Understanding the Smart City Domain: A Literature Review

Leonidas G. Anthopoulos

1 Introduction

Although the term smart city has appeared since 1998 (Van Bastelaer 1998), it is still confusing with regard to its meaning and context (Anthopoulos and Fitsilis 2013), since its definition ranges from mesh metropolitan information and communication technology (ICT) environments (Mahizhnan 1999); to various ICT attributes in a city (Chourabi et al. 2012; Allwinkle and Cruickshank 2011); to urban living labs (Komninos 2002); or to the "smartness footprint" of a city, which is measured with indexes such as, the education level of its inhabitants, the innovative spirit of its enterprises, etc. (Giffinger et al. 2007). The term smart city appeared early in the literature in 1998 (Van Bastelaer 1998; Mahizhnan 1999) from the urban simulations and knowledge bases and is still evolving to eco-cities (Anthopoulos and Fitsilis 2013).

All these different meanings address the scale and complexity of the smart city domain and describe alternative approaches, schools of thought and researchers who deal with this phenomenon. Furthermore, smart cities have attracted the international attention by international organizations (i.e., the European Union (EU; Anthopoulos and Fitsilis 2013)) and big vendors from the ICT industry (i.e., CISCO (2011), IBM (IBM Institute for Business Value 2009) and Alcatel (Alcatel-Lucent 2012)); the electronics (i.e., Hitachi (2013)); and the construction industries (i.e., GALE, POSCO, and HGC Group (Alcatel-Lucent 2012)) are stressed to develop respective products and to utilize this emerging market. To this end, this chapter aims to answer the following question: "What fundamental theories, models, and concepts in research (published between 1998 and 2014) reflect phenomena related to smart city?" This question is crucial to be answered since interdisciplinary studies investigate the smart city and view this topic from different perspectives.

L. G. Anthopoulos (✉)
Department of Business Administration, TEI of Thessaly, Thessaly, Greece
e-mail: lanthopo@teilar.gr

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To answer the above question, this chapter was inspired by Niehaves (2011), methodology for performing a holistic literature review and analyzes different sources that investigates smart city and uses some of its context. This analysis attempts to identify authors, schools, approaches, case studies; classifies research projects and business products; and generates a taxonomy that can clarify this complex domain. To this end, the remaining of this chapter is organized as follows: Section 2 examines the relevant general literature on smart cities, while methods and data on this theme are set out. Section 3 summarizes the literature findings, whereas Sect. 4 contains some conclusions and future thoughts.

2 Background

Various scholars have stressed the smart city term since its initialappearance in 1998 (Van Bastelaer 1998) and attempted to analyze its context (Anthopoulos and Fitsilis 2013; Chourabi et al. 2012; Neirotti et al. 2014; Caragliou et al. 2011; Kuk and Janssen 2011). This chapter extends these approaches and findings with a methodological literature review, which is inspired by Niehaves (2011). In this section, the challenges with regard to the smart city domain are analyzed. Subsequently, the literature search strategy is defined and the corresponding review is performed in order for this chapter's research question to be answered. A rigorous literature study requires defining (a) the domain (the disciplinary field in which the literature search is conducted), (b) the sources (publication outlets from that domain to be included in the search), and (c) the search strategy (search terms applied to extract relevant articles).

a) Domain: This chapter's goal is to examine the smart city research. In this respect, a smart city has been defined with alternative approaches, which range from ICT attributes in the city (i.e., digital, broadband, wireless, etc.) that describe various ICT solutions in the urban space and prioritized differently across the globe (Anthopoulos and Fitsilis 2013); to the "smartness footprint" in an agglomeration area, which is measured with various indexes (Giffinger et al. 2007); to information flows across the urban space (Stock 2011); and to large scale to living labs (Komninos 2002). With this respect, the smart city can be viewed broadly and concerns theinterdisciplinary studies (Anthopoulos and Fitsilis 2013; Anthopoulos and Vakali 2012) such as ICT; urban planning and growth; living labs as large-scale testing beds; eco or green city and corresponding ecological aspects; and creative industry in a city. All the above scientific areas appear to "meet" in smart city and various outcomes are generated.

b) Sources: Therefore, as primary sources for this literature review (phase 1), the following bundles of publication outlets were selected: first, those from journals that publish corresponding works; second, those from major conferences that publish articles relative to smart city in their proceedings; reports from research projects, which have been or are being developed in this domain; corresponding PhD dissertations; research projects funded by the European Framework Programmes

(FPs); and business products. Volumes from 1998—when the first articles appear—till today were included. Journal selection was based on editorial policy conformity with smart city, as well as the criteria that they publish currently (resp. 2014) and have a high level of scholarly recognition (Saunders et al. 2009).

