A Unified Definition of a Smart City

Arkalgud Ramaprasad[1], Aurora Sánchez-Ortiz[2](✉), and Thant Syn[3]

[1] University of Illinois at Chicago, Chicago, IL 60607, USA
prasad@uic.edu
[2] Universidad Católica del Norte, Antofagasta, Chile
asanchez@ucn.cl
[3] Texas A&M International University, Laredo, TX 78041, USA
thant.syn@tamiu.edu

Abstract. There is some consensus among researchers that the first urban civilization labeled a 'city' was Sumer in the period 3,500–3,000 BC. The meaning of the word, however, has evolved with the advancement of technology. Adjectives such as digital, intelligent, and smart have been prefixed to 'city', to reflect the evolution. In this study, we pose the question: What makes a 'Smart City', as opposed to a traditional one? We review and synthesize multiple scientific studies and definitions, and present a unified definition of Smart City—a complex concept. We present the definition as an ontology which encapsulates the combinatorial complexity of the concept. It systematically and systemically synthesizes, and looks beyond, the various paths by which theory and practice contribute to the development and understanding of a smart city. The definition can be used to articulate the components of a Smart City using structured natural English. It serves as a multi-disciplinary lens to study the topic drawing upon concepts from Urban Design, Information Technology, Public Policy, and the Social Sciences. It can be used to systematically map the state-of-the-research and the state-of-the-practice on Smart Cities, discover the gaps in each and between the two, and formulate a strategy to bridge the gaps.

Keywords: Smart cities · eGovernment · Ontology · Framework

1 Introduction

Cities around the world play a key role in the global economy as centers of both production and consumption, generating a large portion of the world's GDP [1]. The growth of cities since the industrial revolution has reached unprecedented levels. The population division of the United Nations has estimated that in 2016 54.5 per cent of the world's population lived in urban settlements and by 2050 this number will rise to 67% [2]. This considerable growth in cities' population will require major urban infrastructure developments in order to cope with the demand of its inhabitants. IEC [3] estimates that the infrastructure development for the next 35 years will surpass the one built over the last 4,000 years. Unquestionably, cities are complex systems and the rapid urban growth that brings traffic congestion, pollution, and increasing social inequality may turn the

M. Janssen et al. (Eds.): EGOV 2017, LNCS 10428, pp. 13–24, 2017.
DOI: 10.1007/978-3-319-64677-0_2

city into a point of convergence of many risks (economic, demographic, social, and environmental). That could seriously surpass their ability to provide adequate services for their citizens [4]. However, well managed cities can provide multiple benefits to the people living there since they produce economies of scale by sharing amenities such as transport, sport and entertainment facilities, business services, broadband, etc. [5]. The World Economic Forum also suggested that cities provide proximity and diversity of people that can be an incentive for innovation, and create employment as exchanging ideas breeds new ideas [6].

Governments and researchers since the 1990s have been using the term 'Smart Cities' as a fashion label, or because it could help certain cities to distinguish and promote themselves as innovative. Being a Smart City is an aspiration for some cities who have been developing long term plans to achieve this purpose. But, this is still a challenge for other that are facing this process sightlessly basically because concept is still ambiguous [7]. Giddens [8] suggested that the modernization process in the cities are linked to risks and many of them are "manmade risks", that have arisen because of the development of new technologies and the advances in scientific knowledge which are associated to the smartness of the city. In this context, Liotine et al. [9] considers the term Smart City as an anthropomorphism (attribution of human characteristics to the city) because it is based on the ability of the city to sense and respond to its challenges smartly—using natural and artificial intelligence embedded in the city's information systems.

There have been numerous studies attempting to define the Smart City concept, but it is still a difficult challenge to tackle. It is a multidisciplinary concept and to define 'Smart' is difficult. The first attempts to define the concept were focused on the smartness provided by information technology for managing various city functions [10–19]. Lately the studies have widened their scope to include the outcome of the Smart City such as sustainability, quality of life, and services to the citizens [20–30]. Murgante and Borruso [31] warned that cities, in the rush of being considered part of the "Smart umbrella", can be susceptible to ignore the importance of becoming sustainable and if they focus solely on improving technological systems they can easily become obsolete.

