 2005) as a useful theoretical framework for analysing these types of projects.

2. Smart Cities

2.1 Context

Today *urban centres*[2] are experiencing a revolution in ICTs. We can observe the popularization of mobile communication devices, like mobile phones, smart phones and tablets, and the proliferation of 'informational territories' (LEMOS, 2007), connective spaces that interface with urban space, like Wi-Fi zones, telephone, 3G and 4G data networks, Bluetooth and NFC. This synergy produces the 'smart cities' phenomenon of the present.

[1] It is interesting to note that the Chicago School thinkers identified the city as a 'living laboratory' in the 1920s. Many of the apparently new themes being discussed in relation to smart cities are, in fact, of much longer date.

[2] Since 2008 residents of metropolises have become a majority on our planet. While in 1900 there were just 16 cities in the world with more than a million inhabitants, in 2010 this number had risen to 442. Today 21 megalopolises have more than 10 million inhabitants, almost all of them in developing regions. Immense urban conglomerates are forming in China, India and West Africa with more than 50 million people in each. National Geographic Brasil magazine, December 2011. Page 52.

Nonetheless, dreams of a smart city fostered by scientific, technological and industrial development have a long history, dating as far back as Plato's Republic, passing through utopian thinkers of the seventeenth, eighteenth and nineteenth century such as T. Morus, T. Campanela, C. Fourier and C. de Saint Simon, to the industrial city of the nineteenth and twentieth centuries. Though we have no intention of reconstructing this history here, such a utopia can be said to be present in today's discourses and projects concerning smart cities.

With the expansion of the Internet during the final decades of the twentieth century, the use of ICTs in urban space was debated under the rubric of "digital cities." (ISHIDA and ISBISTER, 2000; GRAHAM, 2004; TSAGAROUSIANOU, TAMBINI et al., 1998). The objective was to equip this space with an efficient digital infrastructure in order to stimulate innovative solutions to the structures of government, companies and trade. The intention was to reawaken the public sphere, expanding community ties and political participation. These initiatives continue to be implemented and improved, but the growth of the Internet has significantly changed this scenario[3].

2.2 Definition and Model

We have witnessed a rapid and aggressive development of mobile connection systems, cloud computing, Big Data and Internet of Things. Hence while in the 1990s we spoke of digital cities, today the emerging term is smart cities. The adjective refers to computerized processes that are sensitive to context, dealing with a large volume of data, cloud networks and autonomous communication between all kinds of objects.

We can define "smart city" as a city in which infrastructure and services are sensitive to the environment (cloud computing and Internet of Things), producing, consuming and distributing a huge volume of digital information in real time (Big Data), enabling human actors and objects to take decisions, produce actions that affect others and modify their own behaviours (constituting an informational sensitive – or 'smart' – environment for urban management and citizen participation). The main objective is to create an urban space as a digital organism that connects sustainability, economic growth and communication processes. As a whole the smart city projects aim to improve the efficiency of urban management, infrastructure, life and the conscious action of citizens through ICTs and by promoting environmental sustainability, the creative economy and citizen empowerment. Hence we can define the concept via the following formula: Smart City (SC) = Urban Space (US) + Internet of Things (IoT) + Cloud Computing (CC) + Big Data (BD)[4]. In the graph below we set out a model for understanding smart city projects based on three main areas: Conception, Organisation and Action[5]. (Figure 1)

[3] There has been a considerable expansion in access to computers and the internet among the diverse sectors of Brazilian and world society: between 2000 and 2013, the number of web users rose from 361 million to more than 2.4 billion (or 34% of the global population).

[4] The statement seems to disregard the actions of people and social relationships. However, in our approach, people and social relations could not be dissociated from each item of the equation.

[5] In this model, the main areas are presented as an "ideal type". It can be combined to produce a plurality of arrangements.

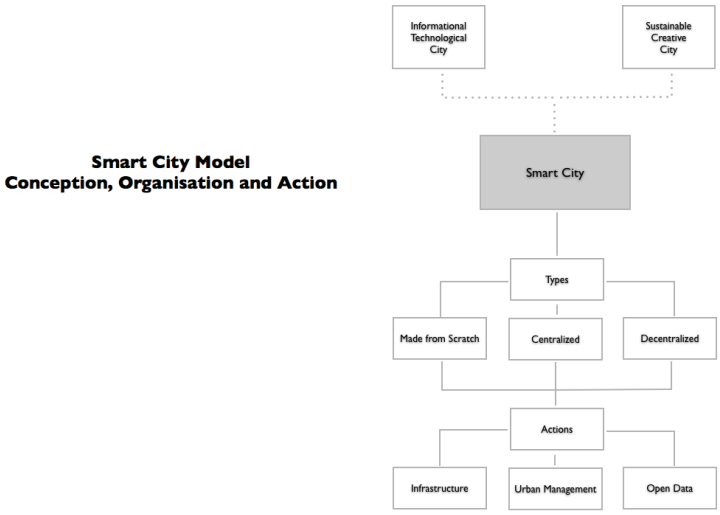


Figure 1: Smart City Model

2.2.1. Conception

Two basic forms exist for conceptualizing smart cities: the "informational/ technological city" and the "sustainable/creative city." In the first conception, the emphasis is on how digital technologies, sensors and intelligent networks are implemented within the urban fabric as the main actors for changing. The vision here is more technocratic and bureaucratic. In the second conception, the focus shifts to stimulating the creative economy, environmental sustainability and forms of conviviality. This conception does not dispense with the use of new technologies, but its main emphasis is other (the sustainable/creative city).

