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The Relationship Between Smart Cities and the Internet of Things in Low Density Regions

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Abstract. In these times of digital transformation, cities have overcome the challenges of the past and are building the future. The use of technological resources as a means of efficiently delivering various services and improving citizens' quality of life has transformed regions and cities into smart regions and cities. There have been a remarkable amount of projects implemented by the Municipalities in the last years, taking the technologies to the cities. However, for a project to be interesting, it must have a positive impact on society, that is, citizens. This evidence gave rise to the present study whose goal was to find out if citizens living in inner cities, labeled as smart cities, actually consider them that way, and whether their city uses innovative solutions that optimize their daily lives. The results are discussed in the light of the literature and future work is identified with the aim of shedding some light on a field as emerging, promising and current as this of Intelligent Cities and the Internet of Things.

Keywords: Internet of Things · Smart cities · Smart regions
Information technologies

1 Introduction

At present, companies with world-renowned prestige that operate in the area of Information and Communication Technologies are betting on innovative solutions that optimize the daily life of citizens, providing a better quality of life for the population. Cisco Systems and IBM, Microsoft already develop new solutions and initiatives for smart cities. CISCO launched the "Global Intelligent Urbanization initiative" to help cities around the world using the network as the fourth utility for integrated city management, enabling a better quality of life for citizens and development economic. Microsoft is working with Coventry University and Birmingham City Council on the Intelligent City Proof of Concept Project, an interoperable technology platform focused on transportation. IBM has announced its Smarter Cities to stimulate economic growth and quality of life in metropolitan cities and cities by activating new approaches to thinking and acting in the urban ecosystem [1].

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The territory can create an environment conducive to innovation, provided its sustained by technology and technological innovation. The concept of smart region appears as an alternative to assist the territorial organization of space, in order to generate an innovative environment capable. Regions function as collectors and repositories of knowledge and ideas, facilitating the flow of ideas, knowledge and learning. In the smart region becomes urgent, the capacity for innovation and adoption of new knowledge, techniques, and technologies. Being these the main vectors of the regional development process [2].

The grouping of people in specific places is inevitable, this generates the need to prevent or reduce the creation of waste in all aspects, infrastructure, resources, management, pollution, health, traffic, among others. The definition of a smart city is linked to an efficient city in which its concept encompasses sustainable urban development that is capable of being able to respond to any political, economic, operational and social environment that may arise.

Until now, cities have been changing, on a greater or lesser scale, and the discussion about their role in the economy and social welfare has been intensified. An intelligent city is aimed at people, whose main objective is the well-being of the population.

The present paper is structured as follows. After this introduction, a brief outline is given of the Portuguese Smart Cities Network, followed by a definition a smart city and Internet of Things. Subsequent to this is the presentation of the research method used in this study, followed by the main results obtained. The paper ends with the conclusions and with suggestions for future works.

2 The Portuguese Smart Cities Network

The Portuguese Smart Cities Network (RENER) was started in 2009 with 25 municipalities as a pilot network for electric mobility launched by the Portuguese government. The cities acted as test sites for electric charging points and intelligent mobility systems [3]. Among these 25 municipalities, 18 are the Portuguese district capitals, and the others are the cities of Vila Nova de Gaia, Almada, Loures, Sintra, Cascais, Torres Vedras and Guimarães.

In 2013, RENER invested in the thematic extension of its action, incorporating other areas such as energy efficiency, renewable energies, water and waste management, governance and citizenship, culture and tourism, all in the sense of a holistic model of smart cities. Over the last year, it has also promoted the geographic extension of the network with the integration of 18 more national municipalities, thus gaining scale, critical mass and cooperation capability. The Portuguese Smart Cities Network was thus formalized in November 2013 as a natural evolution of the Renewable Energy Living Lab (RENER), which had been created in 2009 by INTELI – Association Intelligence in Innovation. In 2015, the network incorporated three more municipalities, namely Macedo de Cavaleiros, Miranda do Douro and Lagoa. The Portuguese Smart Cities Network is currently composed of 46 municipalities throughout the national territory (see Fig. 1).

