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Systematic analysis of digitally enabled services for Sustainable Connected Cities

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Abstract: The investigation on the relationships between digital technologies and the city is more and more acknowledged as a research challenge among Information Systems researchers. As part of an Action Design Research project aiming at the development of a Capability Maturity Framework for Sustainable Connected Cities, this research in progress paper presents a systematic analysis of digitally-enabled services in this context. A taxonomy of services that have a potential positive impact on cities' socio-economical and environmental sustainability is proposed. The KJ (Kawakita Jiro) method, which ingrains Grounded Theory's and Affinity Diagrams' principles, was applied to reach this scope. This project is being conducted by a consortium that involves representatives from academia, industry, and public authority.

Keywords: Sustainable Connected Cities, Capability Maturity Framework, Grounded Theory, Action Design Research.

1 Introduction

Smart Cities is more and more acknowledged as a relevant research challenge among Information Systems (IS) researchers. Although the relationships between technologies and the city have been studied at least for the last two decades (Mitchell, 1995), greater attention by IS researchers started with the grand claims made by IBM (Dirks & Keeling, 2009)(Harrison & Donnelly, 2011) about the potential for such initiatives. These claims are grounded in a wide range of IT-related artifacts. For example, their implementation across different city's domains can enable Intelligent Transportation Systems (e.g. (Chen-Ritzo et al. 2009)), or can increase water (e.g. (Venkatesen, 2010)) and energy supply (e.g. (Stancic, 2009)) efficiency, to mention some general instances. In the following years the IS research around Smart Cities significantly shifted from specific technological problem-solution analysis to more comprehensive studies regarding, for instance, innovative measurement frameworks (Giffinger et al. 2007)(Lombardi et al. 2011) or overall strategies and business models (Chourabi et al. 2012)(Caragliu et al. 2009), due to the increasing level of knowledge maturity of the context (Gregor & Hevner, 2013). Particularly, "cities currently face a problem of standardization of the main building blocks of smart cities in terms of applications, business model, and services" (Schaffers et al. 2011). Additionally, a systematic literature review study (Maccani et al. 2013) exposed a most fundamental of gaps - the availability of a coherent management and organizing lens to enabling smart city adoption and innovation.

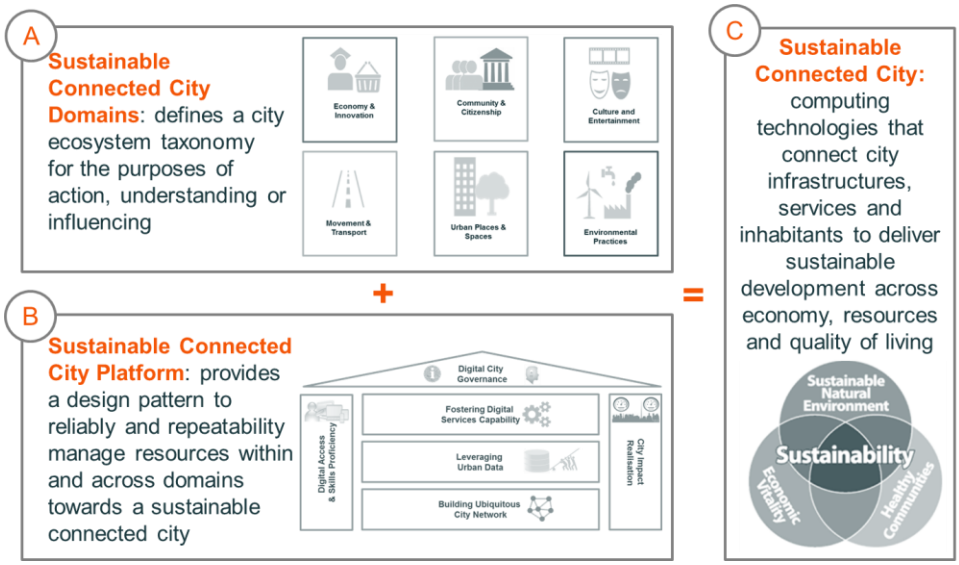
The project presented in this paper refers to design of a Capability Maturity Framework (SCC-CMF) for strategically driving Smart City initiatives. It is the result of collaboration by researchers from academia (National University Ireland Maynooth, Innovation Value Institute, Dublin City University) together with Intel Labs Europe, Dublin City Council (DCC) officials, and Dublin City stakeholders.

