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Internet of Services applications for Smart Cities: a comparative ranking analysis between Sorocaba and Sao Jose dos Campos

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Abstract

The individuals as well as the cities they live, are each day more interconnected, creating new service possibilities and offers. A new digital era is marked by a new society ecosystem focused on the redefinition of the concept of cities, urbanism and way of life, motivated by the introduction or development of Information and Communication Technology. The Internet of Services, coupled with the Internet of Things, has been mentioned as an important pillar for the Smart Cities architecture, however publications focusing on the Internet of Services domain are still missing. This paper aims to fill this gap through characterizing the Internet of Services applications within the Smart Cities and analyzing if cities that already have a high degree of technology and innovation are ready to be smart cities. A case study was carried out using secondary data published about two Brazilian cities: São José dos Campos and Sorocaba By means of a comparative analysis of the last Brazilian Smart Cities rankings, we assessed the performance of the two cities to evaluate if they could be classified as Smart Cities. As main result, we concluded the better the Internet infra-structure and a governance of the municipality authorities on a plan for a Smart City development jointly with the inhabitants, the better ranked as Smart City will become the municipality.

Tanto os indivíduos como as cidades em que vivem estão cada vez mais interligados, criando novas possibilidades e ofertas de serviços. Uma nova era digital é marcada por um novo ecossistema da sociedade focado na redefinição do conceito de cidade, urbanismo e modo de vida, motivado pela introdução ou desenvolvimento das Tecnologias da Informação e Comunicação. A Internet dos Serviços, associada à Internet das Coisas, tem sido apontada como um importante pilar da arquitetura das Smart Cities, porém ainda faltam publicações com foco no domínio da Internet dos Serviços. Este trabalho visa preencher essa lacuna caracterizando os aplicativos de Internet de Serviços dentro das Smart Cities e analisando se as cidades que já possuem um alto grau de tecnologia e inovação estão prontas para serem cidades inteligentes. Foi realizado um estudo de caso com dados secundários publicados sobre duas cidades brasileiras: São José dos Campos e Sorocaba Por meio de uma análise comparativa dos últimos rankings de Smart Cities brasileiras, avaliou-se o desempenho das duas cidades para avaliar se poderiam ser. classificados como Smart Cities. Como resultado principal, concluímos que quanto melhor for a infraestrutura de Internet e uma governança das autoridades municipais em um plano de desenvolvimento de Smart City em conjunto com os moradores, melhor classificado como Smart City se tornará o município.

Keywords. Internet of Services, Smart Cities, Internet of Things

1 Introduction

The growing and disordered urbanization has become a critical issue for main cities worldwide (Gasparotto Storolli et al., 2019). Air pollution, traffic congestions, difficulty in waste management, scarcity of basic resources like energy and water are among the challenges faced by the big cities (Chourabi et al., 2012). It is a challenge to provide services that population severely demand such as safety and security, parking services, assisted living for the older population, medical services, and access to public services. Smart cities come to the scene showing the enabler may be the technology.

Due to such growing importance of cities in the global context, the concept of Smart City has become more present in scientific literature and public policy in recent years (Torres et al., 2019), A new digital era is marked by a new society ecosystem focused on the redefinition of the concept of cities, urbanism and way of life, motivated by the introduction or development of ICT (Information and Communication Technology) (Gasparotto Storolli et al., 2019).

Nowadays all the leading cities have a plan that includes the ICT deployment. A smart city should integrate conditions of its critical infrastructures, from roads to buildings, to better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens (Cretu, 2012). While touching the citizens, the data privacy must be also a concern. The Brazilian General Data Protection Law – LGPD Law n. 13,709/2018, which amended Federal Law n. 12,965/2014 (Brazilian Civil Rights Framework for the Internet), provides rules for the protection and treatment of personal data, protecting the privacy of the natural person (Araujo, 2019).