The assessment of the level of smartness of cities have also become important for researchers and government officials. They have developed rankings that considers variables like economy, infrastructure, innovation, quality of life, resilience, transportation, urban development, etc. [32–34].

Despite the vast literature on smart cities, or because of it, there are more than thirty-six definitions of the term. They address different, but relevant, aspects of the construct. However, the literature does not provide a unified a definition of the construct that is (a) inclusive of the present definitions, and (b) extensible to accommodate the evolution of the construct. We logically deconstruct the construct to define it using an ontology. The proposed definition unifies the present definitions. It can be extended, scaled, and refined/coarsened as necessary [35, 36].

2 Conceptualizing Smart Cities

The term city has been used since ancient times to describe certain urban communities by some legal or conventional definitions. The definitions can vary between regions or nations. The use of the term smart city is more recent and its early use can be traced to the initial use of information technology in urban environments. Many studies have reviewed the literature's definitions and dimensions of a smart city, characterizing and identifying variables and elements to groups them. The authors of these studies include Giffinger et al. [33], Albino et al. [37], Chourabi et al. [38].

Caragliu et al. [7] found some elements that could characterize a smart city. They include (a) utilization of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development; an underlying emphasis on business-led urban development; (b) a strong focus on the aim of achieving the social inclusion of various urban residents in public services; (c) profound attention to the role of social and relational capital in urban development; and (d) social and environmental sustainability as a major strategic component. Albino et al. [37] also identified some common characteristics of a smart city that include: (a) a city's networked infrastructure that enables political efficiency and social and cultural development; (b) an emphasis on business-led urban development and creative activities for the promotion of urban growth; (c) social inclusion of various urban residents and social capital in urban development; and (d) the natural environment as a strategic component for the future.

How we can include all the elements and dimensions that could encapsulate the smart city concept in a unified definition is then the challenge of this study. It is based on an extensive literature analysis and using more than thirty-six different definitions of this concept from disciplines as diverse as urban studies, computers and information technology, sociology, and public health [10, 37–40].

There is no doubt that a Smart City is a multidisciplinary concept that embodies not only its information technology infrastructure but also its capacity to manage the information and resources to improve the quality of lives of its people. The use of information technology has been considered as a key factor in the smartness of a city since it can sense, monitor, control and communicate most of the city services like transport, electricity, environment control, crime control, social, emergencies, etc. [31, 41, 42]. While the information technology can make a city smart (or smarter), the city itself is an entity with multiple stakeholders seeking diverse outcomes. The proposed unified definition integrates the two aspects.

3 Frameworks and Rankings of Smart Cities

Many frameworks have been proposed to encapsulate the critical elements in smart cities, and the underlying relationships between the elements. Some frameworks stress technology and infrastructure as the main components, while others emphasize looking people´s wellbeing. Brandt et al. [43] developed a framework for smart cities based on (a) the information systems research literature within the smart city context, and (b) the insights from interviews with municipal stakeholders from European cities. Their framework combines the resource-based and the ecosystem views to provide a comprehensive representation of the smart city. In this context, they discuss the types of resources a smart city can rely on such as built capital, human capital, natural capital, and information technology infrastructure. In their view the ecosystem includes the stakeholders within the city (city administration, businesses, and resident commuters, etc.).

Chourabi et al. [38] propose a framework that attempts to incorporate sustainability and livability issues, as well as internal and external factors affecting smart cities. They identify eight factors that, based on the literature at that time, were considered fundamental to the comprehension of smart city initiatives and projects. They include: management and organization, technology, governance, policy, people and communities, the economy, built infrastructure, and the natural environment. The same spirit of providing a more integrated perspective of smart cities prevails in Neirotti et al. [4] who present a taxonomy of domains. They divide the research articles into 'Hard' and 'Soft' domains. They grouped the key elements into six categories: natural resources and energy; transport and mobility; buildings; living; government; economy and people.

