Measuring level of friendliness of smart city: a perceptual study

Muhammad Sani Roychansyah¹ and Sushardjanti Felasari²

¹Department of Architecture and Planning, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
²Department of Architecture, Faculty of Engineering, Universitas Atma Jaya Yogyakarta, Yogyakarta, Indonesia

E-mail: saniroy@ugm.ac.id and sfelasari@staff.uajy.ac.id

Abstract. Currently the concept of smart city comes not only at the level of discussion, but some cities have stepped in the stage of implementation. Many of promised benefits will be met for the needs of urban residents if the city applies this concept. Conversely, many professionals and scholars are still in doubt about readiness of a city in the application of this concept. Dimension of friendliness of the real city certainly will have some limitations in a smart city that relies more on interactions with information and communication technology (ICT). This new paradigm becomes background of this paper in viewing the friendliness dimension of a smart city based on city residents’ perceptions. This paper uses case of 2 cities that have different level of readiness in the application of smart city. They are Yogyakarta City and Magelang City, both are located in Central Java. The method applied in this paper is quantitative method based on perceptual answer of respondents structured in a Likert Scale. Importance Performance Analysis (IPA) is then used to look at the attributes of smart city’s dimension which will show the relationship of the level of city friendliness and the level of city readiness in an application of smart city. The result briefly shows that the level of city sensitivity in the application of smart city is very influential in viewing the friendliness of the city. The city that is better equipped to meet the needs of its population according to the dimensions of the smart city based on its existing characteristics has higher friendliness. Time period of applying a smart city concept as the City of Yogyakarta has done longer before Magelang City, is not a guarantee that the city then has a better level of friendliness. The urban citizens have appropriate affective aspect to articulate between what they need and what the city has provided.

Keywords: smart city, friendliness of city, sensitivity of citizen needs, perceptual study, cities comparison

1. Introduction

The development of smart and sustainable cities has been a global trend in the last several years. The concept of smart city is present to address complex problems and challenges that arise in urban areas due to the limited resources available. Most of smart city initiatives in world’s cities involve ‘smartization’ of existing cities such as New York, London, and Singapore while several others has been built from the scratch like Songdo in South Korea which apply "ubiquitous computing" to integrate...
information systems and social systems (U-cities). In a U-City like Songdo, all devices, components, and services in the city are linked to an information network, mainly through wireless networks [7]. A key objective of a U-city is to provide an integrated environment, in which citizens have access to all types of services, everywhere and any time through ICT devices [9].

In Indonesia the smart city initiatives has come not only at the level of discussion, but some cities have stepped in the stage of implementation. Many of promised benefits will be met for the needs of urban residents if the city applies this concept. The Government of Indonesia assisted by a consortium has been trying to map the smart city index for Indonesian cities since 2015. National Planning Bureau [2] has also long established a roadmap for policy and strategy of urban development in Indonesia by issuing 3 keywords namely, livable, green, and smart. Conversely, more in practical level, many professionals and scholars are still in doubt about readiness of a city in the application of this concept. Dimension of friendliness of the real city certainly will have some limitations in a smart city that relies more on interactions with information and communication technology (ICT).

Using two cities i.e. Yogyakarta and Magelang as a case study, this paper examines the level of friendliness of the city in terms of their smartness perceived by their citizens. Yogyakarta City and Magelang City are used as two cases to see at how implementation of smart city that has been done by the government and related stakeholders, is perceived by its citizens. Both represent a middle city size (populated between 100-500 thousand inhabitants) where have different smart city implementation background. Yogyakarta is a city of about 450,000 inhabitants, which has been long enough (10 years) experience in incorporating the concept of smartness in some of its citizens' services. Meanwhile, Magelang is a city that has entered the stage of carrying the concept of smartness in the city services within the period of last 3 years. Yogyakarta City is an award-winning smart city for the city's population of 200 thousands to 1 million inhabitants, while Magelang City is an award-winning smart city in different category (city with population below 200 thousands) in 2015 [6].

