Curry et al. Journal of Internet Services and Applications (2016) 7:6
DOI 10.1186/s13174-016-0048-6

Journal of Internet Services and Applications

EDITORIAL Open Access

Smart cities – enabling services and applications

Edward Curry[1*], Schahram Dustdar[2], Quan Z. Sheng[3] and Amit Sheth[4]

1 Introduction

The proliferation of "Smart Cities" initiatives around the world is a part of the strategic response by governments to the challenges and opportunities of increasing urbanization and the rise of cities as the nexus of societal development. This JISA Thematic Series presents significant research contributions related to the design and development of Infrastructure, Services and Applications for the Smart City and Urban context.

1.1 What is a Smart City?

A Smart City can be viewed as an urban innovation and transformation that aims to harness physical infrastructures, Information and Communication Technologies (ICT), knowledge resources, and social infrastructures for economic regeneration, social cohesion, better city administration, and infrastructure management [1]. We argue that a distinguishing feature of the Smart City concept is the centrality of people or the welfare of city residents. Specifically, smart cities are concerned with the transformation of life and work of city inhabitants [2]. Nam et al. conceptualize a "Smart City" as an interplay between technological innovation, organizational innovation, and policy innovation [3], making a Smart City an inherently "Complex Socio-Technical System of Systems".

1.2 Enabling smart city services and applications

Emerging ICT paradigms such as data-intensive computing (Big Data), Open Data [4], Large-scale Distributed Systems [5], Internet of Things, Physical-Cyber-Social Computing [6], Service-Oriented [7] and Cloud Computing [8], are essential to the realization of the vision of Smart Cities. In fact, real-world Smart Cities are being enabled by a combination of these paradigms using a mixture of architectures (centralized, decentralized, and a combination of both) and infrastructures such as Middleware and IoT platforms to support the development of applications and information systems for Smart Cities [9–12].

The creation of innovative applications and services for Smart Cities is crucial to their success. The spectrum of application areas is very wide from city operations (e.g. real-time traffic management) to entertainment and tourism applications (i.e. augmented reality city tours). Smart City applications need to support a variety of city requirements including a continuing lifecycle, incremental evolution, collaboration between diverse city stakeholders, and privacy concerns when working with the personal data of citizens [3]. A Smart City creates an ecosystem where vast amounts of data can move between actors within complex information supply chains [13]. By leveraging these data flows, Smart City applications can be developed in the areas of Economy, Environment, Energy, Water, Waste, People (intellectual endowment and engagement), Lifestyle, Building, Mobility (Transportation), and Public spaces [1, 14].

1.3 From proof-of-concept to citywide transformations

There is a broad agreement on the potential innovation capacity of ICT within the City context; the challenge is to deliver that potential alongside the wide-scale diffusion of technology. The literature on Diffusion of Innovations and Technology Adoption [15] can assist in understanding how this could happen within Cities. In their study of Technology Change, Anderson and Tushman [16] argue that technology progresses in a series of cycles, hinging on technological discontinuity followed by a design competition which results in the emergence of a dominant design. According to Anderson and Tushman the dominant design is never in the same form as the original discontinuity and is not on the leading edge of technology; it bundles features to meet the requirements of the majority of the market. Once a dominant design emerges, organizations often cease to invest in learning alternative designs and instead focus on developing competencies related to the dominant design [16].

* Correspondence: edcurry@acm.org
[1]LERO at National University of Ireland Galway, Galway, Ireland
Full list of author information is available at the end of the article

Understanding these cycles and patterns can give an indication as to the trends in the Smart City domain. The first wave of Smart City initiatives can be seen as a large-scale design competition consisting of Proof-of-Concept projects that explored the potential for ICT within the city. The goal was to understand the requirements, explore the design space, and discover the boundaries of the many different technologies supporting a Smart City. The defining characteristics of many projects in this wave was a focus on experimental design together with a limited pilot deployment (i.e. sensor deployment in the range of tens to a few hundreds that covered a few city districts).

The second wave of Smart City projects, now underway, are focusing more on citywide deployments of the technology to drive mass adoption. The key challenge in this wave is the need to identify the dominant design needed to support the requirements of mass-market adoption. The Innovation Adoption literature can again guide Smart City researchers in improving the uptake of their technology. The likelihood of an innovation being adopted can be increased if it possesses certain key characteristics [17]. The following criteria have been adapted from [17] for the Smart City context:

- Relative Advantage: enabling a better functioning city and city life (Impact of the technology on the different Smart City domains).
- Compatibility: degree to which a Smart City technology is consistent with existing city stakeholder values, or interests, and city context.
- Complexity: the degree of difficulty involved in implementing the technology and communicating benefits to stakeholders.
- Trialability: degree to which experimentation is possible with the technology.
- Cost Efficiency and Feasibility: with respect to existing comparable practice.
- Evidence: availability of research evidence and practice efficacy.
- Risk: level of risk associated with the implementation and adoption.