Giffinger et al. [33] also conceive a framework, based on the literature, for ranking smart medium-sized cities in Europe. They conceive a smart city as one that would excel, in a forward-looking way, in six characteristics: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. Similarly, Lombardi et al. [16] proposed a framework based on the concept of the Triple Helix [44] that relates university, industry, and government. They identify five clusters of elements in their analysis: smart governance, smart human capital, smart environment, smart living, and smart economy. The indicators for the dimensions in the framework were designed using a focus group and experts in different disciplines to allows a future classification of smart city performance and the relations between components, actors, and strategies.

Most of the analyzed frameworks agree on one or more factors but there is not a complete convergence among them and their relationships. Thus, to synthesize the smart city concept systematically and systemically we propose a unified definition of Smart City as a high-level ontology.

4 A Unified Definition of a Smart City

Our definition of a Smart City is shown in Fig. 1 and described below. It is presented as a high level ontology as described by Ramaprasad and Syn [36] and Cameron et al. [35], in the context of public health informatics and mHealth respectively. It is similar to the approach used by Ramaprasad et al. [45] and Ramaprasad et al. [46] to study eGovernment. (Note: Words referring to those in the framework are capitalized in the text.)

Smart								City		
Structure		**Functions**		**Focus**		**Semiotics**		**Stakeholders**		**Outcomes**
Architecture	[to]	Sense	[+]	Cultural	[+]	Data	[by/from/to]	Citizens	[for]	Sustainability
Infrastructure		Monitor		Economic		Information		Professionals		QoL
Systems		Process		Demographic		Knowledge		Communities		Equity
Services		Translate		Environmental				Institutions		Livability
Policies		Communicate		Political				Businesses		Resilience
Processes				Social				Governments		
Personnel				Technological						
				Infrastructural						

Illustrative Components (total components = 7*5*8*3*6*5 = 25,200):
Architecture to sense economic information by/from citizens for QoL.
Systems to process environmental data by governments for livability.
Policies to communicate technological knowledge by professionals for resilience.
Processes to translate political information to citizens for sustainability.

Glossary:
Smart: Capable of intelligent sense and response through semiotics.
  Structure: The structure required to manage the semiotics.
    Architecture: The overall architecture to manage the semiotics.
    Infrastructure: The physical and virtual infrastructure to manage the semiotics.
    Systems: The computer, social, and paper based systems to manage the semiotics.
    Services: The computer, social, and paper based services to manage the semiotics.
    Policies: The policies on managing the semiotics.
    Processes: The processes to manage the semiotics.
    People: The people responsible for managing the semiotics.
  Function: The functions required to manage the semiotics.
    Sense: To sense the semiotic elements.
    Monitor: To monitor the semiotic elements over time.
    Process: To process the semiotic elements.
    Translate: To translate the semiotics into action/control.
    Communicate: To communicate the semiotic elements.
  Focus: The focus of intelligent sense and response -- smartness.
    Cultural: Cultural dynamics of the city.
    Economic: Economic dynamics of the city.
    Demographic: Demographic dynamics of the city.
    Environmental: Environmental dynamics of the city.
    Political: Political dynamics of the city.
    Social: Social dynamics of the city.
    Technological: Technological dynamics of the city.
    Infrastructural: Infrastructural dynamics of the city.
  Semiotics: The iterative process of generating and applying intelligence.
    Data: The symbolic representation of sensations and measurements.
    Information: The relationship among the data elements.
    Knowledge: The meaning of the the relationships among the data elements.
City: A city capable of intelligent sense and response
  Stakeholders: Those affecting and affected by the city.
    Citizens: The citizens of the city.
    Professionals: The professionals of the city.
    Communities: The communities of the city.
    Institutions: The institutions of the city.
    Businesses: The businesses of the city.
    Governments: Federal, State, and Local governments.
  Outcomes: The desired outcomes of a smart city.
    Sustainability: Sustainability of the city.
    QoL: Quality of life of the stakeholders.
    Equity: Equity among the citizens of the city.
    Livability: The livability of the city.
    Resilience: The ability of the city to resile.