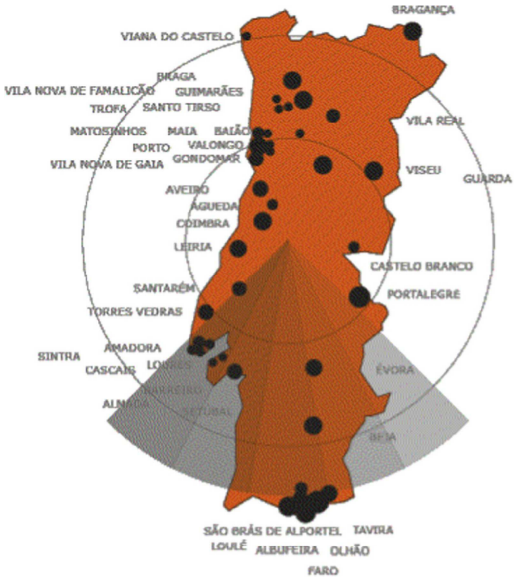

Fig. 1. Map of the Portuguese municipalities integrating RENER (Source [3]).

With the creation of the RENER the Network of Intelligent Cities of Portugal (www.smartcitiesportugal.net), all the cities integrating the RENER network became as well associated with this new platform. INTELI is the managing entity of the RENER Network, made up of 46 municipalities and a member of the European Network of Living Labs. In the Portuguese Smart Cities Network each municipality works as a site of development and experimentation of urban solutions.

This idea of experience sharing among municipalities has already reached Spain with the creation of the Iberian Smart Cities Network, which is currently composed of 111 cities.

3 Smart Cities

The term Smart Cities has been widely used over the last years. The main goal of the smart cities initiative is to enable cities to manage their assets efficiently, investing in innovation and creativity as a way to promote sustainable and inclusive urban development. Initially, the model of a smart city applied to information technologies that could be used to plan city development. The first publication on the subject matter is considered to be the book by Ishida and Isbister [4] on methods the information society applied to create the virtual space of the city [5], using the Internet and IT infrastructure. Subsequent papers evolved towards the city management method [6], the ability to attract top class specialists [7] or the ability to develop and absorb innovation [8]. The concept of "smart cities" currently has come to dominate both the academic literature and the public policies agenda. Several worldwide projects are being

conceived and implemented, with different characteristics, motivations, maturity levels, government models and funding sources. However, the motto is always the use of information and communication technologies to make urban life easier [9].

International Data Corporation defines a Smart City as a city which has stated its intention to use information and communication technologies to transform its modus operandi in one or more of the following areas: energy; environment; governance; mobility; buildings and services. The main goal of a Smart City is to improve the quality of life of its citizens ensuring sustainable economic growth [10]. An smart city can be defined as a multidisciplinary domain gathering several fields of action and skills in order to achieve development. These fields are at their core supported by information technologies, hence the designation of intelligent, but they must also be strongly targeted at a governance model anchored in civic participation and they must be a source of economic development [11].

Nowadays, cities are facing several challenges related to climate change, demography, energy dependency and social exclusion, which calls for new urban development paradigms. In this context, concrete smart city projects are being implemented around the world and an exponential growth is expected in the smart city market [12].

Sassen [13] gives primacy to people, claiming that if a smart city does not mobilize its citizens' intelligence, then it is not that smart and it is no more than the plain implementation of technical services. When people are added to this equation, everything gets more complicated. People do not all have one same shape and we cannot control their opinions, wishes or concerns.

Smart cities are complex systems, often called "systems of systems," including people, infrastructure, and process components (see Fig. 2).

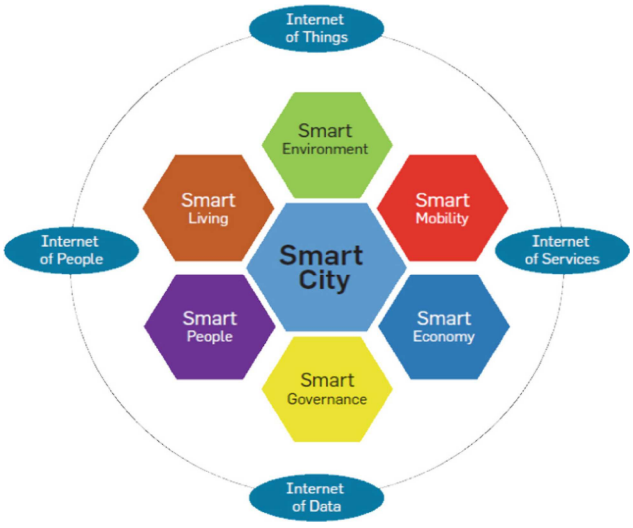

Fig. 2. A smart city model (Source [14]).

Most smart cities models consist of six components: government, economy, mobility, environment, living, and people [14].