Whether for revitalizing an old city or for planning a new city from scratch, technology has to be built in. The goal is to view technology as part of a holistic, services-oriented approach to revitalizing cities (Elfrink & Kirkland, 2012). That is where Internet of Services enters as an important pillar for Smart Cities conception.

The relevance of the Internet of Services comes also from the prominent role as one of the key components of Industry 4.0 and Future Internet. In a nutshell, the Industry 4.0 could be divided into: Cyber-physical systems (CPS), Internet of Things (IoT), Internet of Services (IoS) and the Smart Factory (Hofmann & Rüsch, 2017). And the Future Internet could be defined as the union and cooperation of the Internet of Content (IoC), Internet of Services (IoS) and Internet of Things (IoT) (Balakrishnan & Sangaiah, 2017).

According to Kagermann et al. (2013), the Internet of Things and Services would give direction and solve some current global challenges, such as resources and energy efficiency, urban production and demographic change.

Desdemoustier et al. (2019) report, however, that having a good functioning, efficient and technological infrastructure is not enough to become a Smart City. ICT or other technologies should be considered to achieve certain ends, rather than an end itself. The current realities of the municipalities are much more complex than the technological approach. Territories encompass many other dimensions than just infrastructure. The information and technology alone will not build an intelligent city, but its capacity and ability to effectively and efficiently meet the needs of its citizen (Cebreiros & Gulin, 2014).

For further investigation on such query, the research question of the present study is: Would cities that already have a high degree of technology and innovation be ready to be smart cities?

We performed a literature review regarding the conception models for Smart Cities and the applications of Internet of Services in this area. A case study was carried out using secondary data

published about two Brazilian cities: São José dos Campos and Sorocaba. By means of a comparative analysis of the last Brazilian Connected Smart Cities rankings, we assessed the performance of the two cities to evaluate if they could be classified as smart cities.

This paper is organized as follows: After this introduction, the second section covers the literature review. The third section brings the method and collected data. The fourth section brings the results and discussion, followed by a conclusion on the fifth section.

2 Literature Review

2.1 Smart Cities Conception Model

The term Smart City was adopted in 2005 by the technology companies Cisco®, IBM® and Siemens® as the application of complex information systems to integrate the operation of urban infrastructure and services such as buildings, transportation, public safety, electrical and water distribution (Colin Harrison & Donnelly, 2011). A simple way to conceptualize a smart city is as an icon of a sustainable and livable city, however there are divergent opinions with respect to the understanding of the concept of Smart City and also different terminologies to define it – digital city, intelligent city, to name a few (Chourabi et al., 2012).

As illustrated in Figure 1, Smart Cities are the interoperability among Internet of People (made of Social Web, Wikis), Internet of Services (IoS – it refers to the services organized in clouds) and the Internet of Things (IoT – the wireless world of smart devices and sensors which includes home and business environments) (Cretu, 2012).

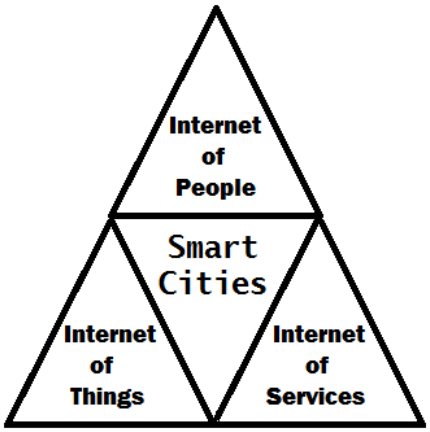

Figure 1 – Smart City concept, adapted (Cretu, 2012)

In a broader view, a smart city framework would consist in six main components: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. For a smart economy perspective, factors included are all around the economic competitiveness such as innovation, entrepreneurship, trademarks, productivity and flexibility of the labor market as well as the integration in the national and global market (Giffinger et al., 2007).

In another concept, a smart city is an instrumented, interconnected and intelligent city (Harrison et al., 2010). Instrumentation relies on the use of sensors, meters, cameras, smartphones, wearables, and any other device able to capture live real-world data. The interconnection means the transfer of such data through the Internet into an enterprise computing platform. This platform is then shaped by combining services to add some intelligence to these connected elements in an interoperable manner that provides the system with a highly heterogeneous content.

