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A crowdsourcing, smart city model for a developing country

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Abstract

With the growing number of people living in cities, the challenges faced by government to maintain service delivery to an acceptable standard are immense. 'Smart cities' is a new and innovative approach that allows the city to use current infrastructure and resources more efficiently. Not many smart city projects have been implemented in developing countries, where challenges that will affect the success of the project are very different from developed countries. These challenges include low literacy rates, high unemployment rates, high poverty levels and the limited availability of technology, all of which will impact on the implementation and success of a smart city. The purpose of the study was to investigate what variables need to be present in order to implement a smart city project making use of crowdsourcing in a developing country. The study found that there are three variables that will must be present to implement a smart city project in a developing country. These include the city management, the trust of the citizens in the smart city initiative, and the crowdsourcing system. The recommendation of this paper then is then that these variables must be considered by city management in order to successfully implement smart city projects in South Africa.

Keywords

smart city; developing country; crowdsourcing; trust; information security; user experience

1. Introduction

The proportion of the world's population that resides in cities has grown exponentially since the start of the previous century. In 1900, only 13% of the world population lived in urban areas, but this has since increased to an estimated 51% in 2012 (Statista, 2014). McConachie (2012) predicts that by 2028 more than 80% of the world's population will move to cities in search of better economic opportunities and social services.

The mandate of local government is to provide an acceptable quality of living for citizens in their constituency. However, finite resources are put under severe strain as the demand for basic services increases from the growing population. This means that local government must find alternative methods to manage existing resources more effectively (Alawadhi, Aldama-Nalda, Chourabi et al., 2012; Alusi, Zuzul, Eccles, & Edmondson, 2011). The cities that are making use of technology to assist in this regard can be described as 'smart cities'. Caragliu,

Del Bo, and Nijkamp (2009, p. 6) provide the following definition of a smart city: "… a city may be called smart when investments in human and social capital and modern ICT fuel sustainable economic growth and a high quality of life, as well as wise management of natural resources, through participatory government." Information and Communication Technology (ICT) is enabling local government to use real-time information to manage the city infrastructure and services better, but in order for smart cities to function effectively and efficiently, large amounts of data must be collected (Washburn & Sindhu, 2010; Dimitriou, 2012). There are two ways that data can be collected in a smart city, the first refers to crowdsensing where sensors are used to collect data automatically, while crowdsourcing makes use of people to report data that they feel may be important to the relevant authorities. The collected data can be analysed making use of predictive analytics to provide information about the state of the city in order to facilitate a proactive approach to resource management (Dimitriou, 2012).

Smart cities is still a relatively new concept with most of the smart city studies reported in literature conducted in developed countries. These smart city projects focus on a variety of areas including the economy, governance, mobility, environment and quality of citizens' living standards (Giffinger, Fertner, Kramar, Kalasek, Milanovic, & Meijers, 2007). Public safety, the context of this paper, is included in the smart living area. There is currently no model to assist with the successful implementation of a smart city project making use in a developing country. Such a model is important as the characteristics of a developed and developing city differ. Some of the typical challenges in a developing city include low literacy rates, high unemployment rates, high poverty levels, and the limited availability of technology, all of which impact on the implementation and success of a smart city (Kumar, Agarwal, & Manwani, 2010). The purpose of the study was to investigate what variables need to be present in order to implement a smart city project making use of crowdsourcing in a developing country.

The paper is structured as follows: The next section will provide the model that was developed in order to implement a smart city in a developing country, followed by a discussion about the research project, followed by the research methodology used in the study. The result of the questionnaire is provided next followed by the conclusion.

2. Variables of a Smart City Model

The paper proposes a model that consists of three variables which must be present to implement a smart city project making use of crowdsourcing in a developing country. In addition, each variable consists of various constructs which will affect the design, implementation and use of smart city initatives. The next section discusses the each varialbe of the model (refer Figure 1).