Smart City innovations will need to possess a number of these characteristics if they are to be successfully adopted within real-world cities. This sets out a clear research direction for Smart Cities.

1.4 The state of research

Current research in the Smart Cities area is wide reaching and combines many different disciplines to address the diversity of challenges. Among the area of enabling services and applications for Smart Cities, the more active areas of research include:

- Requirements for Smart Cities: Researchers in this area are investigating the evolving needs of infrastructure requirements for next-generation Smart City solutions.
- Architectures and Paradigms for Smart Cities: Work in this area is focused on the investigation of the theoretical foundations on architectures for Smart City including City-as-a-Platform, centralized and/or decentralized Architectural Approaches, System of Systems engineering & Cloud Computing for Smart Cities.
- Infrastructures for Smart Cities: Design and implementation infrastructure services for Smart Cities including Internet of Things platforms and middleware, sensor and connectivity infrastructure, and services for cooperative sensing including Context, Resource, and Semantic awareness for Smart Cities.
- City Information Management: Much work is underway in the area of data-intensive computing (Big Data), Open Big City Data and urban-scale data sharing, interoperability, security and privacy. Research in this area also falls into the category of urban analytics, and urban information models.
- Service Innovation and Design for Smart Cities: In order to deliver the applications and services needed for urban management many cities are engaging in an open innovation model to increase the participation of citizens and organizations in citizen-led innovation. Many researchers are investigating new service models based on this model, and a hot topic of research in this area is open data published by city management or authorities. In fact, the alignment and explicit connection between open data policies with open innovation aspects of Smart Cities are increasingly stronger.
- Case Studies: Finally, there is a need for more published case studies of successful Smart City deployments including retrospective analyses of successful (and sometimes unsuccessful) Smart City development. These serve both to increase our understanding of what it takes to deliver impact within a Smart City, as well as providing insights into challenges, techniques, and lessons learned.

1.5 The papers

The focus of this thematic series is to present significant contributions from the active research areas of Smart Cities. We are interested in works possessing characteristics belonging to the second wave of Smart City projects. In particular we have selected papers that 1) demonstrate a clear advantage for enabling a better functioning city for residents and visitors, 2) have a clear value proposition that can be easily communicated in

simple terms to users, and 3) target mass-adoption by a large number of stakeholders in citywide multi-city deployments. The final point is important as the resulting design that meets this criterion will need to support a wider range of requirements than a single city deployment and can exhibit early traits of a dominant design. Based on this selection we are pleased to present the following papers that contribute to the state-of-the-art in the design and development of Infrastructure, Services and Applications for Smart Cities.

Planning, monitoring, and managing crowds of people are fundamental tasks in city management. However, the topic of crowd management has received little attention within the Smart City domain. The first paper "Smart Crowds in Smart Cities: Real Life, City Scale Deployments of a Smartphone Based Participatory Crowd Management Platform," by Tobias Franke, Paul Lukowicz, and Ulf Blanke [18] details a platform for city-wide crowd management based on participatory mobile phone sensing and location/situation specific information delivery. The paper describes the requirements derived through a series of test deployments, the system architecture, the implementation and the experiences of large scale deployments at 14 events in the UK, Netherlands, and Switzerland with over 100,000 users.

Tourism is a major social and cultural activity with significant economic impact for cities. Many Smart City applications focus on improving the experience of a visitor to a city. City governments are supporting this activity by publishing open data for developers to use in their own applications. However, each city is publishing tourism information in its own bespoke way. "CitySDK Tourism API - Building value around open data" by Ricardo Lopes Pereira, Pedro Cruz Sousa, Ricardo Barata, Andre Oliveira and Geert Monsieur [19] provides a common API for accessing this open data to enable applications to seamlessly use data from several cities, increasing their potential market while reducing the development costs. The paper provides an overview of the design and utilization of the CitySDK Tourism API and details a multi-city deployment of the API in Amsterdam, Helsinki, Lamia, Lisbon and Rome.