Following this concept, a proposed model for Smart Cities, also composed of three layers - infrastructure, communication, and intelligence - is illustrated on Figure 2.

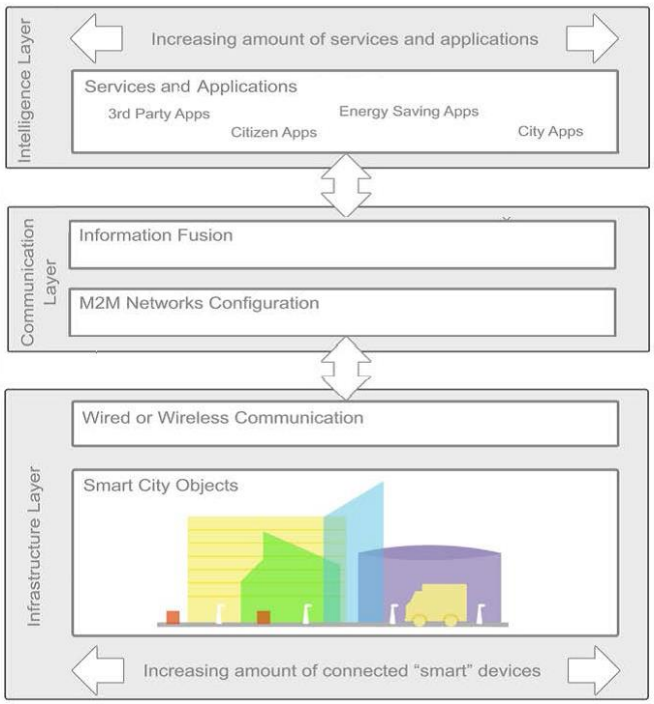

Figure 2. Smart city architecture, adapted (Chamoso et al., 2016)

The infra-structure layer is represented by the hardware or various smart city objects. This physical part is composed of different kinds of sensors and actuators placed in real objects, buildings, and cars.

The communication layer is the interconnection from such objects. All these elements are connected in several different ways and they provide both real and simulated values. The sensors incorporate the mechanism to transmit the information so that it can be integrated in the global system.

The intelligence layer is composed by the services and applications. At this layer, several services are generated based on the platform data or the integration of third-party services. A set of techniques and algorithms are used for the data processing to the set of final applications (Chamoso et al., 2016).

2.2 Internet of Services

The term Internet of Services was raised from the convergence of other two concepts: Web 2.0 and SOA - Service-oriented architecture (Schroth & Janner, 2007). The intersection of these two fields is the notion of reusing and composing existing resources and services.

The first concept, Web 2.0 is characterized by four aspects: interactivity, social networks, tagging and web services (Treese, 2006):

- Interactivity: the gain of interactivity allows the communication and the dynamic manipulation of data between a server and the Web browser.
- Social networks: the social networks up come based on common interests and make the captured information from each network available through different ways.
- Tagging: users can add a keyword as a tag to a certain Web content, making this tag easily reachable when searched by other users.
- Web Services: allow that other software make use of the features offered by a Web application, since such applications become available not only to people but also to machines.

A Web service is an abstract notion that must be implemented by a concrete agent. The agent is the concrete piece of software or hardware that sends and receives messages, while the service is the resource characterized by the abstract set of functionalities that is provided. To illustrate this distinction, a particular implemented Web service can use one agent one day, and a different agent the next day, with the same functionality. Although the agent may have changed, the Web service remains the same (Treese, 2006).

The second concept that forms the Internet of Services is the Service Oriented Architecture – SOA (Schroth & Janner, 2007). SOA is a way of designing and building a set of Information Technology applications where application components and Web Services make their functions available on the same access channel for mutual use. New applications can be assembled from the available components and Web services, like a LEGO®. As a metaphor, it works as a shopping mall underground floor in which various services such as food court, barber chop, repair of cell phones, tailor shop, all are offered in a same physical location, facilitating customer access (Reis & Gonçalves, 2018).