The smart city projects can be seen as an amalgam of these two visions. Some projects place the emphasis on one dimension more than the other, but the two are always present. The task is ambitious and many projects are imbued with strong utopian, technocratic and bureaucratic overtones. In this conception, a sustainable city is interconnected with a technological environment based on smart objects and sensors (Internet of Things) and the generation and subsequent processing of huge amounts of data (Big Data).

2.2.2. Organisation

Smart city projects, as shown by the experiences under way and by the available bibliography, tend to be organized in three forms: projects built from the ground up, i.e. "made from scratch"; those instituted by an official body created by the municipality and designed to integrate actions ("centralized" organisation); and projects implemented in open form by private actors and public administration ("decentralized"). The graph below shows some of the main experiences in the world today, divided according to these three forms of organisation. (Figure 2)

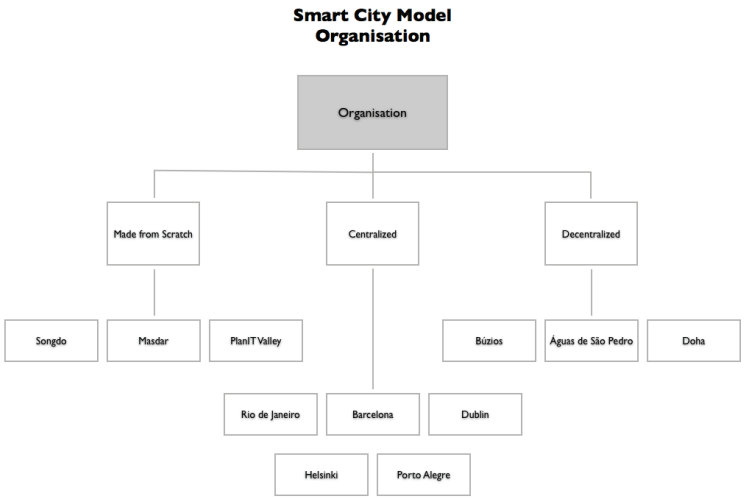


Figure 2: Smart City Model - Organisation

2.2.3. Actions

We can group the actions involved into three major areas: infrastructure, urban management and open data. However much the projects differ from one another, they all present one or other type of action in one of these areas. The first area of action, "Infrastructure," indicates the attempt to achieve what we call an "optimization of urban experience" in its diverse ramifications (street lighting, healthcare, education, public transport, the environment, etc.). The focus is on the use of ICTs to optimize and improve the efficiency of public administration. Low-cost sensors are integrated into urban environments, enabling the optimization of public resources. As examples we can cite smart grids, monitoring public transport, intelligent parking, urban sanitation, monitoring of environmental and noise pollution, identification of infrastructural problems like potholes, equipment failures and various kinds of adverse incidents.

The second area, "Urban Management," focuses on what we call "reaction," aiming to make the city more flexible to diverse events, with an emphasis on the quick response of procedures and on real-time visualization of events and activities in public space. This involves the use of smart technologies for the management of urban space, monitoring and surveillance in real time. Projects with smart cameras, social network monitoring, and command and control centres are all initiatives in this area.

The third form of action, "Open Data," takes as its principal generating data and making it publicly available in order to increase citizen "participation." Making public data accessible will allow citizens to participate actively and become involved as developers and partners in the solutions to everyday problems. The aim here is to create "smart citizens." Examples include competitions for mobile software development, hackathons, production of kits with free hardware ('smart citizens kits'), collective identification and mapping of problems, and so on. (Figure 3)

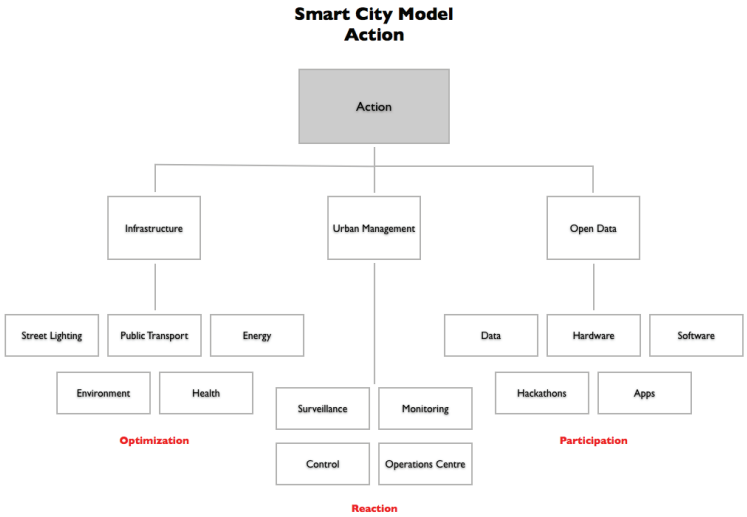


Figure 3: Smart City Model - Action

3. Theoretical Framework: Actor-Network Theory

Actor-Network Theory (ANT) provides the theoretical-methodological baseline for the development of the case analyses in this article. Using this as a starting point, we intend to map the main actors influencing the format taken by the smart cities projects in Brazil. ANT allows us to conceptualize sociotechnical networks in which human and non-human agents (actants) produce mediations and translations that configure the experience under study[6].