Fig. 1. A unified definition of a smart city

A Smart City is a compound construct with two parts, each of which is a complex construct. It can be represented as:

$$Smart\ City = f(Smart + City)$$

The City is defined (for this paper) by its Stakeholders and the Outcomes. Thus:

$$City = f(Stakeholders + Outcome)$$

The desirable outcomes of a Smart City include its Sustainability, Quality of Life (QoL), Equity, Livability, and Resilience. Thus:

$$Outcomes \subset \left[Sustainability,\ Quality\ of\ Life,\ Equity,\ Livability, Resilience\right]$$

The Stakeholders in a city include its Citizens, Professionals, Communities, Institutions, Businesses, and Governments. Thus:

$$Stakeholders \subset \left[Citizens, Professionals, Communities, Institutions, Businesses, Governments\right]$$

Thus, the effects on 'citizens' QoL', 'communities' equity', 'businesses' resilience', and 27 ($6 \times 5 - 3$) other possible combinations of Stakeholder and Outcome, defines the smartness of a city.

Semiotics—the iterative process of generating and applying intelligence—forms the core of smartness. The focus of smartness may be many aspects of interest to the stakeholders to obtain the desired outcomes. It depends on the structure and functions of the systems for semiotics. Thus:

$$Smart = f(Structure + Function + Focus + Semiotics)$$

In the iterative Semiotics process, Data are converted into Information, Information to Knowledge, and the Knowledge is then translated into smart actions. Thus:

$$Semiotics \subset \left[Data, Information, Knowledge\right]$$

The focus of Semiotics may be Cultural, Economic, Demographic, Environmental, Political, Social, Technological, and Infrastructural. The semiotics of each focus will affect the corresponding smartness of the city, its stakeholders, and the corresponding outcomes. Thus:

$$Focus \subset [Cultural, Economic, Demographic, Environmental, Political, Social, Technological, Infrastructural]$$

The Structure and Functions of its Semiotics (Data, Information, Knowledge) management system will determine the smartness of a city. The Functions include Sensing, Monitoring, Processing, Translating, and Communicating [41]. Thus:

$$Functions \subset [Sense,\ Monitor, Process, Translate, Communicate]$$

The Structure includes the Architecture, Infrastructure, Systems, Services, Policies, Processes, and Personnel. Thus:

$$Structure \subset [Architecture, Infrastructure, Systems, Services, Policies, Processes, Personnel]$$

Concatenating the four left dimensions, the smartness of city will be a function of its 'architecture to sense cultural data', 'policies to communicate environmental knowledge', and 838 ($7 \times 5 \times 8 \times 3 - 2$) other combinations in 'Smart' encapsulated in the definition.

Taken together, there are $7 \times 5 \times 8 \times 3 \times 6 \times 5 = 25{,}200$ potential components of a smart city encapsulated in the definition. A truly smart city is one that has realized a significant proportion of them. Thus, cities may be smart in different ways and to different degrees. Four illustrative components are listed below the ontology in Fig. 1. They are illustrated below:

- Architecture to sense economic information by/from citizens for QoL. The architecture to periodically sense the QoL of the citizens of the city, and to make the data available to the citizens.
- Systems to process environmental data by governments for livability. Systems to determine air and water pollution levels, and warn the citizens when they exceed acceptable thresholds.
- Policies to communicate technological knowledge by professionals for resilience. Policies to share knowledge about the technological vulnerabilities of a city, for example its data networks, to assure quick response and recovery in the event of a natural disaster.
- Processes to translate political information to citizens for sustainability. Processes (town-hall meetings, online forums, etc.) to translate the political manifestos into policies and practices that may affect the sustainability of the city.