As long as devices and things are connected to the Internet through sensors and networked with standardized protocols, the Internet of Services applications expand and cover more possibilities of combinations of services to be offered, since the multiple objects turn to new concrete agents. By linking such concepts to the Smart City Architecture of Figure 2, the Internet of Things covers the Infrastructure and the Communication layers, while the Internet of Services is placed most on the Intelligence layer but going through all the three layers.

3 Methods

Initially we carried out a bibliographic, not systematic, research to better understand the role of the Internet of Services in Smart Cities conception model.

Next, two cities were selected for a case study, to assess their performance on evolution to Smart Cities. The municipalities are São José dos Campos and Sorocaba (Figure 3), both located in the state of Sao Paulo, Brazil.

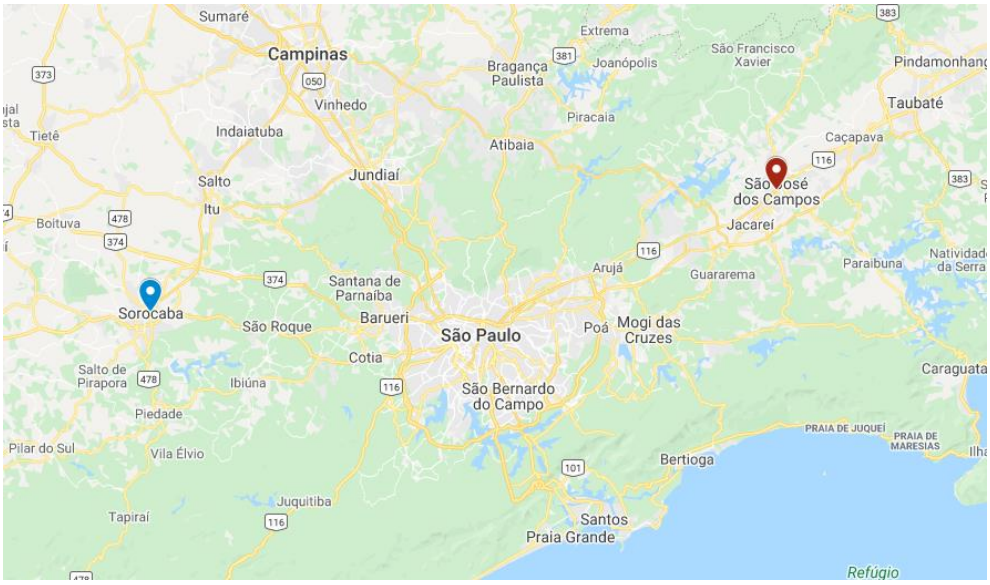

Figure 3. Municipalities analyzed in the study

The case study was carried out using secondary data published by the Brazilian public bodies through three well-known Smart Cities rankings: (1) Ranking of Connected Smart Cities; (2) Ranking of Internet Friendly Cities; (3) Ranking of Smart City Services. By means of a comparative analysis of

the scoring of São José dos Campos and Sorocaba in these Brazilian Connected Smart Cities rankings, we assessed how the two municipalities are evaluated as Smart Cities.

The reason for choosing such municipalities is because both have a legislation for ICT deployment, what encourages the smart city development. São José dos Campos has the Law 9563/2017 that instituted the "Scientific, Technological and Sustainable Innovation Incentive Program of São José dos Campos" aiming to receive innovative projects for evaluation as long as they can optimize public works and services in benefit of the population. Sorocaba has the Law 11726/2018, "Rules for Smart Cities and other measures", that establishes principles and rules that will guide the implantation of equipment, devices, and infrastructure to adapt the city to the concept of smart cities.