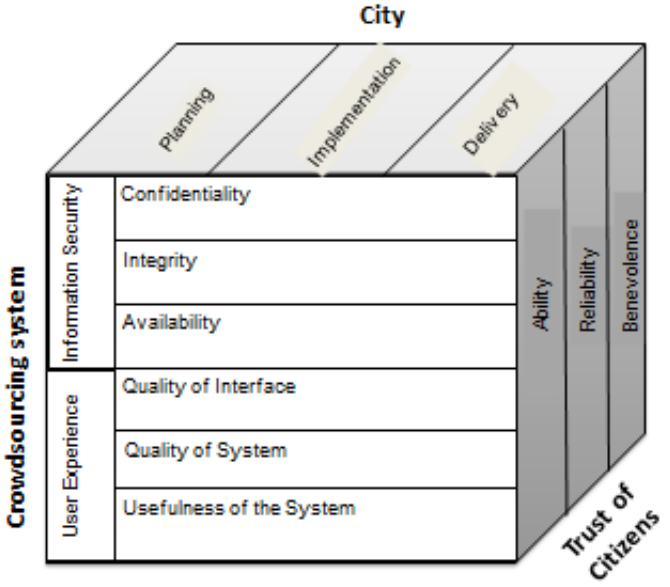

Figure 1: Model to implement a smart city project in a developing country

2.1 Variable 1: The City management

The study was conducted in the city of East London which is situated in the Buffalo City Metropolitan Municipality (BCMM) in the Eastern Cape Province of South Africa. The province has a poverty rate of 57%, while 30.4% of the population is unemployed (StatsSA, 2012; ECSECC, 2012). The BCMM has the highest recorded citizen growth rate for all the metropolitan areas in the country (Skenjana, 2013). The municipality is faced with large backlogs of services, while the East London citizens are demanding better service delivery. For these reasons, East London is considered to be a developing city and ideal to implement a smart city project in order to make use of existing resources more effectively and efficiently.

A literature review identified three steps that local authorities must consider in order to become a smarter city. These steps are discussed in Table 1 below and are used to represent the City Management side of the model as it provides a generic guide to implement a smart city project in a developing city. The reason why this section is done making use of a literature review is because no data was collected from the city management as this fell outside the scope of the study.

PLANNING	IMPLEMENTATION	DELIVERY
Be up to date with smart city developments and best practices	Budget to purchase and implement smart technologies	Roll out smart city administrative and general services
Develop a strategic plan to become a smart city which includes the vision, road	Modernise existing infrastructure and network. Align people, processes and	Educate stakeholders on the smart city benefits and how to take advantage of these

map and stakeholders involved	incentives to take advantage of smart city investments	benefits
Identify skills gaps	Competent staff is necessary – appoint or develop staff	Continue to develop business models to fund smart city initiatives
Develop new business models, technology plans and funding options, including the financial incentives available for smart city investments	Partner with industry stakeholders as well as system and technology integrators	Continue to measure the progress and value derived from the smart city investments
Conduct a situational assessment of how smart your city infrastructure currently is, including the current smart project	Develop metrics to measure the progress and value of smart city investments	

Table 1: Three phases to establish a smart city (Washburn & Sindhu, 2010)

The next section will discuss the second variable: the citizens of the smart city.

2.2 Variable 2: Trust of the Citizens

Crowdsourcing can only be effective and efficient if a large amount of people participate in the project; hence the side of the model is represented by the trust of the citizens in the smart city initiative. Literature has shown that the perception of trustworthiness of the crowdsourcing system will influence the participation of citizens in government introduced projects (Fjeldstad, 2003). The definition of trust, according to Tschannen-Moran and Hoy (2000, p. 556) is: "*Trust is one party's willingness to be vulnerable to another party based on the confidence that the latter party is benevolent, reliable, competent, honest, and open".* If the relationship between the government and the citizens of a country is to include trust, both parties need the assurances that the other's actions will enable them to achieve their interdependent objectives (Fjeldstad, 2003).

Mayer et al. (1995) proposed three constructs, namely: ability, benevolence and reliability, which are often cited in the literature as prerequisites for the trustworthiness of a system. The ability of the crowdsourcing system is determined by the characteristics of the system that will enable it to perform the required functions efficiently and reliably (Mayer et al., 1995). The ability of the crowdsourcing system to capture and forward the provided information correctly will demonstrate to the citizens of East London that the system is capable of reflecting their public safety matters correctly. An example of the second construct, benevolence, is illustrated by the intention of the BCMM, which has been elected by the citizens of East London to a position of authority, to use the reported information for the purpose it was collected for. The last construct, reliability, refers to the belief that the person or institution concerned will act in an honest, reliable and credible manner. Issues that influence the degree of reliability attributed to the system include the consistency of the BCMM's actions in the past, credible communications about the crowdsourcing system from other parties, and the extent to which the trustee's actions are congruent with his/her words (Mayer et al., 1995). The BCMM should therefore provide feedback to the citizens regarding the outcomes of the information that has been reported in order to ensure the trust of the citizens in the smart city.