A component of a Smart City may be instantiated in many ways, not just one. Thus, the 25,200 components encapsulated in the definition may be reflected in innumerable ways in research and practice. Similarly, the innumerable instantiations may be mapped onto the 25,200 components to obtain a comprehensive view of the 'bright', 'light', 'blind/blank' spots/themes in Smart Cities research and practice. The 'bright' spots/themes are those that are heavily emphasized because they are important or are easy. The 'light' spots/themes are those that are lightly emphasized because they are unimportant or are difficult. The 'blind/blank' spots/themes are those that have been overlooked or are logically infeasible.

The ontology defines Smart City simply and visually, without compromising its underlying combinatorial complexity. It is systemic and systematic. Its dimensions (columns) are based on research and practice in the domain. Further, the definition encapsulates all possible components of a Smart City, however many there are. We can describe any research or practice in the domain using the definition.

In summary, the unified definition presented as an ontology represents our conceptualization of Smart Cities [47]. It is an "explicit specification of [our] conceptualization," [48] and can be used to systematize the description of the complexity of domain knowledge [49]. The ontology organizes the terminologies and taxonomies of the domain. "Our acceptance of [the] ontology is… similar in principle to our acceptance of a scientific theory, say a system of physics; we adopt, at least insofar as we are reasonable, the simplest conceptual scheme into which the disordered fragments of raw experience can be fitted and arranged." [50] The many definitions of a Smart City can also be mapped onto the unified definition. It is a domain ontology that "helps identify the semantic categories that are involved in understanding discourse in that domain." [51, p. 23] Ontologies are used in computer science, medicine, and philosophy. Our ontology of a Smart City is less formal than computer scientists', more parsimonious than medical terminologists', and more pragmatic than philosophers'. It is designed to be actionable and practical, and not abstract and meta-physical. Its granularity matches that of the discourse in research and facilitates the mapping and translation of the domain-text to the framework and the framework to the domain-text.

5 Discussion

The Smart City ontology presented in this article provides a path to conceptualize systemically and systematically this novel domain including, refining, and extending previous definitions and conceptualizations of smart cities in a simple but powerful way. The ontology deconstructs the smart city concept into its basic dimensions and elements allowing the visual representation as a graphic-table and the articulation of its components using structured natural English revealing the combinatorial complexity of smart cities. This ontology is logically constructed but it is grounded in the literature and practice of smart cities. The multidisciplinary nature of the topic required to draw upon concepts from Urban Design, Information Technology, Public Policy, and the Social Sciences. The analysis of previous research included more than thirty definitions of the concept, articles about smart cities and rankings currently in use. This ontological framework for smart cities can be a tool for researchers and practitioners to visualize the appropriate elements and components of a smart city.

The logical construction of the ontology minimizes the errors of omission and commission. Smart city is a compound construct of two parts, Smart and City, and every one of it is at the same time composed of other dimensions and elements. For example, the City part of the smart city construct in the ontology encompasses the effect of stakeholders on the desirable outcomes. Most researchers in the information technology field focus their definitions of smart cities on the electronified functions provided to the citizens without consideration of the outcome (Sustainability, Quality of Life, Equity, Livability, Resilience). However, for the urban related disciplines the sustainability and quality of life has been the critical issues associated to most smart city definitions but electronic means have not been always part of those definitions (error of omission). The Smart part of the ontology compels the researcher to structure this part from the logical perspective of the term, the disciplines that converge in it and what is defined by other researchers as smartness (for example Debnath, Chin, Haque and Yuen [41] and Akhras [42] considered sensing, processing and decision making, acting (control), communicating, predictability, healing and preventability fundamental in the smartness of a city). Smart then was deconstructed into four dimensions (Structure, Function, Focus, and Semiotics) where structure, functions, and focus provide the means for semiotics which represents in detail the iterative process of generating and applying intelligence. Thus, the ontology can help specify the four dimensions and its elements for enabling a combination of them, instead of specifying it just generally (error of commission).