Both municipalities will benefit also from the fact that the Brazilian telecommunications services regulator Anatel has approved a set of rules that will pave the way for the government to award spectrum for the provision of 5G services in Brazil (Tomás, 2021)

3.1 Municipalities analyzed in the case study

3.1.1 São José dos Campos

The municipality of São José dos Campos is located in the Paraíba Valley, in the interior of the State of São Paulo, Brazil. The estimated population of the municipality in 2020 is around 629,921 inhabitants and the territorial data show a population density of 572.96 inhab / km². The total surface area is 1,099,409 km² (IBGE, 2020), of which 353.9 km² are urban area. The human development index of the municipality is 0.807, according to the data collected in the period of 2010. This index is considered very high, according to the classification of the United Nations Development Program. The per capita income of the municipality corresponds to approximately € 245.56 (SEADE, 2020)

The economic scenario of the city is based on the primary, secondary and tertiary sectors. The municipality of São José dos Campos concentrates 9.37% on exports from the entire State of São Paulo, being the third largest exporter in the country. Its GDP represents 1.67% of state GDP, being the 20th largest in the country, representing 0.54% of national GDP (SEADE, 2020).

The city is the only one to have in its Technology Park the three largest aircraft manufacturers in the world: Embraer (Brazilian Aeronautical Enterprise), Boeing and Airbus. There are other companies such as: General Motors, Petrobras, Ericsson, Johnson & Johnson and Panasonic (Prefeitura Municipal de São José dos Campos, 2020). The city has the São José dos Campos Technology Park, which houses three business incubators, four business centers, two Local Productive Arrangements (LPA), four technological development centers and six partner universities. The Local Productive Arrangement of Information Technology and Communication (LPA ICT Valley), created in 2011, brings together 67 companies that work in the development of hardware, software and IT services, focusing on Smart Cities and Industry 4.0 (Parque Tecnológico - São José dos Campos, 2020).

3.1.2 Sorocaba

Sorocaba is a municipality in the State of Sao Paulo, located in the southeastern region of the state,with a population of 658,547 inhabitants and a density of 1,462 inhab./km² according to 2020 data (IBGE, 2020). It covers a surface area of 450.38 km2, making it the fourth largest city in the State and the 30th largest in Brazil. The human development index of the municipality is 0,798 (data from 2010), also considered a high index (SEADE, 2020).

The main economic sectors in the city are industry, commerce and services. The GDP per capita is R$ 48.271,34 (IBGE, 2020). The municipality of Sorocaba concentrated, in 2019, 1.97% on exports from the State of São Paulo. Its GDP represents 1.5% of the total state GDP (SEADE, 2020). According to Seade, this figure (GDP) represents the 11th in São Paulo State and the 23rd among all the cities in Brazil.

Some companies located in the city are Toyota, Flextronics, Metso, General Motors, ZF Friedrichshafen AG, Dana Holding Corporation, YKK among others. It has been in the agenda of the city a collaboration between the government, higher education institutions and the business sectors in order to promote innovation and entrepreneurship through a joint: The Sorocaba Technology Park. The facilities are in an area of 1.8 million m^2, strategically organized in spaces for the creation of innovative companies (incubator), development of R, D & I (Research, Development & Innovation) activities, projects with higher education institutions and strategic area for future projects. The main areas of expertise are urban mobility, alternative energy, metal mechanics, integrated technologies and smart cities, electronics (Parque tecnológico de Sorocaba, 2020).

3.2 Comparative ranking analysis of the case study

The cities aim to improve their competitiveness and their position in relation to other cities around the world. Through this new trend, city rankings have experienced a remarkable growth, and so forth, the comparison of cities. Such rankings can support investors in the choice of location to new business and become an important guide for cities to analyze their strengths and weaknesses, as well as to set goals and strategies for future development (Giffinger & Gudrun, 2010).

For the present study, we used three Brazilian rankings and by means of a comparative analysis of the scoring of São José dos Campos and Sorocaba, we assessed their performance evolution.

3.2.1 Ranking of Connected Smart Cities

The Ranking of Connected Smart Cities aims to map the cities with the greatest potential for development in Brazil through indicators that portray intelligence, connection and sustainability (Gaspar et al., 2016).