2. Smart City Readiness in Indonesia’s Cities: Acceptance and Expectation

Smart city consists of 6 dimensions i.e. (1) Smart economy, (2) Smart mobility, (3) Smart environment, (4) Smart people, (5) Smart living and (6) Smart governance (Cohen and Cohen, 2012). As Indonesia located in the ring of fire it is necessary to include smart disaster management related to smart city as the 7th dimension [1].

The smart city concept emphasizes the importance of strategy in choosing priorities, directions, policies, and intelligently utilize technology with automatic computerization (self-configuration, self-healing, self-protection, self-optimization). It also emphasizes the citizen centric approach where people are encouraged to participate actively in the management of the city so that there is a more dynamic and close interaction between citizens and local government. As technology has a significant role in the development of smart city initiatives, therefore it is important to consider community’s technology acceptance. Davis proposed technology acceptance model (TAM) to explain and predict user behavior of information technology [5]. It explains why a user accepts or rejects information technology.

Many examples of the information technology used in smart city initiatives either from top-down approach or bottom up approach such mobile applications, social media, DIY sensors, and etc. According to TAM [5], one’s actual use of a technology system is influenced directly or indirectly by user’s behavioral intentions, attitude, perceived usefulness of the system, and perceived ease of the system. The external factors also affect intention and actual use through mediated effects on perceived usefulness and perceived ease of use (Figure 1).
Perceived usefulness is the degree to which an individual believes that using a particular system would enhance his or her job performance, meanwhile perceived ease of use related to the degree to which an individual believes that using a particular system would be free of physical and mental effort [3]. The dimensions of smart city initiatives can be reduced to measurable (attribute) variables to see their current uses. Ease of recent use of technology for example is one of measurable performance. Similarly, applicability for future uses is related to expectations. From this context, familiarity or friendliness of citizens in interacting with scope of smart city can be measured. Then, adopting from Martilla and James’s importance-performance analysis [8] we used 7 dimensions of smart city and divided it into 42 attributes of which we measured as listed in Table 1.

**Table 1. Dimension and attributes of smart city**

| Attributes                        | Attributes                        |
|-----------------------------------|-----------------------------------|
| Smart Economy (SE)                | Smart Living (SL)                 |
| SE-1 New startups                 | SL-1 Housing sufficiency          |
| SE-2 Internet-based full employment | SL-2 Gini Index                  |
| SE-3 Innovative in business processing | SL-3 Investment in culture        |
| SE-4 ICT-based business license   | SL-4 Smart crime prevention       |
| SE-5 Online transaction between institutions | SL-5 Accessible health & education services |
| SE-6 Business information availability | SL-6 Life expectancy              |
| Smart Mobility (SM)               | Smart Government (SG)             |
| SM-1 Clean-energy transport such as bicycle | SG-1 Online government services |
| SM-2 Innovative and modern parking system | SG-2 Electronic benefit payments |
| SM-3 Integrated multi-modal transit system | SG-3 WiFi coverage at public space |
| SM-4 Real time public transport information services | SG-4 Sensor coverage |
| SM-5 Smart cards for public transportation | SG-5 Integrated health and safety services |
| SM-6 Online transportation apps   | SG-6 Open data and apps           |
| Smart Environment (SN)            | Smart Disaster Management (SDM)   |
| SN-1 Smart homes                  | SDM-1 Emergency warning system    |
| SN-2 Energy saving house          | SDM-2 Responsive mitigation planning |
| SN-3 Public building automation system | SDM-3 Sensor for monitoring disaster |
| SN-4 Certified green buildings    | SDM-4 Evacuation and rescue training |
| SN-5 Solid waste and waste water treatment | SDM-5 Emergency information |
| SN-6 Green open space             | SDM-6 Disaster relief assistance  |
| Smart People (SP)                 |                                   |
| SP-1 Accessible internet at home  |                                   |
| SP-2 Smart phone penetration      |                                   |
| SP-3 Civic engagement activities using ICT |                                   |
| SP-4 Voter participation in municipal election |                                   |
| SP-5 Number of higher education degree |                                   |
| SP-6 Creative industry jobs       |                                   |