ANT foregrounds the importance of observing all the human and non-human actors involved in any association. An intermediary is an agent that transports meanings or forces without transforming them. A mediator, on the other hand, transforms, translates, distorts and modifies the meanings or elements supposedly merely transmitted (LATOUR, 2005). However the role of the actors is not something that can be determined a priori like a predefined script. Their status as intermediaries or mediators is acquired through their agency in the associations.

For this theory, agency is defined as the capacity to provoke some kind of effect on a network. Consequently, an actor-network analysis must attempt to observe the course of actions and identify who produces any transformations, adopting a symmetrical approach that considers the agency of human and non-human actors equally. Each case is singular and the sociotechnical networks formed will always be different. This indeed is what we show in the cases of Búzios, Rio de Janeiro and Porto Alegre. Our proposal is not to downplay the differences between mediators but rather to consider that their forms of agency may be analytically similar. The extension and durability of their connections are responsible for determining the real potency and relevance of each actor (FIORAVANTI & VELHO, 2010). Here, we limit ourselves to describing the networks by compiling a map of the actants involved in each of the experiences.

4. Brazilian Cases

[6] This is a work in progress. We lack the space here for an in-depth description of the theory and we shall therefore confine ourselves here to describing and identifying some programs of action in each case chosen in Brazil (LATOUR, 1994, 2005, 2012; LEMOS, 2013).

In order to analyse the phenomenon in Brazil, we selected the cases of Porto Alegre, Búzios and Rio de Janeiro. The criteria we used were the advanced stage of the projects (all are currently active) and the different forms of conception, organization and action revealed in each case. Porto Alegre possesses a centralized model with actions focused on the areas of urban infrastructure and management, though its implementation is more participatory and based on Open Data. Búzios has a decentralized model of organization and its initiatives are primarily aimed toward infrastructure, hosting a "Living Lab" project developing smart solutions to electricity management. The Rio de Janeiro project has been implemented using a centralized model with actions in all three areas, though it has become known worldwide due to its Rio Centre of Operations (Centro de Operações Rio: COR), one of the most important computerized urban control centres currently in operation.

4.1. Porto Alegre Smart City

In Porto Alegre[7] the smart city project has been developed using diverse strategies and actions, highlighting the integrating role played by the city council. Whether in defining government plans and strategic plans for the city, passing laws, setting up innovation offices, or creating development programs based on technology or communication, the city council acts as a fundamental mediator in the interactions between municipal bodies, private firms and the population.

In 2009 the "Innovation and Technology Office" (Inovapoa)[8] was created. The office's vision is to turn the city into an international reference point in technological excellence and innovation with the mission of using the potentials of entrepreneurship and technology-based innovation in order to develop the municipality over the long-term, generating income and offering new work opportunities for students, professionals and entrepreneurs. Through Inovapoa, the "Municipal Innovation Law" was introduced, establishing measures for stimulating and supporting the science and technology initiatives realized by companies and citizens[9].

Technology-based projects, that use data and information produced by Porto Alegre city council, established partnerships with Procempa[10], a local data processing company and an important player. It supplies technological services offered by the city council in areas such as healthcare, urban mobility, security, education, telemedicine and supplies, as well as social projects, digital inclusion programs and events held in the city.

In 2013, Porto Alegre was one of the winners of IBM's Smarter Cities Challenge program[11]. Cities from all over the world are invited to set a challenge for the company: IBM provides the winning projects with advice from its team towards solving the challenge, together with an investment of U$ 400,000. The "Cognitive City" project looked to simulate the impacts of works and actions required by the participatory budget. The process is undertaken through open assemblies and different negotiation stages involving representatives of the government and society.

IBM's consultancy work produced a number of proposals for actions to be implemented by the city in order to achieve the goals of the "Cognitive City" concept, such as the development of a website with information on

[6] Porto Alegre (capital of Rio Grande do Sul state) was founded in the eighteenth century. The city was shaped by the large influx of immigrants, mainly German and Italian. Though it faces problems related to rises in the levels of violence, traffic and pollution, the city records the highest HDI (Human Development Index) among Brazil's state capitals. Porto Alegre is recognized for its politicized profile. It was the host city for the first three editions of the World Social Forum, from 2001 to 2003, an event that aims to act as a counterpoint to the Davos World Economic Forum. Its participatory budget program (a public management model that involves sharing decision-making on the city's investments with citizens) was named, by the UN, as one of the 40 best democratic public management models.

[8] http://www.inovapoa.com/

[9] The law encourages local entrepreneurship through financial and tax incentives for creative incubators, technological parks and innovative projects.

[10] http://www.procempa.com.br/

[11] http://smartercitieschallenge.org/

the projects approved by the participatory budget, the use of software to measure the population's level of satisfaction with the implemented initiatives, the use of street sensors to improve urban mobility, and the monitoring of taxis and official vehicles via GPS. In addition, IBM, in partnership with Procempa, contributed towards improving the "Integrated Command Centre" (*Centro Integrado de Comando*: CEIC)[12] in a similar form to the work carried out at the Rio Operations Centre (COR).