Finally, the ontology function as a multi-disciplinary lens. The Structure, Functions, and Semiotics are drawn from the information systems literature and refined for Smart City; the Focus, Stakeholders and Outcomes dimensions are drawn from the Public Administration, Urban Design, Public Policy, and the Social Sciences. The ontology compels the user to analyze different aspects of smart cities and synthesize solutions by drawing upon these disciplines.

6 Conclusion

In this paper, we have proposed an ontology that characterizes the logic of the Smart City domain and can be used to study this domain from many perspectives, at different levels of complexity, and at the desired level of detail. The main contribution of this study is the Smart City Ontology which was based on the logic behind the concept and the mapping of the numerous definitions of the term in the literature. The initial review revealed a clear separation among definitions coming from the information technology field, where the focus was on infrastructure, from those from the urban design and the social sciences where the emphasis was on the outcome (mainly sustainability and quality of life).

The Smart City Ontology will be an essential tool that can be used by planners and government officials to: (a) assess the level of smartness of their cities from many perspectives at different levels of complexity (b) provide a roadmap for new smart city designs (c) guide cooperative thinking among government agencies and other stakeholders (d) map the state-of-the-practice and unveil the bright, light and blind/blank spots of cities. Finally, this Smart City Ontology is fundamental for researchers because it allows them to map the state-of-the-research of the domain and it will permit them to systematically identify the 'bright', 'light', and 'blind/blank' spots in the literature. This mapping could reveal the gaps in the literature and practice, and the opportunities for research in various disciplines encompassed in this ontology.

Last, the unified definition of a Smart City as an ontology is in structured natural English, as opposed to linear natural English of the other traditional definitions reviewed in the paper. Thus, it retains its semantic interpretability while at the same time encapsulating the complexity of the construct. Further, the definition can be adapted as the construct evolves and to different contexts, because of its modular structure. It can be plastic. The definition can be expanded by adding an additional dimension (column), and reduced by eliminating a dimension. For example, Temporality of Outcomes (Short term, Medium term, and Long term) can be an additional dimension; or the elements of Outcomes can be aggregated under the broad term of a Smart City, and the dimension could be eliminated. The definition can be refined by adding subcategories of an element, and coarsened by combining several elements. For example, Governments (Stakeholder), can be subcategorized as Federal, State, and Local Governments; and Institutions and Businesses can be combined as Organizations. The unified definition should serve as a seed for the evolution of the research and practice in the Smart Cities domain.

References

1. Cohen, B.: Urbanization in developing countries: current trends, future projections, and key challenges for sustainability. Technol. Soc. **28**, 63–80 (2006)
2. United Nations, P.D.: The World's Cities in 2016. United Nations (2016)
3. IEC: Orchestrating Infrastructure for Sustainable SmartCities. International Electrotechnical Commission (2014)
4. Neirotti, P., De Marco, A., Cagliano, A.C., Mangano, G., Scorrano, F.: Current trends in Smart City initiatives: some stylised facts. Cities **38**, 25–36 (2014)
5. Swinney, P.: Why are Cities Important? (2014)
6. WEF: Global Risks 2015 Report. World Economic Forum (2015)
7. Caragliu, A., Del Bo, C., Nijkamp, P.: Smart Cities in Europe. J. Urban Technol. **18**, 65–82 (2011)
8. Giddens, A.: Runaway World: 1999 Reith Lecture. Website: news.bbc.cu.uk/hi/english/static/events/reith 99 (1999)
9. Liotine, M., Ramaprasad, A., Syn, T.: Managing a Smart City's resilience to Ebola: an ontological framework. In: 2016 49th Hawaii International Conference on System Sciences (HICSS), pp. 2935–2943. IEEE (2016)
10. Nam, T., Pardo, T.A.: Conceptualizing smart city with dimensions of technology, people, and institutions. In: Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times, pp. 282–291. ACM
11. Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., Williams, P.: Foundations for Smarter Cities. IBM J. Res. Dev. **54** (2010)
12. Washburn, D., Sindhu, U., Balaouras, S., Dines, R.A., Hayes, N., Nelson, L.E.: Helping CIOs understand "smart city" initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO. Forrester Research, Cambridge (2010)
13. Bakıcı, T., Almirall, E., Wareham, J.: A smart city initiative: the case of Barcelona. J. Knowl. Econ. **4**, 135–148 (2013)
14. Eger, J.M.: Smart growth, smart cities, and the crisis at the pump a worldwide phenomenon. I-WAYS J. E-Gov. Policy Regul. **32**, 47–53 (2009)
15. Lazaroiu, G.C., Roscia, M.: Definition methodology for the smart cities model. Energy **47**, 326–332 (2012)
16. Lombardi, P., Giordano, S., Farouh, H., Yousef, W.: Modelling the smart city performance. Innov. Eur. J. Soc. Sci. Res. **25**, 137–149 (2012)
17. Mulligan, C.E., Olsson, M.: Architectural implications of smart city business models: an evolutionary perspective. IEEE Commun. Mag. **51**, 80–85 (2013)
18. Coe, A., Paquet, G., Roy, J.: E-governance and smart communities: a social learning challenge. Soc. Sci. Comput. Rev. **19**, 80–93 (2001)
19. Townsend, A.M.: Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia. WW Norton & Company (2013)