Source: Adapted from Anonym (1993)
3. Methodology: Perception of Attributes’ Importance and Performance

As described, this paper uses case of 2 cities that have different level of readiness in the application of smart city initiatives, in term of implementation duration. They are Yogyakarta City and Magelang City, both are located in Central Java. Yogyakarta City where smart city implementation has been for about 10 years implemented is a representative of case that has long experience in applying smart city, while Magelang City that has just experienced with smart city programs within 3 years is a representative of case that has short implementation of smart city. The method applied in this paper is quantitative method based on perceptual answer of respondents that distributed in two cases (Yogyakarta City is 148 respondents and Magelang City is 117 respondents randomly). The attributes of smart city’s dimensions are structured in a Likert Scale model’s questionnaire (level 1 – 7).

In this study the IPA (Importance-Performance Analysis) introduced by Martilla and James [8] is used to measure the level of friendliness of smart city by analyzing the gap perceptions of citizens between the city services related smart city’s existing performance and resident’s expectation of smart city through the city services’ importance in the future. The performance of the city in recent condition presents how ease to use the attributes of smart city. Meanwhile the importance of the attributes shows the usefulness in the future. The differences between the performance and importance of smart city’s attributes can be mapped to evaluate and then to determine the level of priority in smart city development in the future.

![Figure 2. Importance Performance Analysis (adapting from Martilla and James (1977))](image)

In this paper, the level of friendliness can be read from dimensions of citizen’s responses through the used respondents. There are 2 assumptions that used in assessing respondents’ answers. First, the performance of a smart city that exists in the cases will explain the level of community affection in justifying related attributes. The more respondents answered the performance of the smart city that is felt good, then the affection of respondents (to the related attributes) tends to be high. Secondly, the importance of the smart city presented in set of attributes will explain the level of community cognition in understanding problems of the city with a solution that can be given by the related attribute of the smart city. The level of friendliness directly is a combination of cognition and affection given by respondents to each existing smart city indicator or attribute.

4. Perception The Level of Friendliness: The Tale of Two Cities

From approximately 265 respondents who participated to respond the survey that was conducted directly in the fields in the beginning of August 2017, this paper can get various information related to the background of respondents, such as gender, education level, and the area where they live. In general,
out of 148 respondents in Yogyakarta, 44% are male, 78% under 40 years old, and 55% educated up to high school. In Magelang, out of 117 respondents, they are 36% male, 71% under 40 years old, and 62% educated up to high school. Error! Reference source not found. shows that gender affect the perception of friendliness level. Based on the figure, it seems that generally woman perceives lower level of friendliness of the smart city’s dimension compare to man. From the 7 dimensions of smart city in Yogyakarta, environment dimension gets the lowest friendliness, while for Magelang, environment and mobility are lower than other dimensions. Interestingly, women in Magelang have higher perceptions on 3 dimensions of smart city (living, government, and disaster management).

Figure 3. Perceptions of today’s smart city dimensions at Yogyakarta (Top) and Magelang (Bottom) based on gender
If the data is related to the respondent’s age, there is no significant difference of their perceptions. This is somewhat different from the data attributed to the educational background of the respondents. Figure 4 shows that education level seems affecting significantly the friendliness perception of the smart city’s dimension. In the city of Yogyakarta, people with lowest education level (SD/primary school) perceived the lowest level of friendliness (range between 2-3). However, the differences between level of friendliness and level of education seems insignificant at the city of Magelang although it shows the lowest value (range 3-4) in all city’s dimensions for people with primary education level (SD). It can be inferred that the level of education might influence the capability in accessing city’s information, the skill and knowledge of ICT, etc. For both cities, once again, environment has the lowest value (in average, Yogyakarta = 2.44, Magelang = 2.98) compared with other smart city’s dimensions. In both cities, it is also seen that the sensitivity of similar level of educational background has different level of friendliness’s perceptions. This may be due to appropriateness of smart city’s app, the level of the city's problems, level of interaction experience with the smart city’s program, and so on, where it still needs to be confirmed again through further related research.