CEIC is the focal point for monitoring and controlling the city through the integration of diverse municipal bodies and companies linked to services in the areas of mobility, security, public transport, urgent medical care, social welfare, civil defence, urban sanitation, and so on. At CEIC the agents visualize data produced by sensors spread across the city, images from 840 cameras and climate monitoring data via a 48m² screen. The centre operates 24 hours a day, 7 days a week, and is available to journalists to use full time to accompany information on traffic, meteorology and important happenings in the city. News, alerts and other important information are also published via a Twitter account and the official website. For strategic and security reasons, CEIC was installed at the same location as the Procempa data centre.

Proposals for a smarter city based on collaboration, open data and social media are developed in the city mainly through "#POAdigital", Porto Alegre's official online communication centre. With the objective of promoting integration between public agents, collective agents and local organisations, #POAdigital has developed actions such as *hackathons* and #DataPoA, Porto Alegre's open data website. Using the data made available through the #DataPoA site, students, developers, researchers and businesses created projects like Vou de Bike POA[13], a map with tips and bicycle routes in the city, or applications for smartphones and tablets[14]. The graph below shows the main actors involved in developing the Porto Alegre smart city project[15]. (Figure 4)

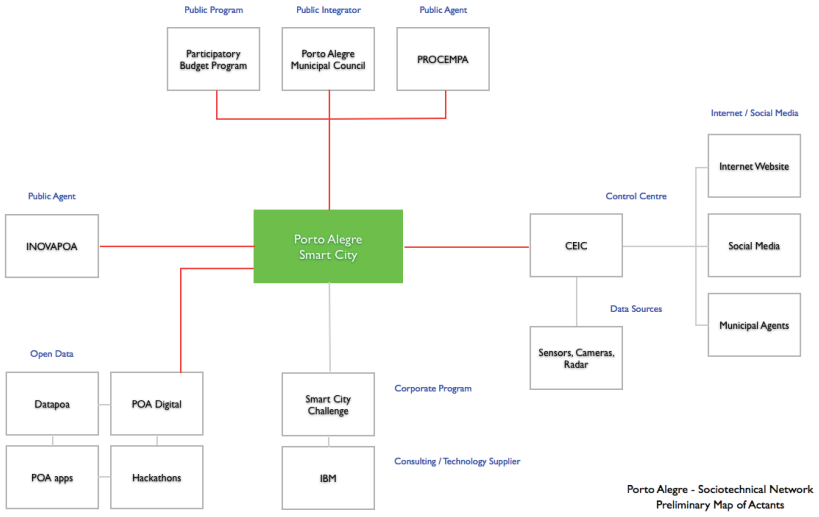


Figure 4: Porto Alegre Sociotechnical Network

Based on the model proposed in this article, Porto Alegre fits the centralized organizational type, made by a mix of sustainable and

12 http://www2.portoalegre.rs.gov.br/ceic/default.php

13 http://www.voudebikepoa.com.br/

14 http://www.datapoa.com.br/apps

15 The red lines (all graphs) show the main actants in the sociotechnical network.

technological city, even though the municipality has not created a specific entity responsible for integrating the actions. Its implementation is still mediated by agents directly linked to the municipal council, whether through Procempa, when resources related to data processing and using the city's technological infrastructure need to be mobilized, or through Inovapoa and its policies, laws and programs, which promote technology-based innovations, or through #POADigital, responsible for implementing actions that involve collaboration, social media, open data and digital inclusion.

In terms of action, CEIC coordinates a series of operations related to monitoring traffic, security and other public services (infrastructure), as well as improving the city's capacity to respond to everyday incidents, weather and so on (urban management). However Porto Alegre is notable for the variety of actions implemented with the aim of encouraging and empowering citizens to think of the city from an open data perspective, including hackathons, workshops, maps, software competitions, lectures and training courses. The model being developed in the city proved to be more open to participation than the other cases analysed in Brazil.

4.2. Búzios Smart City

Through the Búzios[16] Smart City project, the resort became a test bed for solar and wind energy solutions and, in particular, an intelligent power network or "smart grid". A smart grid uses ICTs to collect and manipulate information on electricity generation, transmission, distribution and consumption (Salles et al., 2014). As well as data on electrical power, the network transmits information used to create more effective and sustainable forms of consumption. Furthermore, the integration of renewable energy sources into the system, such as solar panels and mini wind turbines, means that consumers can also become energy producers[17].

The project, considered the most important in Latin America and one of the ten most innovative in the world of sustainable energy, is being undertaken by Ampla Energia e Serviços S.A., an energy concessionaire that supplies power to 66 municipalities in the interior of Rio de Janeiro state. Through ENDESA, Ampla is a subsidiary of ENEL, Italy's largest power company and one of the main concessionaires with shares listed on stock markets in Europe. ENEL, via ENDESA, has developed similar projects in the Spanish city of Malaga, and the Italian cities of Bari and Genoa.

