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Smart City: A Rigorous Literature Review of the Concept from 2000 to 2015

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Abstract. This paper provides a thorough review of publications on smart city from 2000 to 2015 aiming at clarifying the concept. Grounded theory principles are used to systematize and understand the different meanings arising from initiatives in the area. Results have shown that smart city settings in the analyzed period allow the expansion of knowledge on the subject and a better understanding of the concept in its semantic and structural dimensions from the use of coding techniques. The concept of smart city has evolved from an initial emphasis on the technological aspect to a current approach, more focused on human, social aspects and participatory governance aiming at sustainability and quality of life. There have also been efforts to define the theoretical core of the smart city phenomenon due to the prevalence of qualitative and exploratory studies in the period and in recent publications with insufficient definitions to the concept.

Keywords. Smart city, Grounded Theory, Literature review.

1. Introduction

Studies show that more than half of people lived in urban areas in 2010 [1] and this number may increase 75% by 2050 [2, 3] as a consequence of population growth. This scenario points to the rapid urbanization of society and the emergence of challenges related to the management of cities in order to find ways to treat and solve problems related to population growth, such as traffic, air pollution and increased crime [1].

The concept of smart city arises in the search for innovative solutions to these management challenges. It brings a new approach to address these urban problems aiming at a sustainable city and quality of life [1, 4]. It has an extended meaning since it represents an alternative and sustainable way to these problems in urban areas.

The concept of sustainability covers aspects related to the economy, governance, environment, people, mobility and the way of life in its framework developed for smart cities [5]. There are also other initiatives adopting different definitions of smart city in various research fields, characterizing it as multidisciplinary.

It is relevant to broaden the understanding of the concept of smart city. This study intends to contribute conceptually to the debate on this issue, reviewing systematic publications from 2000 to 2015. It employs analysis principles of the Grounded Theory (GT) [6] looking for a possible answer to the following question: what are the different definitions and meanings adopted in these publications to the concept of smart city? The results of this study may contribute to this multidisciplinary management

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approach to cities' urban problems as it can brighten and systematize the concept of smart city from previous publications on the subject.

Besides this introduction, the paper is organized in four sections. Section 2 deals with the concept of smart city. Section 3 presents the methodology adopted here while section 4 shows the analysis of valid publications for the scope of this study and its results. In section 5, final considerations about the study are presented and discussed.

2. Smart City

The smart city theme has its origin in the search for quality of life among citizens living in urban areas. This challenge involves practices and initiatives to improve the services offered by public management and sustainable urban development. As a result, a number of initiatives and projects are being developed worldwide [7].

In the literature on this topic the concepts of digital city and ubiquitous city (U-city) can be found; however, the concept of smart city is regarded as more comprehensive than the others, although they are all linked and have semantic similarities since they require specific settings for the understanding of each of the concepts [7].

Smart city in turn has a similarity with the concept of digital city [27]. Although there is an overlap with the concepts of digital and ubiquitous cities, smart city may be considered a broader concept, aiming to unite, promote and encourage dissemination of information and, therefore, quality of life for all citizens [7]. It differs due to the collaborative aspect among stakeholders of the city, including citizens [8].

The broader scope of smart city is evident when analyzing its origin and stages in the evolution [9], mainly, from 2010, when the concept is seen as an opportunity to increase quality of life, emphasizing both hardware and software. The concept de-parts initially from a point of view restricted to technology infrastructure, evolving in recent years to a systemic view, which considers all the parties involved and their relationship, an approach now focused on sustainability and improved quality of life.

However, it appears that there is still no consensus on the definition of smart city in the scientific community [4, 10, 11, 12, 13, 14, 15, 16, 17, 18]. The concept is adopted internationally with different terminology, contexts and meanings and also with variation around the word smart, which has been adopted as digital and as smart [4]. Alawadhi et al. [1] report extensive discussion about definitions of smart city with different emphases being placed on natural resources and on technology. Another study suggests a knowledge-based conceptual vision of the smart city [16], centered on people's information and knowledge of people, in order to improve decision-making processes and enhance the value-added of business processes of the city Meijer and Bolívar [18] point out that smart cities governance approaches have ended up reproducing fuzzy and inconsistent literature on the concept of smart city.

Remarkably, in one of the first publications on the topic already represented an expanded concept, mobilizing different forces, multidisciplinary aspects and agents looking for an innovative and sustainable solution to the various problems of cities urbanization: "smart city is a city well performing in a forward-looking way in these six characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens" [5, p.11]. In addition to the digital and technological perspective of the city, it includes the active involvement of stakeholders through an interactive and participatory urban environment favoring co-creation.

Smart city can be regarded as an instance or exercise of e-Government (e-Gov), being a part of this domain. As much as e-Gov, the concept of smart city is still under development and far from reaching maturity, being considered underdeveloped in many areas [19], within its scope and understanding, deals with lack of organization, standards and more systematic academic studies [20] being an emerging field [18].