Figure 4. Perception of today's smart city dimensions at Yogyakarta (Top) and Magelang (Bottom) based on education level
**Figure 5.** Importance performance analysis for smart city’s dimensions and attributes in the city of Yogyakarta

**Figure 6.** Importance performance analysis for smart city’s dimensions and attributes in the city of Magelang
Importance performance analysis (IPA) that depicts the level of friendliness level of the citizens for the dimensions and attributes of the smart city is shown in Figure 5 and Figure 6, where x axis is for performance and y axis is for importance. Respectively, the figures represent the condition of friendliness in Yogyakarta City and Magelang City. As the role [8] the quadrant should be read as follows. Quadrant A has high importance/low performance, where the citizens perceive that the attributes are important but the city’s performance is low. Quadrant B is for high importance/high performance, where the citizens perceive that the attributes are important and the city’s performance is high. Quadrant C is low importance/low performance, where the citizens perceive that the attributes are less important as well as the city’s performance. And in Quadrant D, there is low importance/high performance, where the citizens perceive that the attributes are less important but the city has already had a good performance. In IPA, follow-up on findings can be concentrated in quadrants A and B only.

Quadrant A is where the existing indicators have good importance, but not supported by adequate performance. And in Quadrant D, there is low importance/high performance, where the citizens perceive that the attributes are less important but the city has already had a good performance. In IPA, follow-up on findings can be concentrated in quadrants A and B only.

Quadrant A shows in which attributes the citizens perceived that city’s performance is low and that affect the level of friendliness. Both Yogyakarta and Magelang have similarity that the city performance is low in the dimension of city’s mobility (SM), environment (SN) and disaster management (SDM). In addition, Yogyakarta citizens also perceive low ratings on the performance of smart government (SG), in which Magelang does not own it. However in which attributes the performance is low are quite different. Yogyakarta has more attributes that have an effect on low city performance appraisal (14 attributes) than Magelang city (6 attributes). From this perspective, through existing respondent data that has shown a better percentage of educational background, Yogyakarta citizens have a friendliness-sensitivity to the high attribute’s standard of smart city than the citizens of Magelang. With the same environmental standards in Indonesia nowadays, for example in the smart environment (SN), Yogyakarta citizens perceive that what they earn does not meet the criteria of smart city (certified green building, energy saving house, green open space). Meanwhile, Yogyakarta citizens consider that ICT-related city services in public space, such as WiFi coverage, sensor coverage, open data and apps (all included in smart government (SG)) have not met their expectations. In this context, friendliness is seen from how the degree of sensitivity of citizens in assessing the attributes of smart city, based on the demands of citizen’s needs.

In Quadrant B shows a high appraisal of city attributes and city performance. In this case, the citizen of Yogyakarta City perceives that the level of friendliness of smart city is currently good, but limited to certain attributes for smart people (SP), smart living (SL), smart government (SG) and smart disaster management (SDM). Totally, there are only 10 attributes that are considered to have good performance and important in the city of Yogyakarta. Meanwhile in Magelang City, there are more attributes that categorized into Quadrant B (16 attributes). Almost all attributes in smart living (SL) and smart government (SG) in Magelang City are in this category. These findings indicate that the city of Magelang has a level of friendliness-sensitivity in the provision of community needs, according to the attributes of smart city. The city is able to prioritize what is needed by the citizen, especially through government services (SG) to improve the life of its citizens (SL). In this case, from the city service perspective, friendliness is the city’s sensitivity in improving service performance towards better smart city implementation.