The aim of this research project was twofold, firstly, creation of a management and organizing lens (i.e. artifact) for informing Dublin City's Digital Masterplan (http://digitaldublin.ie/masterplan/). Secondly, the artifact aims to go beyond the specific case solution by acting as a design pattern to be applicable in any city environment that is seeking to manage towards Smart City outcomes. The conceptual artifact is extensively presented in (Kenneally et al. 2013). It comprises of six city domains in which digitally facilitated services for city sustainability can exclusively and comprehensively reside within. Each domain is managed by a common management lens to drive service delivery, connectedness within and across the six domains i.e. consistently manage the enabling factors (i.e. IT capabilities) that support and foster smart city service innovation delivery. A summary of its general features and conceptual components is provided in Figure 1.

Hence, at this stage of the research, we needed to systematically define the content of the SCC domains. In other words, we needed to define at a greater level of detail the services that are potentially delivered, once the enabler factors are properly implemented.

In detail, this paper is structured as follows: after this introductory section, section 2 will focus on the research methodology, while in section 3 the design of a taxonomy of services/initiatives in which ICT solutions at a city level have environmental and socioeconomic sustainability impacts, is presented. Finally, before outlining the conclusions, a reflection on areas for feedback and development is presented.

Figure 1 SCC-CMF general structure; source: (Kenneally et al. 2013).



2 Research Methodology

The overall research project addresses two main issues. The first, as mentioned above, refers to the need highlighted by the senior management team in DCC of an innovative way to both inform their strategy to become a Sustainable Connected City, and to help city manager's understanding, communication, and implementation of such strategy. On the other hand, many gaps within the theory related to Smart Cities became evident during a Systematic Literature Review study (Maccani et al. 2013). If we consider these issues separately, it becomes clear that a Canonical Action Research (Davison et al. 2004) approach is probably the most suitable for the design of the specific solution for DCC. On the other hand, considering the problem related to the dearth of existing theory, it is clear that an IS-related artifact is needed. As a consequence, a Design Science Research (DSR) method could be used for this project (Hevner et al. 2004). All in all, we had to incorporate an "action component" within a DSR approach. Indeed, the latter see the organizational intervention (in this specific case DCC) happening only in the evaluation phase of the so called "build and then evaluate" path (Cole et al. 2005). Accordingly, we chose a recently proposed methodology called "Action Design Research" (ADR) which is defined as a research method for generating prescriptive design knowledge through building and evaluating ensemble IT artifacts in an organizational setting (Sein et al. 2011). The ADR cycle is based on four main research stages: (1) Problem Formulation, (2) Building Intervention and Evaluation (BIE), (3) Reflection and Learning, and (4) Formalization of Learning. After defining the organizational problem as an instance of a class of problems in theory, we had to select and customize the BIE cycle. Due to the multiple actors that are part of this research project, our BIE cycle identifies a highly participatory process (for more details see (Kenneally et al. 2013)). The evaluation phase is being conducted as a concurrent step, rather than a separate stage. Consistently with the objectives of this study, steps 3 and 4

of ADR emphasize the importance of having a generalized outcome that can be further developed into general solution concepts for a class of field problems.
The specific techniques adopted for the categorization and analysis of digitally enabled services in this context are outlined in the next sub sections.