In this study, an initial search for source identification was conducted in SCOPUS, Science Direct and Google Scholar. The queries that were used contained "smart city" and relevant terms (i.e., "digital city," "ubiquitous city," etc.) that were identified by Anthopoulos and Fitsilis (2013) as smart city classification areas (Table 1).

The initial search was performed in late January 2014. A broad set of results was returned, where many journals—only in Elsevier an amount of 37 journals—appear to publish relative to smart city works. This initial finding is not surprising due to the broad smart city context. It is beyond the purposes of this chapter to illustrate how many articles per journal appeared. Moreover, for the purposes of this chapter, these results were limited to the ICT context, which resulted in a list of 32 journals from various publishers. This list contains the *Communications of the ACM; International Journal of Electronic Government Research; New Media & Technology; Public Administration Review; Cities; Pervasive and Mobile Computing; Journal of Urban Technology; Environment and Planning B; City; Environment and urbanization; Applied Geography; Information and Management; Electronic Commerce Research and Applications; Expert Systems with Applications; Sustainable Cities and Society; IEEE Internet Computing; Wireless Communications Journal; Behaviour and Information Technology; Journal of The Association For Information Science And Technology; Technological Forecasting & Social Change; Journal of Economic Literature; Future Generation Computer Systems; Automation in Construction; Environmental Modelling & Software; Applied Energy; Habitat International; Journal of e-Government; Government Information Quarterly; Electronic Government, An International Journal (EGAIJ); International Journal of Electronic Government Research; Information Polity; Electronic Journal of e-Government; Transforming Government: Process, People and Policy; and Journal of Information Technology and Politics*. All were located to have hosted several articles regarding smart city dated from 1998.

Table 1 Terms for phase 1 search and corresponding article results

Term	SCOPUS	Science Direct	Google scholar
Smart city	616	198	389
Digital city	448	188	405
Virtual city/information city	331/43	264/74	239/33
Knowledge based city	10	12	10
Broadband city/broadband metropolis	1/1	8/1	0/2
Wireless city/mobile city	27/33	20/30	47/57
Ubiquitous city	61	16	59
Eco-city	264	215	494

Fig. 1 Search method.

The above systematic search in journals was complemented by an analysis of secondary sources (phase 2), including articles referenced by papers identified in phase 1, as well as articles from non-systematic searching (especially in conference proceedings and books), research projects' reports, PhD theses and business products (Fig. 1). To this end, international conferences that have been organized by IEEE, that is, the Hawaii International Conference on System Sciences (HICSS), Info-tech and Info-day and PICMET; Digital Government Society (dg.o); DEXA; United Nations University (ICEGOV); Association for Information Systems (AMCIS); and IARIA also demonstrate relevant work. Various scientific books that have been published by publishers such as Springer and Routledge host as technological aspects, social issues, financial and managerial perspectives of the smart city, etc. Finally, postgraduate dissertations and PhD theses have been developed in the smart city domain and they return useful findings with regard to smart city and urban development (Lee and Oh 2008; Wang and Wu 2002).

c) Search strategy: As for the articles published in the aforementioned list of journals, their title, abstract, and keywords were scanned for smart city classification terms (Table 1). From the resulting set of articles, duplicates, and papers irrelevant to this study were excluded manually (screening). This applies to papers irrelevant to the ICT, for instance, on "urbanism" returning from the crawl of the search term "city"; "houses" that came up from "smart city"; and to "smart city regionalism" that was triggered by "smart city". Moreover, due to the size of the returned results, emphasis was given on a set of the most recent articles (dated between 2011 and 2014), as well as on corresponding review articles, which have already analyzed extensive literature parts. A comparison was performed on these review articles, with regard to the perspectives (or domains) they use to analyze smart city and a common framework is summarized.