High levels of insolation and constant winds make Búzios ideal for testing the production of solar and wind energy. The city is geographically small and possesses a suitable number of inhabitants for the implementation of pilot projects. There are a little over 20,000 inhabitants living in an area just 69 km² in size. Its population also has a high level of energy consumption; almost three times the average of Brazilian cities. Búzios does not occupy a central position in Ampla's network, which facilitates conducting experiments that will have little impact on neighbouring localities.

The project aimed to include 10,000 clients by the end of 2014. In the residences already included, electronic devices measure energy

[16] Located in Rio de Janeiro state, Búzios is an internationally renowned coastal resort, 179 km from the state capital, which four years ago became a smart city laboratory based on new models of energy management

[17] In Brazil pilot smart grid projects are being implemented in cities in diverse regions. The main ones are: "Cities of the Future" in Sete Lagoas/MG, "Smart Grid Light" in Rio de Janeiro/RJ, "Smart Grid Program" in Barueri/SP, "InovCity" in Aparecida/SP, "Aquiraz Smart City" in Aquiraz/CE, "Paraná Smart Grid" in Curitiba/PR, "Parintins Project" in Parintins/AM and "Fernando de Noronha Archipelago Project" on Fernando de Noronha Island/PE. See http://redesinteligentesbrasil.org.br/projetos-piloto-brasil.html

consumption, allowing users to match their consumption to times of the day with lower price rates. Users can visualize the energy consumed by each appliance connected to the network and control them remotely via smartphones. Solar panels and small wind turbines also enable residents to produce a certain amount of electrical power, which can then be sold to Ampla. Street lighting includes 150 LED lamps connected to the grid and 40 telecommanded light points, which regulate the levels of luminosity in accordance with the time of day and flux of people.

The town's streets are served by four electric cars, ten electric bicycles belonging to the Municipal Guard, six bicycles run by the Health Department and another 30 bicycles for hire at tourist points, as well as a water taxi. At Ampla's Monitoring and Research Centre, located in the town centre, an electric service station was installed to recharge the vehicles. A number of residential stations are also planned. The actions involved in the Búzios Smart City project were categorized into 8 main areas in order to set goals for future development and expansion. These are: 1) Smart power management, 2) Smart vehicles, 3) Energy storage system, 4) Smart power generation, 5) Smart street lighting, 6) Aware and informed citizens, 7) Smart buildings, and 8) Telecommunications, control and broadband Internet.

In Brazil, electricity production, transmission and commercialization are regulated and monitored by ANEEL (National Electricity Regulatory Agency). ANEEL's Research and Development (R&D) Program[18] stipulates that concessionaires, licensees or other companies authorized to distribute, transmit and generate electricity must annually invest a set minimum percentage of their net operational revenue in energy efficiency, innovation or technology programs in the sector. The obligation to invest these resources is established in legislation and specified in the concession agreements[19]. Of the R$ 40 million invested in total in the Búzios Smart City project, R$ 17 million were assured by the investment fund run by ANEEL's Research and Development Program. The rest was invested by Ampla and partner firms[20].

The Rio de Janeiro state government is involved in the project through its "Economic Development, Energy, Industry and Services Office" (SEDEIS) and the "Rio Energy Capital" program[21]. According to the official web site, the aim of this program is to mobilize society and focus resources around the debate on sustainable development in the energy sector, turning the state into a benchmark for technological innovation, energy efficiency and environmental sustainability. The program is coordinated by a strategy committee, headed by the state governor, and formed by presidents from institutions and entities with head offices based in Rio de Janeiro. The executive committee, composed of technicians from participating companies and associations, is responsible for planning and controlling actions. The program has a portfolio of more than 30 projects with investments of around R$ 1 billion.

The "Sustainable Relationship Network" was also instituted with the aim of fomenting the involvement of local actors and thereby identifying priority issues and defining projects and interventions in a shared form. Moderated by the "Integrated Centre for Sustainable Development Studies and Programs" (CIEDS)[22], this initiative brings together Ampla, local

[18] http://www.aneel.gov.br/area.cfm?idArea=75

[19] Is worth noting that by normative 502, from August 2012, ANEEL has also stipulated a deadline of 18 months to distribution companies offered smart meters to its customers. In 2014, this deadline was discontinued. However, the normative indicate a large future demand for smart meters. See http://www.aneel.gov.br/cedoc/ren2012502.pdf

[20] The project's official website lists the support of the following companies from the energy and technology sectors: Enel Sole, Mibra Telecom, Landis+Gyr, Synapsis, Greenpower Tech, Enersud, Eletra, Treetech, GE, Telefonica, Agora, Corinex and AMRTEC. Just five of these are Brazilian companies. See http://www.cidadeinteligentebuzios.com.br

[21] http://www.riocapitaldaenergia.rj.gov.br

[22] http://www.cieds.org.br/

companies and institutions, research institutes and universities, as well as NGOs, associations, cooperatives and schools[23].

The composition of the network involved identifying organizations and leaders from the municipality, which in turn gave rise to six thematic technical groups in the areas of: 1) the environment, 2) tourism and economic activities, 3) income generation and qualification, 4) social, educational and cultural projects, 5) public services, monitoring and transparency, and 6) smart city and energy. Each technical group is formed by five agents or organizations that take part in regular meetings to elaborate collective plans of action: these contain objectives, goals, strategies and the designation of responsibilities. Below we provide a map of the actors involved in the project. (Figure 5)

[23] Universities and academic centres also participate in the project through cooperation and research agreements. Studies related to the systems and their technical structures, as well as analyses of the effects of the program's actions on the local community, have been published in the form of articles and master's thesis.