As digitization has become an integral part of everyday life, huge amounts of data are now generated across all aspects of city life, from daily commute to healthy lifestyles. Effective analysis and utilization of this big data is a key factor for success in many Smart City domains. Big Data Analytics can improve the performance of health, transportation, energy, education, and water services leading to improved efficiency and citizen satisfaction. The paper "Applications of Big Data to Smart Cities," by Eiman Al Nuaimi, Hind Al Neyadi, Nader Mohamed, and Jameela Al-Jaroodi [20] explores the opportunities, challenges, requirements, and benefits of big data applications for Smart City services.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
All authors read and approvedthe final manuscript.

Author details
[1]LERO at National University of Ireland Galway, Galway, Ireland. [2]TU Wien, Wien, Austria. [3]University of Adelaide, Adelaide, Australia. [4]Kno.e.sis Center at Wright State University, Fairborn, OH, USA.

Received: 27 May 2016 Accepted: 27 May 2016
Published online: 21 June 2016

References

1. Ojo A, Curry E, Janowski T. Designing Next Generation Smart City Initiatives - harbessing Findings and Lessons from a Study of 10 Smart City programs, 22nd European Conference on Information Systems (ECIS 2014), vol. 2050. 2014. p. 1–14.
2. Hollands RG. Will the real smart city please stand up? Intelligent, progressive or entrepreneurial, City Anal. urban trrends, Cult. theory, policy action, vol. 12. 2012. p. 37–41. 2008.
3. T. Nam and T. Pardo, "Smart city as urban innovation: Focusing on management, policy, and context," Proc. 5th Int. Conf Theory Pract Electron Gov. 2011:pp. 185–194.
4. A. Ojo, E. Curry, and F. Sanaz-Ahmadi, "A Tale of Open Data Innovations in Five Smart Cities," in 48th Annual Hawaii International Conference on System Sciences (HICSS-48). 2015:pp. 2326–2335.
5. van Steen M, Pierre G, Voulgaris S. Challenges in very large distributed systems. J Internet Serv Appl. 2011;3(1):59–66.
6. Sheth A, Anantharam P, Henson C. Physical-cyber-social computing: An early 21st century approach. IEEE Intell Syst. 2013;28(1):78–82.
7. Issarny V, Georgantas N, Hachem S, Zarras A, Vassiliadist P, Autili M, et al. Service-oriented middleware for the Future Internet: state of the art and research directions. J Internet Serv Appl. 2011;2(1):23–45.
8. Höfer CN, Karagiannis G. Cloud computing services: taxonomy and comparison. J Internet Serv Appl. 2011;2(2):81–94.
9. Qin Y, Sheng QZ, Curry E. Matching Over Linked Data Streams in the Internet of Things. IEEE Internet Comput. 2015;19(3):21–7.
10. Baresi L, Mottola L, Dustdar S. Building Software for the Internet of Things. IEEE Internet Computing. 2015;19(2):6–8.
11. Schleicher JM, Vögler M, Dustdar S, Inzinger C. Enabling a Smart City Application Ecosystem: Requirements and Architectural Aspects. IEEE Internet Comput. 2016;20(2):58–65.
12. Billet B, Issarny V. Dioptase: a distributed data streaming middleware for the future web of things. J Internet Serv Appl. 2014;5(1):1–19.
13. Cavanillas JM, Curry E, Wahlster W, editors. New Horizons for a. Data-Driven Economy: A Roadmap for Usage and Exploitation of Big Data in Europe. Springer International Publishing; 2016.
14. Schleicher JM, Vögler M, Inzinger C, Fritz S, Ziegler M, Kaufmann T, et al. A Holistic, Interdisciplinary Decision Support System for Sustainable Smart City Design. In: International Conference on Smart Cities (SMART-CT 2016). 2016.
15. EM Rogers. Diffusion of Innovations, New York, NY 10020: Free Press, 1230 Avenue of the Americas; 1962.
16. Anderson P, Tushman ML. Managing Through Cycles of Technological Change. Res Technol Manag. 1991;34(3):26–31.
17. Wisdom JP, Chor KHB, Hoagwood KE, Horwitz SM. Innovation Adoption: A Review of Theories and Constructs. Adm Policy Ment Heal Ment Heal Serv Res. 2014;41(4):480–502.
18. Franke T, Lukowicz P, Blanke U. Smart crowds in smart cities: real life, city scale deployments of a smartphone based participatory crowd management platform. J Internet Serv Appl. 2015;6(1):1–19.
19. Pereira RL, Sousa PC, Barata R, Oliveira A, Monsieur G. CitySDK Tourism API - building value around open data. J Internet Serv Appl. 2015;6(1):1–13.
20. Al Nuaimi E, Al Neyadi H, Mohamed N, Al-Jaroodi J. Applications of big data to smart cities. J Internet Serv Appl. 2015;6(1):1–15.