As a result, 41 publications related to the smart city domain were selected and analyzed in this chapter, 24 of which were extracted from corresponding journals (Table 2). Most of these papers, five in each, were identified in *Technological Forecasting & Social Change,* while *Cities* and *Journal of Urban Technology* follow with three articles. *Journal of Urban Technology* alone, has published several works

Table 2 Smart city in research journals (1998–2014)

Investigated journals	Results from crawling "smart city"	Dated after 2011	Number of articles after screening	Results (complete list)
Technological Forecasting & Social Change	134	50	5	Bulu (2014); Lee et al. (2014); Lee et al. (2013); Marletto (2014); Paroutis et al. (2014)
Cities	305	170	3	Neirotti et al. (2014); Debnath et al. (2014); Desouza and Flanery (2013)
Journal of Urban Technology	96	35	3	Allwinkle and Cruickshank (2011); Caragliou et al. (2011); Kuk and Janssen (2011)
The Journal of Systems and Software	50	23	1	Piro et al. (2014)
Journal of the Association for Information Science and Technology	43	18	1	Stock (2011)

in smart city domain (96 results come out from the keyword "smart city"), but only three have been included in this chapter's analysis according to their relevance and date.

The smart city was introduced in the Australian cases of Brisbane and Blacksbourg (Anthopoulos and Vakali 2012) where the ICT supported the social participation and the community's cohesion with the narrowness of the digital divide, together with the availability of public information and services. The smart city was later evolved to (a) an urban space for business opportunities, which was followed by the network of Malta, Dubai, and Kochi (www.smartcity.ae) and (b) ubiquitous technologies installed across the city, which are integrated into everyday objects and activities.

Moreover, smart city has been approached as part of the broader term of digital city by (Anthopoulos and Tsoukalas 2006), where a generic multi-tier common architecture for digital cities was introduced, and assigned smart city to the software and services layer of this architecture. For the purposes of this chapter, the term smart city will refer to all alternative approaches to metropolitan ICT cases. In the following paragraphs an analysis over various important smart cities is presented, outlining their mission, business case, and organizational structure.

Anthopoulos and Fitsilis (2013) performed an extensive review on smart city technological evolution and resulted in a corresponding classification with regard to the ICT that is installed in urban agglomerations. Churabi et al. (2012) investi-

gated smart city definition and concluded on an integrative framework for smart city analysis. Neirotti et al. (2014) provide a recent corresponding literature review and they define two classification domains for smart city theory with regard to the exploitation of tangible and intangible urban assets: Hard domain, which concern energy, lighting, environment, transportation, buildings, and health care and safety issues. Soft domain, which address education, society, government, and economy. From their domain analysis, they conclude on six application domains for smart city, which address corresponding challenges: natural resources and energy, transport and mobility, buildings, living, government, and economy and people. This six-domain model comes in contrast to the six main challenges to managing an urban community: providing an economic base, building efficient urban infrastructure, improving the quality of life and place, ensuring social integration, conserving natural environmental qualities, and guaranteeing good governance (Yigitcanlar and Lee 2014). Additionally, an analysis over a set of European research projects (Piro et al. 2014) addresses nine smart growth areas: transportation, government, safety, society, health care, education, buildings and urban planning, environment, energy, and water. Furthermore, Desouza and Flanery (2013) perform a smart city classification with regard to their resilience and they identified seven domains (components and interaction), which concern resources, physical, people, institutions, processes, activities, and social. Moreover, Lee et al. (2014) introduce their framework for smart city analysis, which is rather economic oriented and consists of seven dimensions: urban openness, service innovation, parnerships formation, urban proactiveness, infrastructure integration, and governance. New urbanism on the other hand (Wey and Hsu 2014), introduces a nine principles' model, most of which aligns to the aforementioned application domains, while it does not focus on government issues. This comparison seems to extend Giffinger et al.'s (2007) urban smartness "footprint" measurement model, with the incorporation of two more domains: urban infrastructure and social coherency (Table 3).