2.3. Variable 3: Crowdsourcing System

The third side of the model consists of 2 constructs called information security and user experience. Both these constructs will be discussed in the next section.

2.3.1. Information Security

In a smart city environment, the need to collect information must be weighed against the level of privacy that citizens expect. In the current study, the citizens of East London made use of the crowdsourcing system to provide information about public safety matters to the BCMM. However, this indicates a level of vulnerability as the citizens have no control over the information once it has been recorded. Covey (1989) stated that in order to enhance the trust of the citizens in a crowdsourcing system, it is essential that control measures be put in place to ensure privacy when making use of the system. Information security involves maintaining the confidentiality, integrity and availability of reported information (ISO/IEC 27002, 2013). The CIA triad constitute one of the most cited frameworks in information security literature and must therefore be considered in any discussion involving the protection of information in a crowdsourcing system (Kainda, Flechais, & Roscoe, 2010). Information is regarded to have integrity when it is whole, complete and uncorrupted; however, majority of the citizens did not believe that this was a serious threat (Cilliers & Flowerday, 2014). Potential threats to the integrity of information include exposure to corruption, damage and destruction. The confidentiality of information refers to the prevention of disclosure or the exposure of information to unauthorised individuals or systems. This was a concern for citizens as 73% reported that they preferred to report anonymously to the crowdsourcing system (Cilliers & Flowerday, 2014). Citizens also indicated that the availability of information at all times is very important as it enables authorised users to access information without interference or obstruction, and to receive the information in the required format (Cilliers & Flowerday, 2014; Whitman & Mattord, 2005).

2.3.2. User experience of the technology

Trust in an information system will also increase if the user receives positive feedback from the system (Colesca, 2009). The citizen reports public safety information to the crowdsourcing system, but as it is an asynchronous system they do not receive immediate feedback. Instead, the user experience of the system will be determined by the experience of the citizen with the crowdsourcing system.

User experience is an abstract concept and is difficult to define as it is dependent on the characteristics and attributes of the information system concerned and dependent on the context in which the system is developed (Madan & Dubey, 2012). With regards to the crowdsourcing system that was used in this research project, three constructs were identified in relation to the user experience with the system making use of the ISO/IEC 9241-11, 1998 standard. These three constructs are system quality, interface quality, and usefulness of the system (Wallace, Reid, Clinciu, & Kang, 2013). The IVR system was ‘trained’ through multiple iterations to recognise various accents. In addition, after the caller had made the recording, it was played back to the caller and if he/she was not satisfied with the recording, the caller was able to rerecord the message. The quality of the crowdsourcing system would be affected by the efficiency and effectiveness of the system. Efficiency was measured by the length of the telephone call. This was important because of the high cost of telephone calls in South Africa, which together with the high unemployment and poverty rates in East London, discourages citizens from making use of the crowdsourcing system. The effectiveness of the

system was measured as the ease of use regarding reporting a public safety matter by making use of the IVR system. Paine-Schofield and Joinson (2008) state that if the user feels that the crowdsourcing system is trustworthy and useful, the confidence and subsequently the participation of the user in the system will increase.

3. Research Methodology

The University of Fort Hare (UFH), in conjunction with IBM, developed an Interactive Voice Response (IVR) system which allowed citizens of East London to report public safety matters in their immediate environment. The project was active for 3 months. Kumar et al. (2010) stated that an IVR system is suitable for developing countries as the existing infrastructure can be used; users can report public safety matters at their own pace and the IVR system would not exclude illiterate users. Furthermore, crowdsourcing allows citizens to choose when and what they want to report, eliminating privacy concerns associated with crowdsensing (Mehta, 2011; Cilliers & Flowerday, 2014). This approach is also useful to gather data on a large scale about short-term concerns such as accidents or other public safety related issues - the context of this study. In addition, the citizens, who possess first-hand knowledge about the patterns and anomalies in their immediate environment, are able to contribute appropriate information which not only empowers the community, but also enhances the quantity, quality and credibility of the data (Burke et al., 2006). Citizens typically reported public safety information such as accidents, theft and dangerous conditions that could potentially cause safety concerns such as potholes or illegal electricity connections.