20. Anthopoulos, L.: Defining smart city architecture for sustainability. In: Proceedings of the 14th IFIP Electronic Government (EGOV) and 7th Electronic Participation (ePart) Conference 2015. Presented at the14th IFIP Electronic Government and 7th Electronic Participation Conference 2015, pp. 140–147. IOS Press (2015)
21. Bifulco, F., Tregua, M., Amitrano, C.C., D'Auria, A.: ICT and sustainability in smart cities management. Int. J. Public Sector Manag. **29**, 132–147 (2016)
22. Herrschel, T.: Competitiveness and sustainability: Can 'Smart City Regionalism' square the circle? Urban Stud. **50**, 2332–2348 (2013)
23. Lee, J., Kim, D., Ryoo, H.Y., Shin, B.S.: Sustainable wearables: wearable technology for enhancing the quality of human life. Sustainability **8** (2016)
24. Huston, S., Rahimzad, R., Parsa, A.: 'Smart' sustainable urban regeneration: Institutions, quality and financial innovation. Cities **48**, 66–75 (2015)
25. Shapiro, J.M.: Smart cities: quality of life, productivity, and the growth effects of human capital. Rev. Econ. Stat. **88**, 324–335 (2006)
26. Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., Airaksinen, M.: What are the differences between sustainable and smart cities? Cities **60**, 234–245 (2017)
27. Aloi, G., Bedogni, L., Di Felice, M., Loscri, V., Molinaro, A., Natalizio, E., Pace, P., Ruggeri, G., Trotta, A., Zema, N.R.: STEM-Net: an evolutionary network architecture for smart and sustainable cities. Trans. Emerg. Telecommun. Technol. **25**, 21–40 (2014)
28. Hara, M., Nagao, T., Hannoe, S., Nakamura, J.: New key performance indicators for a smart sustainable city. Sustainability **8** (2016)
29. Marsal-Llacuna, M.L.: City indicators on social sustainability as standardization technologies for smarter (citizen-centered) governance of cities. Soc. Indic. Res. **128**, 1193–1216 (2016)
30. Lee, J., Lee, H.: Developing and validating a citizen-centric typology for smart city services. Gov. Inf. Q. **31**, S93–S105 (2014)
31. Murgante, B., Borruso, G.: Cities and smartness: the true challenge. Int. J. Agric. Environ. Inf. Syst. **6**, 5 (2015)
32. IESE: Ranking The World's 'Smartest' Cities. Forbes. Forbes (2016)
33. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., Meijers, E.: Smart Cities. Ranking of European Medium-Sized Cities, Final Report, Centre of Regional Science, Vienna, UT (2007)
34. Giffinger, R., Gudrun, H.: Smart cities ranking: an effective instrument for the positioning of the cities? ACE: architecture. City Environ. **4**, 7–26 (2010)
35. Cameron, J.D., Ramaprasad, A., Syn, T.: An ontology of mHealth. Int. J. Med. Inform. 16–25 (2017)
36. Ramaprasad, A., Syn, T.: Ontological meta-analysis and synthesis. Commun. Assoc. Inf. Syst. **37**, 138–153 (2015)
37. Albino, V., Berardi, U., Dangelico, R.M.: Smart cities: definitions, dimensions, performance, and initiatives. J. Urban Technol. **22**, 3–21 (2015)
38. Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J.R., Mellouli, S., Nahon, K., Pardo, T.A., Scholl, H.J.: Understanding smart cities: an integrative framework. In: 2012 45th Hawaii International Conference on System Science (HICSS), pp. 2289–2297. IEEE (2012)
39. Zubizarreta, I., Seravalli, A., Arrizabalaga, S.: Smart city concept: what it is and what it should be. J. Urban Plan. Dev. **142**, 04015005 (2015)
40. Marsal-Llacuna, M.L., Colomer-Llinas, J., Melendez-Frigola, J.: Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative. Technol. Forecast. Soc. Chang. **90**, 611–622 (2015)
41. Debnath, A.K., Chin, H.C., Haque, M.M., Yuen, B.: A methodological framework for benchmarking smart transport cities. Cities **37**, 47–56 (2014)