3. Research Methodology

This is a qualitative and exploratory study [21]. It carries out a review of the literature aiming at providing a systematic account of the concept of smart city [22] and applying principles of analysis from GT [23, 24, 26]. It allows an in-depth and theoretically relevant analysis of the research topic [6] resulting in a greater contribution. Data gathering criteria included scientific articles published between 2000 and May 2015 from ProQuest, Science Direct, Scopus and version 10.5 Egrl databases [25] which contained the keywords "Smart City/Smart Cities" or "Digital City/Digital Cities" in their abstracts. Non-academic studies or incomplete texts were excluded.

All 168 articles identified in this stage were stored in digital repository and the files named with the title with no special characters to avoid the occurrence of duplicate work in the initial sample. For refinement, the introductory sections and theoretical basis of these articles were read in order to extract the smart city concept adopted and further spreadsheet cataloging of each study selected. In this refinement, 107 articles were discarded because they did not contain such a concept and 32 previous studies cited in the collected publications were added to the final survey sample.

Content analysis of the final sample articles involved the application of analysis principles from GT [23, 24, 26], by means of open coding, axial coding and selective techniques in the concepts extracted from these publications [6]. Introductory sections and theoretical basis of the articles were examined again in depth, with the goal of identifying codes that represented the meaning of smart city to the authors.

Categories emerged from the identified concepts and codes and were arranged in dimensions: semantic and structural. The Semantic Dimension (SD) refers to the meaning and the role that the concept of smart city expresses in the categories "what?" and "what for?" respectively. The Structural Dimension (ScD) is concerned with smart city components and refers to the way the concept is formed or structured, represented by the category "how?". Full analytical framework resulted from encodings [6] and each identified code was described in detail in a memorandum with excerpts of the concepts in the dimensions and categories already mentioned. The description and the codes in the analytical framework were refined and adjusted in each article of the sample. Qualitative analysis here differs from previous studies by analyzing various concepts in these two dimensions and by employing principles of analysis of the GT [23, 24, 26] in a rigorous literature review [6].

4. Data analysis

The articles analyzed were categorized by year, and 2013 and 2014 contain the highest number of publications. Following the criteria adopted no article was found between 2008 and 2010. The analysis identified 37 definitions, distinguished in DS and ScD,

which demonstrates the academic effort to create a definition for this new urban phenomenon, in development since the first definition found in 2000.

Table 1 presents the ten most cited definitions in an analytical framework resulting from the application of coding techniques. The contents of the "What?", "What for?" and "How?" were listed considering the settings shown in the definition and presented under "Cited by". The analysis of different definitions in the literature using the principles of GT enabled the identification of a multi-dimensional nature to the concept, which can be seen in the semantic and structural dimensions shown in Table 1.

Table 1. Semantic Dimension (SD) and Structural Dimension (ScD) of smart city

Ten most cited definitions
Definition: A city that invests in human and social capital and traditional and […] [28]; **SD: What?** Participatory city; **SD: What for?** Sustainable economic growth, Quality of life, Management; **ScD: How?** ICT, Social and Human Capital, Participatory Governance; **Cited by:** [3, 4, 15, 18, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54].
Definition: A city well performing in a forward-looking way in economy, people, […] [5]; **SD: What?** Combined city; **SD: What for?** Performance, Independence, Awareness; **ScD: How?** Citizen actions; **Cited by:** [3, 4, 7, 8, 13, 14, 15, 17, 18, 31, 32, 34, 36, 37, 42, 46, 47, 49, 50, 51, 53, 54, 55, 56, 57, 58, 59, 60, 61].
Definition: [...] territories with a high capacity for learning and innovation, which is […] [11]; **SD: What?** Evolved city; **SD: What for?** Politics, Inclusion, Equality, Innovation; **ScD: How?** Advanced technologies; **Cited by:** [3, 14, 15, 18, 30, 31, 33, 36, 41, 42, 43, 45, 49, 50, 53, 54, 59, 62, 63, 64, 65, 66, 67].
Definition: A city that monitors and integrates conditions of all of its critical […] [70]; **SD: What?** Monitored city, integrated city; **SD: What for?** Optimality, Planning, Preventive maintenance, Monitoring, Public services; **ScD: How?** Infrastructure; **Cited by:** [3, 4, 14, 15, 35, 43, 50, 53, 54, 59, 68, 69, 59].
Definition: An instrumented, interconnected and intelligent city. […] in the […] [71]; **SD: What?** Monitored city, Connected city, Virtual city; **SD: What for?** Visibility, Monitoring, Integration, Provision of services, Optimality, Decision-making; **ScD: How?** ICT; **Cited by:** [4, 13, 14, 32, 53, 54, 55, 59, 68, 69].
Definition: The use of Smart Computing technologies to make the critical […] [72]; **SD: What?** Connected city; **SD: What for?** Provision of services, Interconnection, Efficiency; **ScD: How?** ICT; **Cited by:** [1, 4, 13, 14, 18, 55, 59, 68, 69].
Definition: A city combining ICT and Web 2.0 technology with other organizational […] [73]. **SD: What?** Combined city; **SD: What for?** Sustainability, Life quality; **ScD: How?** ICT, Web Technology 2.0, Organizational efforts; **Cited by:** [4, 15, 20, 39, 63, 68, 69].
Definition: [...] as the organic integration of systems. The interrelationship between a […] [74]. **SD: What?** System of systems; **SD: What for?** Integration; **ScD: How?** Systems; **Cited by:** [4, 47, 52, 59, 77, 81].
Definition: A city striving to make itself "smarter" (more efficient, sustainable, […] [75]; **SD: What?** Effort; **SD: What for?** Efficiency, Sustainability, Equality, Livability; **ScD: How?** -; **Cited by:** [4, 13, 55, 59, 68].
Definition: […] city well-performing in a forward-looking way in various […] [76]; **SD: What?** Combined city; **SD: What for?** Performance, self-government, Awareness; **ScD: How?** Citizen actions; **Cited by:** [13, 14, 20, 69, 77].