4 Internet of Things

Since the beginning of the Internet in the late 1960s, when the number of linked sites was reduced, through the 1990s when 1 billion people connected to the Internet with their desktops and laptops, and by the first decade of the 21st century, where more than 2 billion people connected to the Internet through their phones cell phones, and Cisco Systems has predicted that 25 billion things will be connected to the Internet and to each other in 2015, being this number in 2020 doubled (50 billion) [15, 16].

Innovation at the information and communication technologies level is happening at fast speed. Since the rapid development of wireless technologies, sensor networks, smart networking, and wearable's are creating new sources of business value [17].

IoT represents the first real evolution of the Internet, with a major advance in the ability to collect, analyze and distribute data. It represents a breakthrough that will lead to the use of revolutionary applications. The number of devices like tablets, smart phones, personal computers, laptops, PDAs and even other portable embedded devices connected to the Internet is increasing and a large part of these mobile devices incorporates different sensors and actuators that can detect, make intelligent decisions, perform calculations and transmitting collected information via the Internet. A network of such devices with different sensors can give rise to numerous amazing applications and services that can bring significant personal, professional and economic benefits [18].

The Internet of Things (IoT) is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies [19].

5 Research Approach

The unprecedented urban growth rate gives rise to an urgent need to find more intelligent ways of managing challenges [20]. However, little has been said about what residents/citizens understand by smart city or about internet of things and what technologies should be implemented for a city to be identified under that denomination.

With a view to empirically characterize citizens' opinion on the relationship between smart cities and internet of things, the application of the survey technique seemed appropriate, since it enhances a clear, straightforward and objective answer to the questions presented to the respondents. Moreover, since the aim was to characterise a high number of people, such number made the use of alternative research techniques impossible or not recommended.

5.1 Population

Since the inland cities integrating RENER are in lower number than the coastal ones, our interest in the inland cities grew. Nonetheless, the major question was: How do we get to the citizens of those cities? In the first place, among the 10 possible cities, the choice fell on those which might eventually be considered the most remote due to the fact that they are further from big urban centers and smaller.

Secondly, which citizens should be inquired? Since many selection criteria were found possible, a relatively deep analysis was made and one criterion was chosen. The survey would be conducted in higher education institutions.

Therefore, two inland cities in Portugal were selected and the study sample was composed of the students and teaching and non-teaching staff of two Polytechnic Institutes. Since the email addresses are available in the portal of each institution, the selection of the sample was relatively easy. In order to carry out the survey, 450 online questionnaires were sent to the 450 citizens constituting the sample. Among those, 273 people answered the questionnaire, which corresponds to a response rate of 61%.

5.2 Structure

The structure of the survey resulted from the review of literature regarding smart cities. The survey questions, to be answered individually and confidentially, were organized into three groups. The first group corresponds to the characterization of the respondents. The second group is related to the main questions leading this study, which are what they understand by smart city and what technologies they consider important for a city to be considered a smart one. The third group aims to assess what areas the respondents consider as priorities, what technological resources they find important in the transformation of a city and which they find to be the most imperative. The last question asked was whether or not they consider the city where they live a smart city.

6 Results

The data analyzed for the presentation of these results was produced based on a representative sample of students, teachers and other staff from polytechnic higher education institutions. Among the sample, 59% of the respondents are male and 41% female.

The ages of the respondents range from 19 to 63 years old. Among the 273 people surveyed, 198 are students, 58 are teachers and 17 are other staff. As was mentioned in the section on the structure of the questionnaire, a number of questions were put to the respondents; however, given the incidence of this work, it is the issues related to the second and fourth survey groups that will merit our attention.

The second group of questions in the survey inquired the respondents over what they understand by smart city. From the 273 respondents, 62 stated that they did not know what a smart city was and therefore could not define it.

Among the remaining answers (211), a number of definitions were given, some of them being transcribed as follows: “They are environmentally friendly cities, where the

use of public transport and other means which do not pollute so much is promoted"; "They are cities with projects which enable to spend less electrical energy, investing in other energy sources"; "They are cities considered to be intelligent, which invest in the use of information technology to make their residents' life easier"; "… it is a city where there are easy, accessible and sustainable ways to provide quality of life at the disposal of the citizen". It is clear that it is difficult to reach one single concept to define a smart city. However, from the answers obtained, it can be said that some aspects are mentioned more often, which enables us to state that for the respondents of this survey, a smart city is one where a number of projects are implemented using technology as a means to improve the life of the people who live in those cities.