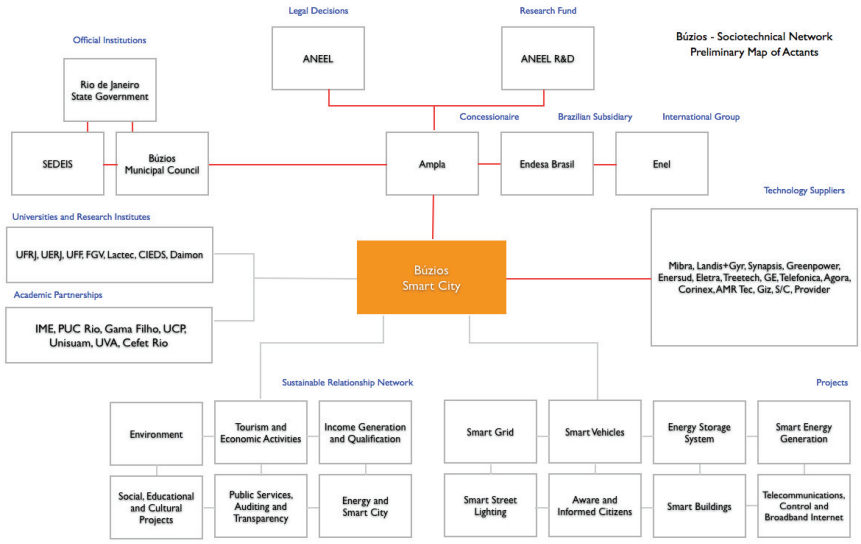


Figure 5: Búzios Sociotechnical Network

Búzios Smart City can be identified as a decentralized project and the conception is based on technological city model, since its actions are integrated and were designed by a company from the electricity sector rather than the public authorities. However, the execution of any smart city project depends on the mediation of the city government, as any other project associated with the municipal infrastructure. In the case of the creation of a Living Lab for smart grid technologies, the design of services and the implementation of devices and systems are directly dependent on the activities of an integrating company and its technological partners.

We can note that both the energy concessionaire, acting as an integrating agent, and its partners exert a greater influence on the project's design than the municipal council or any specific public body. Government programs like "Rio Energy Capital" and the resolutions passed by ANEEL, which make the investment of resources in innovative initiatives in the electricity sector compulsory, are also important factors in the viability of this type of project. They create the political and financial conditions needed for them to become concrete.

In terms of types of action, there is a predominance of infrastructural improvements, logically connected to the use of electrical power, rather than initiatives related to urban management or open data. Although the

academic partnerships have enabled the production of specialized technical articles, there is currently no program for opening up the data produced by the town's smart grid to the public.

4.3. Rio Operations Centre (COR)

In Rio de Janeiro (capital of Rio de Janeiro state), a project already fully up and running looks to combine what is presently the world's most advanced operations centre, the Rio Operations Centre (COR), with actions that promote citizen participation in formulating solutions to urban problems based on open data and collaborative processes. However, the central position of COR and its applications based on technologies with strong surveillance and control aspects have also been a source of controversies.

It is important to observe two actors and their influences on the smart city model developed in Rio de Janeiro. One of them is the series of mega events hosted by the city recently or in the near future, including the World Youth Day (2013), the FIFA World Cup (2014) and the Summer Olympics (2016), which have posed considerable challenges to the municipality (provision of public services, security, urban mobility and crisis management). The other is the heavy rainfall that regularly causes problems for the city's inhabitants. In April 2010 a rainstorm lasting more than 36 hours provoked hundreds of landslides and caused more than 250 deaths, as well as leaving more than 10,000 people homeless in the metropolitan region and nearby municipalities. These events became a political justification for the creation of the operations centre.

The centre was designed with the capacity to anticipate and prevent tragedies through a smart risk prediction system, backed by data produced in the city in real time. The Rio Operations Centre (COR)[24] coordinates more than 30 public bodies and concessionaires, responsible for traffic management, urban infrastructure, meteorology, security, civil defence, and other public services. A team of 400 professionals works in three shifts, 24 hours a day, 7 days a week, monitoring the city through images generated by more than 1,200 cameras. The data produced by diverse systems are combined for analysis via a 80 m² screen which displays the location of ambulances, police cars, fire trucks, barges, helicopters and more than 10,000 buses via GPS. The screen provides access to information on construction and repair work in the streets, problems with street lighting, the operation of the subway lines, updates on the intermunicipal bus lines, trains and flight times. In all there are more than 120 layers of georeferenced data.

COR possesses an independent meteorological stations, more than 100 rain gauges and a weather prediction system that uses a mathematical model developed by IBM especially for Rio de Janeiro, capable of combining data on its hydrographical basin, topographical survey and rainfall history, as well as satellite and radar information, in order to predict storms, landslides and flooding with up to 48 hours notice. In emergencies, COR's agents can sound alarms in communities, send messages to local leaders, block roads and alter the operation of traffic lights. All the municipal public schools and hospitals can be located on the map and their teams mobilized.