It also shows the evolution of the smart city concept from a restricted technological infrastructure perspective to a systemic perspective [9]. In recent years, however, the concepts have considered all parties involved and their relationship, emphasizing sustainability and improved quality of life through participatory governance. This evolution in definitions resulted from the evolution of society itself, which has started to value information and quality of life in cities more. Problems with traffic, crime, energy, for example, have demanded incremental needs and, as a consequence, innovative solutions with citizen participation on the part of government and industry.

In DS the significance of the city is expanded to a geographical area with a high level of development and capacity for learning and innovation from the effective participation and people's actions [11]. In this sense, smart city is shown as a new paradigm of intelligent urban development and sustainable socio-economic growth. When analyzing the concept of function in DS, one confirms its broader scope, encompassing various departments and areas of the city. This characteristic suggests a

possibility of implementing smart cities initiatives with direct and indirect benefits to the city, its inhabitants and visitors on a larger scale and even beyond their initial expectation.

As far as the way or the means by which the concept can be operated in ScD, one finds that there is no fundamental centralization in ICT as in early publications. Therefore, in this dimension of concept analysis, structuring of a smart city initiative depends and can be complemented by other factors besides technological ones such as effort and effective participation of city citizens.

An extensive, multidisciplinary literature on smart cities is found in the sample with publications in various fields, when examining the areas of knowledge and sources of articles whose concepts were extracted and analyzed. The diversity of research fields in the analyzed publications may help explain the fuzzy characteristic of the concept and the various definitions found for smart city. Since it is a multidisciplinary literature, each research field adopts their perspective to interpret and give meaning to the concept. This multidisciplinary character and the multidimensional nature of the concept identified in coding and in the use of analytical principles of GT, can account for the inaccuracy of the concept as well as for the difficulty in recognizing a unique concept in this field and its related scientific production.

There are some definitions often mentioned in publications, which, in the final sample, can be considered as established definitions [5, 11, 28]. There are also recent works, self-defined, with few or no quotation [3, 37, 78] and other less cited that were removed due to space limit. These works provide a conceptual contribution on this issue and represent an ongoing effort to define the concept in the scientific community.

5. Final remarks

Other similar literature reviews were made also with different search criteria and methods [79, 80]. However, this work contributed conceptually to the debate on smart city through a rigorous literature review based on principles of analysis of the GT [6]. It shows a possible answer to the question guiding this study, consolidating and systematizing different definitions and meanings in Table 1, which was built from a review and rigorous analysis of the content of relevant and recent publications on the subject. The results obtained here corroborate the findings by Chourabi et al. [4], highlighting the fact that the smart city conceptualization is still underway in the scientific community, considering different definitions of this concept in this research.

There is a need for in-depth studies of a unique initiative of smart city [1] and this practice can also be found in most publications analyzed in this study. The focus and goal of research prevalent in these publications are associated with qualitative approach and exploratory objective, an academy effort to define the theoretical core of the smart city phenomenon. The criterion adopted for the selection of initiatives is not shown in the analyzed publications and neither was the concept of a smart city initiative identified in the content. This can be evidenced by the volume of discarded publications of the initial sample and may be due to the maturity level concerning the topic, suggesting the need for academic research on a continuous basis to broaden understanding of the concept and of the phenomenon.

Further research may be carried out on the content of these publications in order to identify research gaps. A comparative analysis of concepts in relation to the approach or theoretical framework adopted as a basis here and the type of research goal can also

be conducted for trend identification and research opportunities. An expansion in the scope of analysis to include definitions from the industry and other bodies.

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