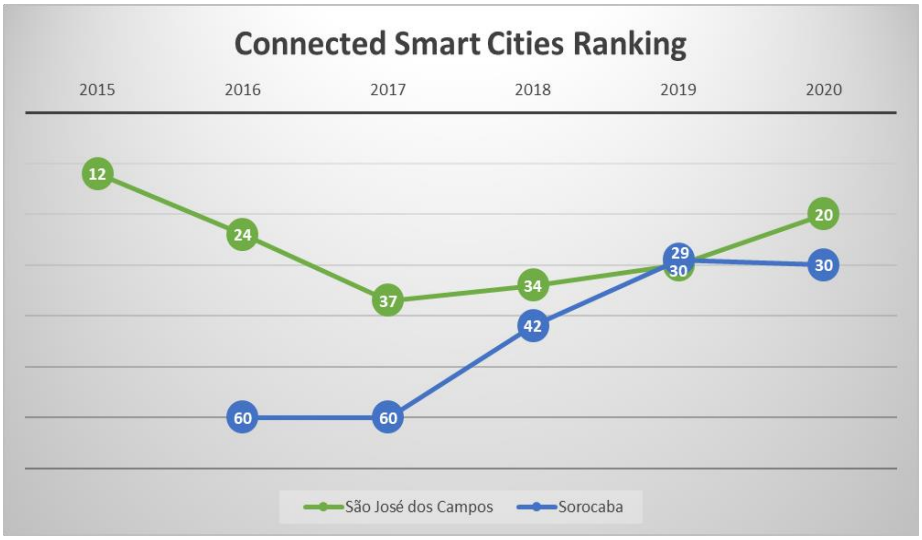

Figure 4. Performance of the municipalities analyzed in the Connected Smart Cities Ranking

Because of the breadth of information and connectivity between the sectors covered in the Connected Smart Cities ranking, the indicators used were designed and studied to meet the principle of a smart

city being one that grows in a planned way through analysis of the development of 11 sectors, which are: Mobility, Urbanism, Environment, Energy, Technology and Innovation, Economy, Education, Health, Safety, Entrepreneurship and Governance (CONNECTED SMART CITIES, 2020)

The performance of the municipalities of São José dos Campos and Sorocaba was analyzed in the Connected Smart Cities ranking (Figure 4). São José dos Campos has been listed since 2015 among the hundred smartest cities in the country. Sorocaba was not listed in the first year of the ranking. As of 2016, the city shows a significant improvement in its score, getting a position ahead of São José dos Campos in 2019.

3.2.2 Ranking of Internet Friendly Cities

The Ranking of Internet Friendly Cities, organized by Teleco Consulting, highlights among the 100 largest Brazilian municipalities those that offer a suitable environment for the installation of telecom network infrastructure (antennas and fiber optics) (TELECO, 2020).

A better position in the ranking means that the municipality is improving citizen's internet access and bringing investments to the municipality. For the composition of the ranking, restrictions, bureaucracy, time and cost for the implementation of Radio Base Stations (ERBs) and Networks (Underground or overhead) are evaluated (TELECO, 2020).