Figure 2 is a graphical representation of the project. During the first step, participants had to register on the official website and accept the terms and conditions of the project. This was a legal requirement as the information reported was not passed onto the authorities, but only used for research purposes. The citizens acknowledged that they were aware of this when they registered on the website. The citizens were also informed that the data would only be used for the stated research purposes. Step two was to call the provided number and report a public safety matter. Step three entailed completing the online questionnaire that was sent to the registered participants in order to share their experience of the system and validate the model.

This section provides an overview of the research project. This study made use of a descriptive research design and a quantitative approach. A survey method was used to gather data from the study population about two of the variables, the crowdsourcing system and trust of the citizen in the smart city initiative, making use of a convenience sampling technique. The third variable, the city management, was inductively developed making use of an extensive literature review and as such was not tested in the questionnaire. The study population identified for this research project was citizens in the East London area in South Africa. Citizens were recruited through marketing of the project in local newspapers, distribution of flyers and social media. A total of 485 people registered on the official website and they were sent a questionnaire to complete. A total of 394 questionnaires were completed. Thus, the response rate was 81.2%. However, only 361 (91.6%) of these questionnaires were found to be complete and was used in the final analysis.

Figure 2: Steps of the Public Safety Project

The primary aim of the questionnaire was to determine which variables of the smart city model are important for successful implementation in developing countries. The theoretical framework for this study is underpinned by the model of trust as proposed by Mayer, Davis, & Schoorman (1995) to determine the trustworthiness of the citizens in the smart city initiative, the information security CIA triad (ISO/IEC 27002, 2013) is used as a guideline for reducing risk and improving the participation of the citizens, and the ISO/IEC 9241-11, 1998 standard which proposes that if the smart city technology is viewed as user-friendly by the citizen, the confidence of the citizen in the smart city will improve. The research instrument, a questionnaire, created for this study was based on all three of the variables mentioned above. The questionnaire data consisted of four sections. Section A solicited demographic information from the citizens, while section B tested the three trust constructs (ability, benevolence and integrity). Section C considered the information security constructs (confidentiality, integrity and availability of information) and section D tested the user experience of the system (quality of system/interface and usefulness of the system). All the constructs were measured on a five-point Likert scale (1=Strongly Disagree to 5=Strongly Agree).

Pre-testing and pilot testing of the questionnaire was conducted using academics who were asked to provide input on the questionnaire. Based on this process, items were modified to make them relevant to the aims of the research based upon the feedback provided. Ethical approval for the study was obtained from the Research Ethics Committee of the University of Fort Hare.

4. Statistical Analyses

The questionnaire was sent to the 485 citizens registered on the official website. The study sample consisted of 219 (60.7%) males and 142 (39.3%) females. Almost half of the participants (48.2%) were younger than 30 years of age. The next age group, 30−39 years, made up the second largest group (23.5%), and was followed by the 40−49 years age group

(14.7%). The two oldest age groups, 50−59 and 60+, were the smallest groups with the lowest percentages of 10.2% and 3.3%, respectively.

The statistical analyses were carried out with the SPSS v22. Cronbach's Alpha coefficient was used to determine the internal consistency of the measuring instruments (Clak & Watson, 1995). This analysis also provided measures of reliability and mean inter-item correlations to test for internal variable consistencies. According to Bryman and Bell (2007), Cronbach's Alpha values above 0.50 denote an acceptable level of reliability. As can be noted from Table 1, all of the variables identified recorded a Cronbach's Alpha coefficient score in excess of 0.688 and were therefore considered to be at an acceptable level of reliability. The variable called 'City management' was not tested as it was created inductively making use of a literature review. Also, it would not be suitable to request the citizens to comment on the capability of the city to implement a smart city project.