Grounded Theory Principles and Affinity Diagrams

In order to develop a new field of knowledge IS literature recognizes that is necessary to develop theory about pertinent phenomena (Glaser & Strauss, 1967). In our case the relevant component is represented by services that are delivered under the Smart City concept. So, due to the complexity of the "raw data" that had to be analyzed (i.e. Smart City Services/Initiatives), we needed a method that was both rigorous (to ensure the contribution to existing knowledge of the final outcome), and flexible (in order to be able to study a complex range of data). Among IS researchers, a methodology that is acknowledged to have both these characteristics is Grounded Theory (Birks et al. 2013). It is seen as a powerful tool for rigorous theory development, and it is defined as "*a systematic methodology involving the discovery of theory through the analysis of data*" (Martin & Turner, 1986). This theory is believed to be grounded in the analysis of actual settings and processes (Urquhart et al. 2010). Thus, to study them, the technique of Affinity Diagrams was adopted. Affinity Diagrams are here understood as a business tool that allows large number of ideas from brainstorming and/or data to be sorted into groups based on their relationships. An approach and a guideline that allows looking at this concept from a Grounded Theory perspective, is provided by the so called KJ Method (Scupin, 1997). It takes the name from its inventor, the Japanese anthropologist Kawakita Jiro. He defined this method as "*a tool used to organize large amount of qualitative data into logical and linked categories based on recognizable relationships*", and proposed four steps for its implementation: (1) collection of data, (2) creating post-its / notes, (3) putting up the notes, and (4) grouping the notes. Moreover, we customized this systematic process adding a further step concerning the evaluation of the results that were achieved.

3 SCC Digitally Enabled Services Taxonomy

A systematic approach to categorize Smart City services, based on their digital components/capabilities within each of the SCC Domains previously defined will be described in this section. We started from a collection of services and initiatives already implemented at an urban scale all around the world. Then, we decomposed our SCC Domains Blueprint and derived a categorization of Smart City services.
As a first step we had to collect the relevant data. To do this, the research team spent one month collectively populating a database of evidence and examples. In total, we collected 164 instances of services/initiatives implemented in cities around the world and/or designed in theory. For each of them a brief description, the benefits (where available), and the reference were provided. Hence, one of the members of the focus group started to carefully read each of the initiatives. Meanwhile, all the others were responsible for writing their ideas, thoughts, and interpretations about those initiatives/services, highlighting the elementary digital component/capability of each of them. This activity was conducted through small post-its. All of the post-its were put on whiteboards under

the column of the domain of pertinence. The process ("reading", "writing", "putting randomly on the whiteboard") was re-iterated for every domain (see Figure 2a). Once all the post-its were on the whiteboard, we started the grouping stage. First of all we checked the interpretation of the notes, and then we conducted the so called "sniff test", aiming at grouping the notes in relation to their affinity to each other. In order to facilitate the next step, we also labeled in first approximation each of these groups (see pink post-its in Figure 2b). Finally, as suggested by the KJ Method, we created groups of groups, and where possible also a hierarchical diagram was provided (see Figure 2c). At this stage the first version of the Smart City Services Categorization was available.
Starting from the left of Figure 2, step 3, and 4 of the KJ Method are represented.

Figure 2 KJ Method; from the left: 2a, 2b, 2c.

As previously stated, we added a further step to this methodology concerning the evaluation of the results. To do this we involved most of the representatives of the relevant stakeholders and service providers within Dublin city. In detail, a workshop involving 34 stakeholders from both the public and the private sectors was organized. The main aim of the day was to collect feedback in order to improve the results from the grounded theory exercise described above. One table for each of the six SCC Domains was set, and the people were placed to the one that was pertinent to their own daily activities. To each of the tables a facilitator from our working team was assigned. In doing this, these categories were discussed with the facilitator within each of the tables to check both their completeness and consistency. Then, a questionnaire made of 18 questions was given to them. The questions were related to each of the enabler factors for SCC (see point B in Figure 1). The respondents gave an individual score (in a scale from 1 to 5) to each of the questions in relation to the current state of development of that particular enabler factor within their field of interest. As a second step they were asked to discuss the scores they had previously assigned with the rest of the table's participants. The objective here was to stimulate a discussion regarding Dublin City as a whole, and to check "*Where is Dublin?"* in terms of its SCC strategy implementation. Finally, they highlighted their ideas about future initiatives, potential benefits, as well as the challenges and obstacles that have to be overcome to allow their actual implementation. This analysis allowed us to properly refine the first version of our outcome based on the discussion stimulated between the representatives of the service providers, and on their expectation for the future. The final result of the SCC Services Categorization is shown in Appendix 1. As a summary, after demonstrating the validity of the six SCC Domains chosen, these studies allowed the research team to structure and populate them. Particularly, consistently with the state of the art of the Smart City context, 24 sub-domains were clearly defined as more focused units of analysis encapsulated in the

broader SCC-CMF. A total of 164 instances of services populated the sub-domains at a further level of detail.