Inevitably, the concept of friendliness in a smart city program through the attributes that are implemented is a condition in which supply and demand meets. The case in the two cities used in this paper, in which both of them have been selected as award winning cities for the smart city award in 2015, have given a concrete picture of how the attribute condition exists from its citizen perception. Yogyakarkat City with number population of 3 times more than the Magelang City, more complex background and needs of its citizen, as well as more complex problems it has, resulted higher demands on some of existing smart city attributes. Yogyakarta City Government for example should more concentrated to improve services on the existed attributes in Quadrant A. In contrast, the City of Magelang, a city with about 120 thousand inhabitants, its citizen has a good perception of what has been done by the government with a standard that may be similar to what has been done in Yogyakarta. Sensitivity of the city in serving the needs of population appropriately in the context of smart city application is indispensable. Increasing readiness of the city (stakeholders) through preparation of
appropriate roadmap based on suitability of the population needs is a basic strategy that can be applied immediately.

5. Conclusion
The result briefly shows the level of city sensitivity in the application of smart city is very influential in viewing the friendliness of the city. The city that is better equipped to meet the needs of its population according to the dimensions of the smart city based on its existing characteristics has higher friendliness. Time period of applying a smart city concept as the City of Yogyakarta has done longer before Magelang City, is not a guarantee that the city then has a better level of friendliness. The urban citizens have appropriate affective aspect to articulate between what they need and what the city has provided.

Cities that have more complex citizen needs and have a high knowledge (cognitive aspect) of smart city application will have a higher sensitivity of the needs. Yogyakarta City citizens are already in a step to argue that smart environment (SN) and smart disaster management (SDM) is important priority to take into account currently. In this case, once again, the effort to bring together supply and demand in a smart city becomes a key part of friendliness. This paper is expected to be a basis for further research to see what kind of strategies are appropriate in responding to the city's performance improvement according to the smart city attributes.

References
[1] Anonim 2016 Final Report of “Jogja Istimewa” Smart City Study (Laporan Akhir Kajian Smart City Jogja Istimewa) Badan Perencanaan Pembangunan Daerah (Bappeda) Kota Yogyakarta and Pusat Studi Perencanaan Pembangunan Regional (PSPPR) (Yogyakarta: UGM)
[2] Bappenas (National Planning Bureau) 2014 National Policy and Strategy for Urban Development (Kebijakan dan Strategi Pembangunan Perkotaan Nasional (KSPPN)) [WWW Document] URL http://tataruangpertanahan.com/regulasi/pdf/kepmen/kepmenppn_65_2014.pdf, accessed 22 April, 2017.
[3] Chuttur M 2009 Overview of the Technology Acceptance Model Origins, Developments and Future Directions Sprouts Working Papers on Information Systems 9 (37) (USA: Indiana University)
[4] Cohen B 2012 What Exactly Is a Smart City? Co.Design. [WWW Document] URL https://www.fastcodesign.com/1680538/what-exactly-is-a-smart-city, accessed 10 April 2017
[5] Davis F D, Bagozzi R P and Warsaw P R 1989 User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. Inst. Manag. Sci. 35 pp 982-1003 doi:10.1287/mnsc.35.8.982.
[6] Kompas 2015 These are Smart City-Award Winning Cities 2015 (Inilah Kota-Kota Penerima Anugerah Kota Cerdas 2015) [WWW Document] URL http://print.kompas.com/baca/2015/08/13/Inilah-Kota-Kota-Penerima-Anugerah-Kota-Cerdas-2015, accessed on May 20, 2017.
[7] Kshetri N, Alcantara L L and Park Y 2014 Development of a Smart City and its Adoption and Acceptance: The Case of New Songdo Digiworld Econ. J. Commun. Strateg. 96 4th quarter 113
[8] Martilla J A and James J C 1977 Importance-Performance Analysis J Mark 41 pp 77-79 doi:10.2307/1250495.
[9] Murgante B and Borruso G 2013 Cities and Smartness: A Critical Analysis of Opportunities and Risks, in: Computational Science and Its Applications – ICCSA 2013, Lecture Notes in Computer Science. Presented at the International Conference on Computational Science and Its Applications, Springer, Berlin, Heidelberg pp 630-642 doi:10.1007/978-3-642-39646-5_46.