Variable	**Construct**	**Cronbach Rating (α)**
Trust of the citizen		0.765
Crowdsourcing system	Information Security	0.688
	User Experience	0.796

Table 2: **Empirical reliability of instrument**

Based on the results of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test of sphericity, the data was deemed suitable for factor analysis. Thus, exploratory factor analysis was conducted to determine validity of the variables and relevant scales. The trust scale reduced the number of items from 8 to 3; information security stayed the same with 3 items and the user experience scale increased from 6 to 8 items. Table 3 shows the rotated component with Varimax adopted as a rotation method.

Correlations analysis was used to identify and evaluate the strength and direction of the relationships that exist between the variables and the multicollinearity of these relationships. Suitably high correlations (refer Table 4) between the independent and dependent variables were achieved, and it was ensured that an excessive degree of multi-collinearity between the independent variables did not exist. Tolerance values were significantly large enough (.724, .957 and .706) to demonstrate lack of multi-collinearity and VIF values (1.382, 1.045 and 1.416) were also deemed acceptable, thus demonstrating that the assumption of multi-collinearity would not be violated in the resulting model.

The Pearson correlation was used to determine the relationship between the dependent variable, the successful implementation of a crowdsourcing system, and the two variables, trust of the citizen and the crowdsourcing system, which were identified in the previous section (Bryman, 2012). The crowdsourcing system variable was further divided into two constructs: information security and user experience. The correlation matrix is presented in Table 4 in order to show the relationships that existed between the variables measured.

	Construct 1	Construct 2	Construct 3
User Experience 1	0.916		
User Experience 2	0.656		
User Experience 3	0.589		
User Experience 4	0.584		
User Experience 5	0.572		
User Experience 6	0.337		
Trust 1		0.837	
Trust 2		0.734	
Trust 3		0.602	
Information Security 1			0.794
Information Security 2			0.680
Information Security 3			0.325

Table 3: Component Matrix Rotation

		Dependent Variable	TotalUser Experience	TotalTrust	TotalSecurity
Pearson Correlation	*Dependent Variable*	*1.000*	*.534*	*0.127*	*0.559*
	Total User Experience	0.534	1.000	0.135	0.525
	Total Trust	0.127	0.135	1.000	0.204
	Total Security	0.559	0.525	0.204	1.000
Sig. (1-tailed)	Dependent Variable		0.000	0.008	0.000
	Total User Experience	0.000		0.005	0.000
	Total Trust	0.008	0.005		0.000
	Total Security	0.000	0.000	0.000	
N	Dependent Variable	0.361	0.361	0.361	0.361
	Total User Experience	0.361	0.361	0.361	0.361
	Total Trust	0.361	0.361	0.361	0.361
	Total Security	0.361	0.361	0.361	0.361

Table 4: Correlation of variables

In terms of the analysis of variance results, the R Square value indicates that the proposed model explains .392 (39.2%) of the variance in the citizens intent to make use of a crowdsourcing system to report public safety matters. This result can be deemed to be acceptable. The next section discusses the crowdsourcing model that can be used to implement a smart city initiative in a developing country.

5. Conclusion

This paper presented a smart city model making use of crowdsourcing for a developing country. The three variables that were found to influence the implementation of a smart city in a developing country are the city management, trust of the citizens in the smart city initiative and the crowdsourcing system. Trust in the smart city will increase either if the risk associated with using the crowdsourcing system decreases making use of information security controls, or if the user is satisfied when making use of the system. The city must be prepared and committed to the smart city concept, while both information security and user experience are important constructs that must be taken into account in order for the smart city to be successful.

The value of the study may be determined by the impact it has on the implementation of future smart city projects. Overall, the model may be regarded as crucial for the implementation of smart cities in developing countries as these cities have specific requirements that must be taken into consideration if they are to become smarter. If the proposed model is used, these requirements would be met and local governments would be able to use the existing resources of their cities more effectively and efficiently.

The study does have some limitations that must be taken into consideration. The first limitation of the study was the lack of predictive analytics on the information that had been reported via the system. This activity was outside of the scope of this research project, but it could add valuable insights into the benefits of a smart city project in a developing country. Related to this limitation is the volume of calls that must be made in order to perform the predictive analytics. Thus, more calls would have to be made to the system in order to secure enough data that could be used.

Future research would involve incorporating a motivational model that could investigate how to attract more callers to make use of the system in order to perform the predictive analytics. Another avenue of research could involve the feedback loop that could be used by the city of East London to provide information about the outcomes of the public safety data that had been reported to the crowdsourcing system.

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