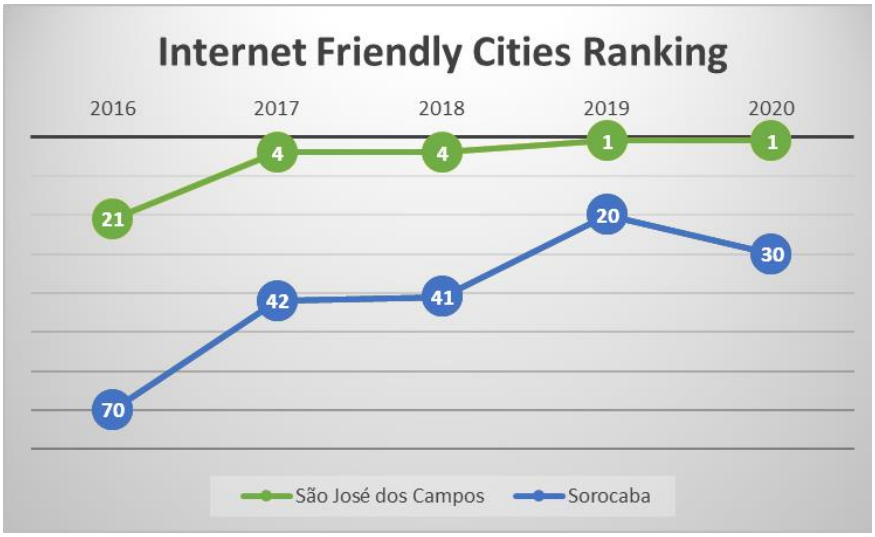

Figure 5. Performance of the municipalities analyzed in the Internet Friendly Cities Ranking

Figure 5 details the performance of the two municipalities in the Internet Friendly Cities ranking. São José dos Campos showed an increase in its score since the first year of the ranking, being in the first position in the years 2019 and 2020. The good performance happened after the city adopted measures to simplify and reduce the bureaucracy in the implementation of the telecommunications infrastructure. Sorocaba also improved its performance from 2016 to 2019 but had a drop of ten positions in 2020.

3.2.3 Ranking of Smart Cities Services

The Ranking of Smart Cities Services, organized by Teleco Consulting, aims to identify, among the 100 largest Brazilian municipalities, the Brazilian municipalities with the greatest offer of intelligent services for citizens (TELECO, 2020).

The rankings allow the municipalities to check their position in relation to the others and to identify the points that require improvements, in order to make their cities more intelligent (TELECO, 2020).

Figure 6 details the performance of the two cities in the Smart Cities ranking. In this ranking São José dos Campos shows stability in the three years analyzed reaching the twelfth position in 2020. Sorocaba showed a significant improvement, moving from 58th position in 2019 to 16th position in 2020.

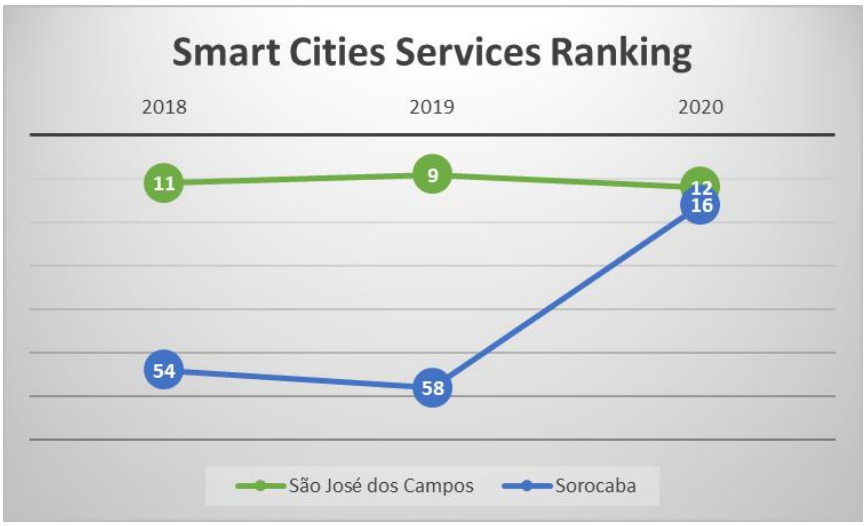

Figure 6. Performance of the municipalities analyzed in the Smart Cities Services Ranking

4 Results and Discussion

More and more cities around the world are committed to developing projects for Smart Cities. The decline in costs of connectivity and of required devices are driving the growth of this kind of communications. In addition, there are some open data services available to provide useful information, such as the city's weather forecast or traffic (Chamoso et al., 2016).