However, an in-depth analysis of the articles in this study extends the above review and provides an evidence of the following arguments and key areas of the study:

a. Smart city: A wide range of articles were identified to present various ICT approaches to urban challenges. These challenges vary from measuring and increasing urban capacity for smartness (smartness "footprint"; Giffinger et al. 2007; Akçura and Avci 2014; Lee et al. 2014), everyday life's improvement (Piro et al. 2014), energy consumption (Kramers et al. 2014; Lazaroiu and Roscia 2012; Kim et al. 2012; Yamagata and Seya 2013), urban planning and building architectural facts (Rassia and Pandalos 2014; Vollaro et al. 2014). Moreover, 19 research projects, which were funded by the EU (Piro et al. 2014), are focused on Internet-of-Things (IoT), the corresponding architectures and smart city services, while they are aligned to nine application domains.
b. Smart growth: With regard to sprawl management and resilience (Desouza and Flanery 2013; Wey and Hsu 2014); hard asset management such as transportation (Marletto 2014; Debnath et al. 2014), even with big data utilization

Table 3 Smart city conceptual framework

Domain	Neirotti et al. (2014)	Piro et al. (2014)	Desouza and Flanery (2013)	Wey and Hsu (2014)	Lee et al. (2014)	Yigitcanlar and Lee (2014)	Churabi et al. (2012)	Giffinger et al. (2007)
Resource	Natural resources and energy	Environment, energy, and water	Resources	Sustainability	Urban proactiveness	Environment	Natural environment	Smart environment
Transportation	Transport and mobility	Transportation	Activities	Walkability, green transportation				Smart mobility
Urban infrastructure	Buildings	Buildings and urban planning	Physical	Quality architecture and urban design, mixed housing, traditional neighborhood structure	Infrastructure integration	Urban infrastructure	Built infrastructure	
Living	Living	Health care, safety, education	People	Increased density	Quality of life	Quality of life and place	Technology	Smart living
Government	Government	Government	Processes		Governance	Good governance	Policy, governance	Smart government
Economy	Economy and people		Institutions	Mixed-use and diversity	Urban openness, partnerships formation, service innovation	Economic base	Economy	Smart economy
Coherency		Society	Social	Connectivity		Social integration	People and communities	

(Dobre and Xhafa 2014); to smart communities' and urban innovation networks' development, which account cities within regional and national urban systems (Malecki 2014; Lee et al. 2013); sustainable development and eco-living (Yigitcanlar and Lee 2014; Yamagata and Seya 2013); or even city's efficiency and effectiveness increases (Bulu 2014).

c. Living labs: They concern areas for large-scale testing beds (Cosgrave et al. 2013) as well as flourish landscapes for citizen-sourced innovation (Komninos 2002; Pallot et al. 2011); citizens as sensors is a novel approach that is applied for bottom-up information collection from the urban space (Arribas-Bel 2014; Sanchez et al. 2011).
d. Creative industry: It concerns ICT utilization for entrepreneurship in creative market (Anthopoulos and Fitsilis 2013); the niche smart city market, which varies from "smart city in a box" products (Paroutis et al. 2014; Alcatel-Lucent 2012) as well as cities from scratch (Lindsay 2010).

3 Discussion

The number of the located research journals (32 journals) and their context's differentiation—varying from construction, energy, social sciences, transportation, urbanship, ICT, etc.—that present corresponding to smart city works illustrate the attention, which the scientific community pays on this domain. The term is confirmed to be ambiquous, although the perspectives (application domains) that scholars use to approach smart city can be considered to be common.

The outcomes from the analysis of these articles illustrate that despite identifying 24 exceptional articles, which are clearly oriented to smart city, their corresponding scholars approach the term with four key areas (schools of thought): smart city, smart growth, living labs, and creative industry. Representatives from these schools approach the smart city from corresponding perspectives and utilize the intelligent urban space with means that address particular problems (i.e., creative industry considers city's capacity for innovative or media production).

Moreover, a conceptual framework for approaching a smart city appears to be structured and consists of the following application domains:

- *Resource (utilization and management)*: deals with natural resources, energy, water monitoring and management
- *Transportation*: concerns ICT utilization for transportation management, as well as intelligent transportation products and mobility in general
- *Urban infrastructure*: refers to building, agglomeration and sprawl management with the ICT
- *Living*: covers education, health, safety, and quality of life in urban space
- *Government*: mentions public e-service delivery, e-democracy and participation, accountability and transparency, and administration's efficiency within the city

- *Economy*: covers areas that reflect domestic product in city, innovative spirit, employment, and e-business
- *Coherency*: deals with social issues that address digital divide, social relations, and ICT connectivity

Beyond the above analyzed journal articles, a set of 17 publications was analyzed under phase 2 which contributes useful findings to this chapter. An important outcome concerns the involvement of three different industrial sectors (ICT, electronics and construction) in this niche international smart city market. Major representatives from these three industries appear (i.e., Gale and HGC; CISCO and Alcatel; and Hitachi accordingly) to play an important role in this market's formulation and they are mainly grounded in the USA and in the emerging Asian market.