[24] http://www.rio.rj.gov.br/web/corio

Social media are used to share information and alerts among citizens through official Twitter and Facebook accounts. Waze users can report accidents and problems in the streets via the application, which, in turn, divulges information produced by COR's sensors and systems. Automatized content monitoring processes also work non-stop to identify mentions and hash tags and to visualize trends across diverse social media platforms.

The entire COR structure was put to the test in January 2012 when an old 20-storey building collapsed in the city centre. The first reports were captured via Twitter feeds through posts by users close to the location. Agents then used images from cameras to assess the problem and issued alarms to the civil defence and fire department. The gas and electricity companies cut the supply of their services to the nearby area. Metro stations were closed, traffic diverted, citizens advised to avoid the region through social media messages and hospitals warned of a potential increase in the demand for emergency care services. COR privileges actions relating to the climate, traffic and crisis situations. Traffic and crisis situations are challenges in any metropolis, but the expected arrival of a high number of tourists from around the world at events involving large concentrations of people also focused the city's attention on ways of monitoring and responding to urban mobility and security issues, as well as the supply of a series of urban services.

In addition to providing the resources of a central control system, the Rio project also develops initiatives based on open data and collaboration with the aim of increasing citizen participation in its smart city model. The "Rio Datamine"[25] project is a catalogue of open databases produced by municipal agencies and institutions. The databases are available in formats that can be read by diverse platforms and are displayed by category, agency or institution of origin. Data shown includes information on traffic, bus routes, service addresses, tourist points and real time updates from the "City Council Control and Management Centre" and COR. The catalogue also offers an interface of Application Programming Interface (API) allowing connection to its databases. In Brazil the promotion of transparency in public administration and ease of access to specific municipal data aim to meet legal requirements, principally the Transparency Law (N. 131/2009) and the Access to Information Law (N. 12.527/2011).

Based on the data available from the "Rio Datamine" project, the city council promotes actions such as "Rio Ideas[26]", a contest for smartphone applications with the creative and technological potential to solve some of the everyday problems faced by residents. In just its first 5 weeks, the competition received 2,000 ideas, which highlighted the interests of citizens, programmer groups, designers and start-up companies in discussing solutions for the city.

Along these lines we can also pick out initiatives like "Rio+[27]", a proposal for prototyping creative and innovative ideas for the city through the integration of citizens, companies, government and universities, and the organisation of hackathons in which programmers of smartphone applications camped out in the City Palace, the seat of Rio de Janeiro City Council, at weekends, taking part in competitions to develop solutions for the main demands received by the municipal call centre. However the actions based on collaboration, open data and creative competitions, even

[25] http://riodatamine.com.br

[26] http://ideias.rioapps.com.br

[27] http://riomais.benfeitoria.com

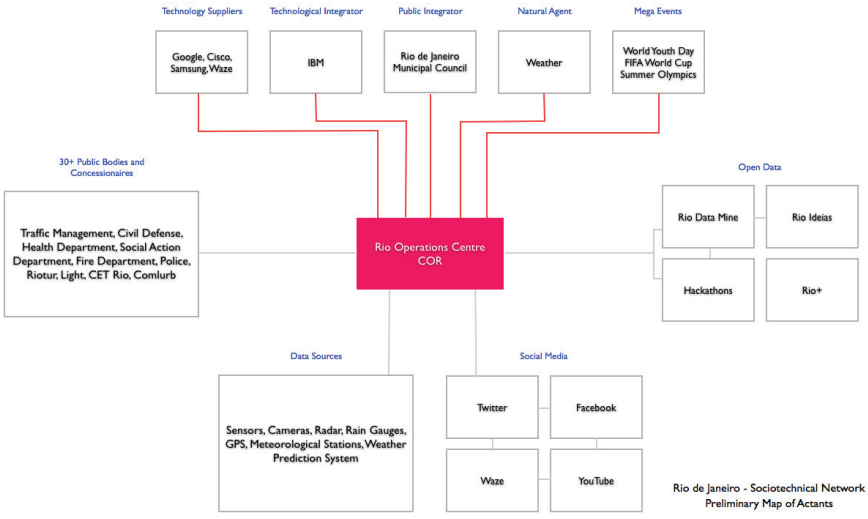
when they make use of data produced by COR and other municipal bodies, have little influence on the design of the operations centre and its priority areas of action.

From the design to the implementation of the smart city project in Rio de Janeiro, the municipal council assumed a central role, coordinating the relations and activities between public bodies, concessionaires of urban services and technology suppliers, as well as the design of ways for citizens and independent groups to participate. In its position as a public integrator, the city council is an influential actor in mediating a wide network of other actors and their particular interests[28].

As well as the mediation of a political integrator, we should also note another fundamental influence on the model being developed in Rio de Janeiro: the mediation of a technological integrator. IBM is the main IT partner of Rio de Janeiro City Council[29]. The company was responsible for integrating diverse systems already existing in the municipality and others supplied by companies like Google, Samsung and Cisco. In the context of a control centre (even though public policies, innovations and services are defined by local managers) their implementation will depend in the final instance on the action of the technological integrator and its partners.