From the literature review, we learned that the pillars of the Smart City for Murgante & Borruso (2014) are: connections, such as networks and technological infrastructures; open data, to allow the development of innovative solutions and the interaction between users, citizens, and the city; including citizens able to actively participate in a bottom-up way to city activities.

It can be seen through the comparative ranking analysis we did in the case study that the municipalities analyzed, São José dos Campos and Sorocaba, have similar initiatives such as free internet signal distribution, lighting with LED lamps, monitoring cameras, intelligent traffic lights, electronic parking systems, operations control center, investments in fiber optic network infrastructure, automation of processes and public services in electronic media, and an efficient electronic government portal.

The present study brought the research question "Would cities that already have a high degree of technology and innovation be ready to be smart cities?". We can conclude the answer is affirmative from the case study we carried out by analyzing the performance evolution of São José dos Campos and Sorocaba. As long as the infra-structure devices and things are connected to the Internet and well implemented, the potential for Smart Cities grows proportionally. By consequence we understand that more Internet of Services applications can be explored and cover a wider range of service offering possibilities to the inhabitants.

Internet of services applications have become a promising paradigm with the development of smartphone sensing and mobile social networking techniques as allow mobile phone users to share information such as traffic conditions and location information. Additionally, users can further upload the data to the cloud for large-scale sensing and community intelligence mining ramping up other

applications like mobile social recommendation, environment monitoring and traffic planning (Kong et al., 2020).

The deployment of a smart city enables direct interaction with the end-users. And the interaction with real end users allow not only assessment of technologies but also the release of new services. The services applications, enabled by the Internet of Things, trigger a market that can be measured in trillions of transactions. The revenues with recurrent services make the services offer bigger than the sum of all the connected devices worldwide and potentially more profitable to the companies and developers. With the enterprise companies moving to software and subscription models, services become even more important for staying relevant and strategic (Cisco Systems, 2017).

This research shows that both municipalities are well positioned with their current implementations of Smart Cities, driven by technology but also by legislation and governance that encourage their development. Their evolution as Smart Cities has been revamping by an evolution of their Internet infra-structure and services, as long as they started to give more attention to the subject and trigger a plan of rules for Smart Cities development.

A similar study was applied by Angelidou (2017) who examines the Smart Cities plans of fifteen major cities worldwide and shown how the focus is mainly on ICT as a factor that can improve urban systems. A critical review of the implemented project, however, highlights the lack of bottom-up approaches, the involvement of independent parties and a general disregard for local conditions, in sharp contrast to the (theoretical) principles of Smart City policies and practices.

The “smartness” of a city can be defined as the ability to provide the infrastructure needed for the nodes or four entities: people, software services, devices, and sensors to produce, discover, understand and process events in real-time. The events represent meaningful information based on which people or software agents may act. Services may be seen also as agents acting in the name of people. Thus, signals (data) may come from any of those four entities which coexist within the smart city space. The inhabitants of a smart city integrate themselves into an ecosystem where ubiquitous computing is the norm and software agents may be configured to act in the name of people by analyzing real-time data converted into events (Cretu, 2012).

Anyway, there is indeed a complexity for allocating all the different resources to deploy and sustain a Smart City. And this is the path that we see the two municipalities studied are doing. They have a legislation that includes a master information and communication technology (ICT) deployment and they have been indeed investing in innovative projects to optimize public works and services in benefit of the population.

5 Conclusion

The present study explained the Smart city architecture giving focus on the Internet of Services and its role on this model conception. The service is experienced when resources make use of any of the information gathered by the deployed infrastructure to build a smart city application or service. The target of these applications or services, is, in general, to improve the efficiency of the city and facilitate a more sustainable development of the city and its citizens.

Through a case study, we concluded the better the Internet infra-structure and a governance of the municipality authorities on a plan for a Smart City development jointly with the inhabitants, the better ranked as Smart City will become the municipality.

Smart cities are an important upcoming domain for the Internet of Services due to the multitude of application areas, therefore representing a realistic and fertile ecosystem for such technology's development.

Acknowledgments

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