Another useful finding concerns the identification of an indicative representative picture with regard to the most recently active countries, their involved stakeholders (universities, research centers, enterprises, etc.) and scholars (Table 4). From the investigated articles it appears that although smart cities are spread around the globe, this domain mainly interests South Korea, southern Europe Countries, and the USA.

Table 4 An indicative picture of the involved academia and industry around the world

Country	Institutes	Scholars
Greece	Two universities One research center	5
Italy	Five universities	13
Japan	One university One insitute	3
Mexico	One public organization	1
Netherlands	One enterprise	1
Romania	One university	2
Singapore	One university One institute	5
South Korea	Five universities One research consortium Two enterprises	5
Spain	One university	1
Sweden	Two universities One enterprise	4
Switzerland	One university	2
Taiwan	Two universities	3
Turkey	Two universities	3
United Arab Emirates	One enterprise	1
UK	Two universities	2
USA	sixteen universities Four enterprises Three public organizations	18

All the above findings can be used to answer this chapter's research question. More specifically, with regard to the fundamental theories, four key areas appear to attract smart city research: ICT in urban space (smart city), smart growth, living labs, and creative industry. Their corresponding concepts illustrate almost all urban challenges and how they can be addressed by the ICT. Furthermore, all recent ICT trends were found in the corresponding literature analysis: IoT, Big Data, Open Data and e-Government, and Smart Grids are only some of these trends. Moreover, eight different models have been introduced for smart city analysis, which can all align to a common conceptual framework consisting of eight perspectives (application domains).

4 Conclusions

Smart city is a "booming" phenomenon, which is still ambiguous in literature. Many different sciences look into the smart city domain and this can be met both in the academia (from the involved journals, schools and scholars) and the industry. Almost all sciences can be met in the smart city domain, which approach this phenomenon from different perspectives. Scholars and schools across the world are being or have been investigated this phenomenon and an indicative "picture" is provided. On the other hand, three alternative industries appear to meet in this domain and create an emerging corresponding market: the ICT, the construction, and the electronics.

To answer this chapter's question, a holistic literature review was performed, with a method that was inspired by Niehaves (2011). In this respect and with regard to the initially grounded research question, a smart city was viewed with four disciplinary perspectives, which were documented to form the corresponding smart city fundamental theories: ICT, urban planning and growth, living labs as large-scale testing beds, eco or green city and corresponding ecological aspects, and creative industry in a city. All the above scientific areas appear to "meet" in smart city and various outcomes are generated. Moreover, corresponding concepts illustrate almost all urban challenges and how they can be addressed by the ICT. Furthermore, all recent ICT trends were found in the corresponding literature analysis: IoT, Big Data, Open Data and e-Government, and Smart Grids are only some of these trends. Finally, eight different models have been introduced for smart city analysis, which can all align to a common conceptual framework consisting of eight perspectives (application domains). This conceptual framework is introduced in this chapter, which can be utilized in further smart city exploitation. Although this framework is based on existing literature findings, it would be useful to be tested and validated either by experts or under a real case study.

Finally, some limitations have to be considered, which address future research; although a quite effective sample of research journal articles were investigated, many were not included in this review either because they were citations in the investigated publications or they did not meet the criteria of this study. To this end, smart city studies older than 2011 are also important to this domain and they con-

cern a roadmap to today's smart city (Anthopoulos and Fitsilis 2013). Moreover, other industries are also involved in smart city domain but they were not accounted in this study, since they did not meet directly to the ICT context (i.e., biomedicine, economics, smart materials, etc.). However, it is estimated by the author that a unique literature review is extremely complex to be performed with regard to the smart city. On the contrary, detailed reviews will be more effective if they address the alternative perspectives of the introduced conceptual framework or the identified key areas.

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