Another approach was if they could define what the Internet of things is. Of the 273 respondents, 152 replied that they did not know what the Internet of Things was and therefore could not define it.

The remaining 121 developed some definitions: "…sensors installed on the treadmills"; "It is the Internet directed to" things ", considering" things "such as buildings, public transportation, parking lots etc"; "They are technologies that, for example, installed in a city lead to smarter city management"; "They are digital network connections, interactions and controls of everyday objects, appliances and vehicles"; "They are technological devices and tools that make life easier for people, for example streamlining processes in public administration"; "… allows the connection of everyday objects between us and the internet".

When talking about Smart City and Internet of Things there is a term that stands out, "connectivity", as this is what will allow us to interconnect various devices to the Internet. Asked how many devices are connected to the Internet, the responses can be observed in Fig. 3. Most respondents have between 1 and 3 devices connected to the Internet.

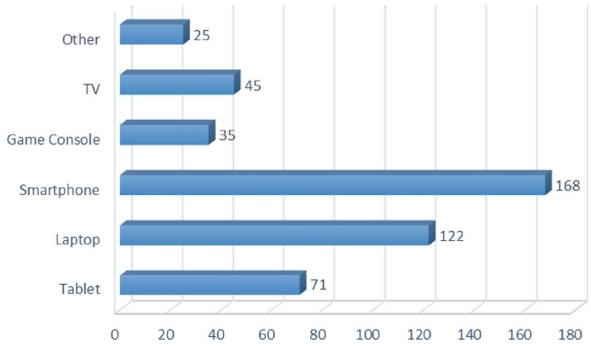

Fig. 3. Connectivity of devices.

Asked about the integration of different aspects and the benefits provided by the intelligent city, the answers were dissolved by the various options (see Fig. 4). It should be noted that the answers in this question were multiple choice.

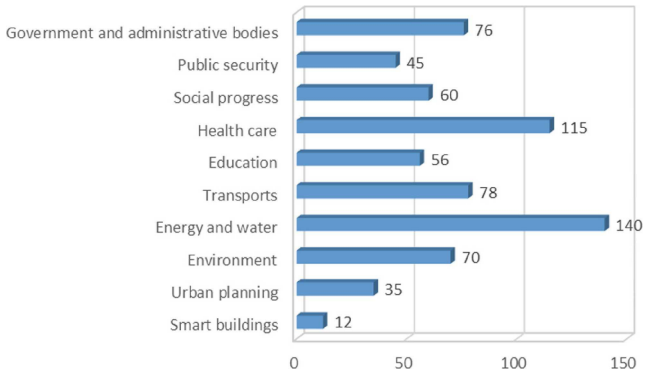

Fig. 4. Aspects to consider.

As can be seen, the highlights are Energy and Water, followed by Medical Assistance, Government and Administrative Bodies and the Environment.

Asked if they considered that there is a relationship between the use of the Internet of Things in cities and their classification as smart cities, the answer was almost unanimous, since 92% of respondents consider that yes, against 8% who think that a city can be considered a smart city without using any kind of information and communication technology.

Was observed that 235 (96%) of the respondents considered that there is a relationship between the applicability of the Internet of Things and a city considered to be intelligent, 22 (8%) do not consider there is any relation and 16 (6%).

7 Conclusions

One of the main IoT goals is to make the Internet more immersive and pervasive. As a network of highly connected devices, IoT technology works for a range of heterogeneous devices (such as sensors, RFID tags, and smartphones). Multiple forms of communications are possible among such "things" and devices. IoTs must be designed to support a smart city's vision in terms of size, capability, and functionality, including noise monitoring, traffic congestion, city energy consumption, smart parking meters and regulations, smart lighting, automation, and the salubrity of public buildings [21]. They must exploit the most advanced communication technologies, thus supporting added-value services for a city's administration and citizens [14].

With the possibility of everything connected, developments aimed at intelligent cities are gaining more and more expression, as they generate benefits and consequently a better quality of life for the citizens who inhabit it. Without doubt, the Internet of Things is the new technological period that will eloquently change the way people interact, cities and "things". One of the limitations of this research work is the delimitation of the study to two regions. While it is believed that sufficient data has been generated for the purposes of this paper, it will readily be accepted that a greater number and scope could result in a richer and more sustained data set.

Among the future work to be done, the scope of the study is highlighted to other regions of the country or even to other regions of the globe.

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