4 Conclusions and Future Works

This paper presents a systematic categorization of smart city services and initiatives (see Appendix 1) encapsulated by the SCC-CMF concept. The SCC-CMF offers an intuitive and systematic approach towards planning the adopting of smart city initiatives, by focusing on underling IT capabilities required to successfully deliver such initiatives (Kenneally et al. 2013). The artifact is being developed in close cooperation between researchers, end-users (i.e. city managers responsible for a Smart City strategy development), and practitioners (from Intel). As a consequence, there is a big risk to design a solution for Dublin City that will not be reflected into a contribution to the existing theory and practice. However, we can state that we avoided this risk because of two main reasons. In first place, by strictly following Action Design Research (Sein et al. 2011) as methodological guidance, we ensured the design of prescriptive knowledge starting from a specific organizational-related issue. Secondly, we showed that our grounded theory exercise used as underline concepts the main findings achieved in literature so far, and initiatives that were either implemented in cities all around the world, or designed in theory. Hence, we leveraged the needs-inputs-ideas-knowledge from DCC to enrich existing knowledge on Smart Cities. So, we made a significant step towards an innovative easy to read format of a Smart City strategy.
The next stage of this research will involve evaluating the perceived attractiveness and achievability of identified smart city initiatives that were derived from the above described grounded theory exercise. This step will be undertaken through use of online surveys and workshops across a number of international Cities - involving city service providers (from both the public and the private sectors) as well as city inhabitants. Diffusion of innovation (DoI) theory (Rogers, 1995) will be applied to interpret the perceived utility and attractiveness; and estimate general adoption rates for smart city initiatives.

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Appendix 1

DOMAIN: CULTURE AND ENTERTAINMENT	
Categories	**DESCRIPTION / GOALS**
1) Tourism Information and Services	This area sees digital technologies placed to improve the quality of visitors' stay in the city, by providing them useful and customized information. By improving their experiences, the city would result more attractive for tourism.
2) Leisure Planning & Logistics	This category aims at providing to citizens integrated information on entertainment around the city. It includes for instance pubs, restaurants as well as singular events.
3) Digital Interactivity for Cultural Attractions	Within this sub domain the goal is to digitalize the interaction between people and culture, and so leverage the usage of technologies across the city's cultural points of interest, that can vary from museum till outdoor monuments.
4) Enabling Creative Commons	Here digital technologies are introduced in order to support citizens' creativity and their interaction with arts, with the potential for users to create their own ideas and play an active role in urban art-related initiatives.
5) Universal Accessibility Practices	Here digital technologies might be used to design innovative family friendly activities as well as involving isolated classes of people around the city, or to give imformation / improve access to existing ones.
DOMAIN: MOVEMENT AND TRANSPORT	
Categories	**DESCRIPTION / GOALS**
1) Intelligent Traffic Management	The digital technologies here are deployed to improve movement around the city, including reduction of traffic congestions that can be linked with better environmental performances, and can also increase productivity.
2) Multimodal Transport & Journey Planning	This area is meant to encompass all the digital initiatives that aim at integrating information and data of movements around the city performed with different means of transport. The goal is to facilitate movement and transport across the city, and to improve their efficiency and effectiveness. Also services provided by public transport are included.
3) Payment and Ticketing	Here the focus is on how to use ICTs to facilitate payment processes connected to people and veichles' movement around the city.
4) Issues Management	Within this sub domain ICTs are used for efficient and effective reporting of issues related to the transport physical infrastructure, including roads.
5) Parking	Here technological solution are introduced to again reduce traffic congestion and reduce carbon footprint, as well as to facilitate citizens' movements, by providing real-time information on parking data.