The centrality of the city council, the technological structure's dependence on companies, and the control and surveillance systems based on thousands of cameras and sensors dispersed throughout the urban space, have all raised doubts about the final result of the project for the city. Today, for example, it is now possible to monitor the location of municipal guards through their mobile communication devices. Tests are also in progress using Google Glass to allow COR operators access to the field of view of agents on the street, multiplying the number of cameras and thus increasing the surveillance capacity of the control centre.

One of the controversies commonly associated with COR, therefore, is the possibility that its infrastructure – initially conceived as a smart response centre to urban crises and severe climatic events – may transform into a huge instrument for monitoring and analysing everyday life, capable of altering the dynamics of the city in accordance with other interests. (Figure 6)



[24] The mayor Eduardo Paes often presents COR's structure and functionalities in interviews and at events, as well as using the crisis room available on site as the city council's headquarters during emergency situations. When necessary, a telepresence system allows virtual meetings to be held with the mayor's office, his residence, the head office of the civil defence and more than 40 meeting rooms across the municipality.

[29] Under the slogan "Smarter Cities" – an initiative that IBM states is intended to assist companies, governments and society to achieve economic growth, sustainable development and social progress through the potential of smart systems – we find a complex association of executives, programmers, business plans, service packages, corporate expansion targets, hardware, software, use manuals, programming languages, technological platforms and above all algorithms.

Figure 6: Rio de Janeiro Sociotechnical Network

Based on the model proposed in this article, the smart city project developed in Rio de Janeiro is organised in a centralized form due to the integrating role performed by the municipal council. Actions are implemented in practically all the categories, though there is a greater emphasis on infrastructure (optimization) and urban management (reaction). The initiatives related to open data (participation) have involved citizens, developers and companies, but without the same degree of influence as other categories on the current form taken by the project and its functionalities and resources. COR's central role allows us to state that the Rio experience focuses more on urban management through the use of systems for visualizing, monitoring and controlling its main services and the urban infrastructure.

5. Conclusion

We have presented a model for conceptualizing smart cities. The model includes the forms of conception, organisation and action. We have chosen emblematic cases in Brazil and identified and used Actor-Network Theory as the theoretical framework for the present and future development of the research on the communication role of ICTs in the smart city projects, combining algorithms, Big Data and IoT.

Based on the model, Búzios is organised in a decentralized form, comprising a Living Lab projected by a company from the electricity sector. Among the Brazilian cases, decentralized organisation appears as the most common type in small cities and towns. The smaller size favours the activities of companies and their control over the result of the experiments. In this context, they can become increasingly influential as they expand their technological control over the devices, algorithms and systems that support the project. One of the challenges for the municipalities and citizens will be to avoid the technologies and knowledge produced from becoming enclosed in black boxes inaccessible to the majority.

Rio de Janeiro and Porto Alegre have projects with a centralized organisation, their actions integrated by the city council or public bodies. The existence of a public integrating entity is one of the factors helping ensure the viability of this model in large Brazilian cities: a city council, for example, is an agent capable of exercising the leadership necessary for coordinating a broad network of actors, both public and private. It has the means to ensure the implementation of projects through municipal laws, programs, budgets and its technical infrastructure. In the cases analysed here there is no example of organisation "made from scratch."

Among the cases described we can further observe the predominance of particular types of actions. In Búzios there are only actions targeted at optimizing its infrastructure, including the smart grid. In Rio de Janeiro, meanwhile, the challenges of a city facing complex urban problems and the influence of climatic phenomena have shaped a project that primarily aims to improve the city's capacity to respond to crisis situations, whether in relation to traffic, the organisation of large events or heavy rainfall. Urban management is COR's main focus of activity. Finally, Porto Alegre, through

its "Cognitive City" project based on the demands of the Participatory Budget program, combines a series of actions implemented by its public agents, like Inovapoa and #POADigital. It stands out for its initiatives stimulating participation, open data and citizen empowerment in the creation of a city 'intelligence.' This fits, therefore, into the kinds of action we label "Open Data."

Each case presents different expectations of citizen participation. In Búzios if there is no engagement of citizens in the use of the proposed services and technologies, then the project cannot be realized. This is in contrast to Rio de Janeiro, which essentially does not rely on the active participation of citizens, since its structure and smart systems are supported by the autonomous data production using sensors, meteorological radars, monitored vehicles and the visualization of urban dynamics at a larger scale. Most of the population may indeed be unaware of COR's modus operandi. Porto Alegre is positioned halfway, since it has a command and control structure (CEIC) like Rio, yet it also promotes citizen participation through hackathons, application competitions, open data and other initiatives.

The analysis conducted in this article also makes an initial attempt to use ANT by presenting a preliminary description of the main actants involved in designing and implementing smart city projects in Brazil. Our next stage will be to develop a more detailed description of the communicational components and determine how 'non-human' actants are important in the networks constituted in these cities. As indicated in an earlier article [name deleted to maintain the integrity of the review process], the algorithms, the communicating devices involved in the Internet of Things and the Big Data management systems are just some of the important actants involved in these associations that we shall examine in more detail later, aiming to pay greater attention to infocommunicational processes rather than urban management. Based on a review of the historical aspects of the relation between cities and communication technologies, we shall also look to highlight the main controversies provoked by the smart city projects, such as bureaucratization, an excessively technocratic or utopian vision.

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