42. Akhras, G.: Smart materials and smart systems for the future. Can. Mil. J. **1**, 25–31 (2000)
43. Brandt, T., Donnellan, B., Ketter, W., Watson, R.T.: Information systems and smarter cities: towards an integrative framework and a research agenda for the discipline. AIS Pre-ICIS Workshop—ISCA 2016 (2016)
44. Leydesdorff, L., Deakin, M.: The triple-helix model of smart cities: a neo-evolutionary perspective. J. Urban Technol. **18**, 53–63 (2011)
45. Ramaprasad, A., Sánchez-Ortiz, A., Syn, T.: An ontology of eGovernment. In: Tambouris, E., et al. (eds.) EGOV 2015. LNCS, vol. 9248, pp. 258–269. Springer, Cham (2015). doi: 10.1007/978-3-319-22479-4_20
46. Ramaprasad, A., Sánchez-Ortiz, A., Syn, T.: Gaps in local eGovernment research: an ontological analysis. In: Proceedings of the 21st Americas Conference on Information Systems (AMCIS 2015), Puerto Rico, USA (2015)
47. Gruber, T.R.: Ontology. In: Liu, L., Özsu, M.T. (eds.) Encyclopedia of Database Systems. Springer, New York (2008)
48. Gruber, T.R.: Toward principles for the design of ontologies used for knowledge sharing. Int. J. Hum. Comput. Stud. **43**, 907–928 (1995)
49. Cimino, J.J.: In defense of the desiderata. J. Biomed. Inform. **39**, 299–306 (2006)
50. Quine, W.V.O.: From a Logical Point of View. Harvard University Press, Boston (1961)
51. Chandrasekaran, B., Josephson, J.R., Benjamins, V.R.: What are ontologies, and why do we need them? IEEE Intell. Syst. **14**, 20–26 (1999)

Springer

http://www.springer.com/978-3-319-64676-3

Electronic Government
16th IFIP WG 8.5 International Conference, EGOV 2017,
St. Petersburg, Russia, September 4-7, 2017,
Proceedings

Janssen, M.; Axelsson, K.; Glassey, O.; Klievink, B.;
Krimmer, R.; Lindgren, I.; Parycek, P.; Scholl, H.J.;
Trutnev, D. (Eds.)

2017, XVI, 422 p. 60 illus., Softcover
ISBN: 978-3-319-64676-3