DOMAIN: URBAN PLACES AND SPACES	
Categories	**DESCRIPTION / GOALS**
1) Participatory Urban Planning	Here the main goal is to involve citizens in both active (e.g. Crowdsouring) and passive (e.g. Designing urban patterns from their movements) manner, in supporting the urban planning process. Also climate adaptation initiatives are included.
2) Building Sensing and Management	The main goal here is to install computer-based systems in buildings to control and monitor their mechanical and electrical performances, such as ventilation, lighting, power systems, fire systems and security systems.
3) Collaborative Issues Resolution	Here the digital technologies are meant to be used by city's inhabitants to report various kinds of issues to the municipality. Also "city's objects" can be monitored; through the usage of advanced sensor networks connected to a communication infrastructure, there is a great potential for municipalities to be alerted on city's crises and disasters in a timely-enough-manner.
4) Outdoor Lighting Optimisation	Here the main goal is to transform outdoor lighting system into intelligent, energy-efficient, and remotely managed networks. This allows cost savings and leads to substantial improvements of environmental performances.
DOMAIN: COMMUNITY AND CITIZENSHIP	
Categories	**DESCRIPTION / GOALS**
1) e-Government Information and Services	This subdomain includes all the digital initiatives within the e-government field. The main goal is to make as much digital (and so effective and efficient) as possible the interaction between citizens and the municipality in relation to the delivery of government information and services.
2) Social Inclusion	How technology can help prevent or mitigate social isolation or exclusion of older people, single parent families, caregivers, etc in our urban populations and promoting participatory democracy.
3) Public Safety	Within this area the main goal for the city is to ensure the safety of its citizens and to protect assets. Innovative techological solutions have the potential to reduce urban crimes and improve emergency response in real-time ("or in a timely enough manner").
4) Health & Wellbeing	Here digital technologies are introduced to solve problems related to the healthcare sector such as rising costs, inconsistent quality, limited access to timely care and so on. Seamlessly and secure information sharing can be considered the critical success factor.
5) Volunteering & Social Innovation	ICT to support individuals, NGOs and other stakeholders working to improve their own communities and the lives of other citizens through volunteering.
DOMAIN: ECONOMY AND INNOVATION	
Categories	**DESCRIPTION / GOALS**
1) Education & Learning	Education-related sub domain that aims at providing digital skills to citizens and more generally end users, in order to allow them to create, deliver and/or consume digital services.
2) Employment and Job Creation	The goal here is to leverage the digital technologies in order to reduce the number of unemployed, providing them and the businesses embedded information through integrated platforms and networks.
3) Research & Development Incubation & Ecosys	This area looks at the promotion of the digital economy through the support for new (and existing) businesses, ranging from local ones till foreign entrepreneurs, in a qudruple-helix collaboration model. The R&D secotr is also included.
4) eBusiness	Within this area all the activities related to businesses are included. The name eBusiness was given to underline the digital focus of the analysis. Here the goal is to digitalize the processes within and between businesses and between companies and their customers. The so called Smart Economy would result stimulated and efficiency improved.
5) Flexible Workplace	Here digital technologies are placed to increase flexibility within the workplace (e.g. Remote working facilities).

DOMAIN: ENVIRONMENTAL PRACTICES	
Categories	**DESCRIPTION / GOALS**
1) Intelligent Resource management	Here the main focus is on improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. The same principle can be also linked to water management practices (smart bays). Other general initiatives to reduce and make more efficient the management of resources are object of this sub theme.
2) Renewables Promotion and Integration	Here are included all the digital-related initiatives that enable and push-towards the implementation of more environmental friendly practices, also across other city's domains. The common example refers to the usage of renewable sources of energy.
3) Pollution Monitoring and Quality	In this sub-domain digital technologies are deployed to collect, analyse and report infromation on air and noise pollution. Through innovative apps, also citizens can be actively involved in this process.
4) Waste Management and Recycling	The main goal here is to enable and promote responsible waste disposal, management and recycling, in order to further contribute in ensuring a better future for the environment.