



Designing a Model for Smart City through Digital Transformation

Noor Athirah Muhammed Asri¹, Rosziati Ibrahim², Sapiee Jamel³

¹Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, athirahasri0310@gmail.com

²Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, rosziati@uthm.edu.my

³Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, sapiee@uthm.edu.my

ABSTRACT

The concept of smart city is still debatable and yet gives attention to every country around the globe as to provide their community a better quality of life. In Malaysia as well, new ideas for development has always evolved and arise to enhance quality, performance and interactivity of services. Putrajaya has been suggested to be the first smart city in Malaysia. However, there is no model of smart city in Malaysia yet. Thus, it is crucial to form a model of smart city in Malaysia. The model is designed using the requirements gathering by questionnaires distributions, interviews and observations. The relations between Internet of Things (IOTs) and culture influence are the foundation of designing the smart city model in Malaysia.

Key words: smart city, digital transformation, information and communication technology (ICT), Internet of Things (IOTs)

1. INTRODUCTION

The explosive growth of information and communication technology (ICT) has led to integrating applications and systems to produce a better outcome. Industry 4.0 phenomenon which still evolving and has improved tremendously in the past years are caused by explosive growth of the use of ICTs which led to integrating different scopes of development such as economic, mobility, environment, people, living and governance. The smart city concept has been drawing people into it globally for the past decades. Smart city has become an emerging paradigm with the flourishing and innovation of Internet of Things (IOTs) involving of ubiquitous sensing, heterogeneous network infrastructure, and intelligent information processing and control systems [1].

The world's urban population increase from years to years as a result the cities are growing and become increasingly crowded. As forecasted, in 2030 the population that will live in city environment has greater than 60% as the growing trend of large numbers of populace moving towards to urban

living [2]. Furthermore, we cannot deny the rising economy and social transformations in city are one of the factor people want to live in urban areas. To provide a reasonable quality of life to the people live in city has always a challenge for the government. In order to achieve it, concepts, systems, environments, energy, citizens, infrastructures, information, policy and technology are elements that matters in developing a city to improve quality of life.

The 21st century is experiencing the modern urbanization with the introduction of digital revolution that leads to digital transformation. Digital transformation means change of a community or organisation in deliver improvement of services or products by enhance information technology (IT) as the core element [3]. The implementation of digital technologies encourage city in developing a balanced ecosystem and set a scale as aims to be the best. According to Telefonica [4], mobility and connectivity, collaborative society, cloud computing are vital in keeping up to the trends in transforming digitally. Expected in 2020, 90% of world population have a mobile phone for each which drives to generate more amount of information. Then, the collaborative society affects the economy in vigorous way which causes to consumer and society in good way. Lastly, Telefonica [4] mentioned cloud computing which make the service more efficient by carry a large volume of data in managing a community.

In Malaysia, Kuala Lumpur city is planning to become a smart city. According to Zunaira [5], Kuala Lumpur is a potential candidate for a smart city by next year. With the cooperation from Alibaba Cloud, Kuala Lumpur is the first city outside China to embrace smart city system of Alibaba. As for now, the pilot study has been carried out and the result shows that time travel will be reduce about 12% which equal to saving 10 minutes in traffic congestion [5]. Emily [6] highlighted that Putrajaya, a territory of Kuala Lumpur, plays vital role in leading Malaysia into the Information Age with the theme to become an intelligent garden city. Vijenth [7] mentioned that Putrajaya has move towards smart city by introducing residents an application called Putrajaya Mobile which provides information of public services and tourist location. In technology wise, prime minister of Malaysia,

Tun Dr Mahathir highlighted in [8] that in the next three years, Malaysia is possible to utilise 5G technologies to enable the sustainability of country and moving towards intelligent city. This proves that Malaysia always ignited in becoming high technology country.

2. RELATED WORKS

Smart city defines as the new urban environment, one that's designed for performance through information and communication technologies (ICTs) and other forms of physical capital [9]. Industry 4.0 is still evolving and has improved tremendously in the past years. The explosive growth of the use of information and communication technologies (ICTs) has led to integrating different scopes of development such as economic, mobility, environment, people, living and governance.

To improve its operations of the advantage of inhabitants, better public services make a better smart city. Saraju *et al.* [10] highlighted that any combination of Figure 1 with various smart components can make cities smart. A smart city do not necessarily has all the components to label as smart but depends on the cost and availability of the technology. To diminish the problem of rapid urbanization phenomenon, smart cities, regardless of the expensive cost, can help in resolve the issue. Furthermore, it can reduce energy consumption, water consumption, carbon emissions and city waste [10].

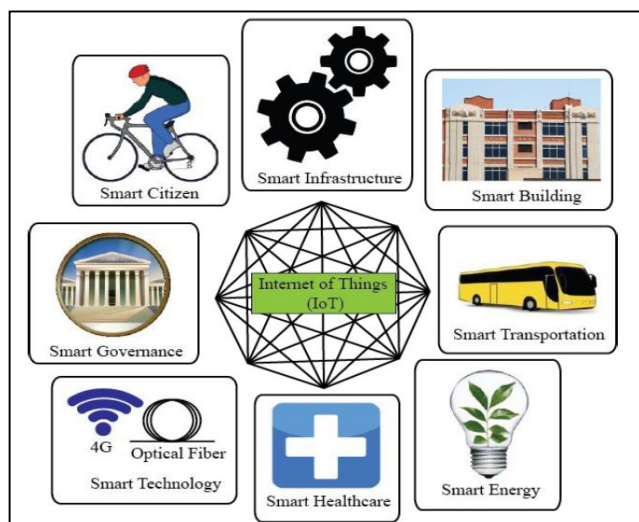


Figure 1: A Broad Overview of Smart City Components [10]

Giffinger *et al.* [11] mentioned there are six characteristics as shown in Figure 2 of smart city which is smart people, smart governance, smart mobility, smart environment and smart living. Smart economy describes as the economic competitiveness to increase high productivity in communities, Smart people is not only based on level qualification education of people but the way netizens interacts or socialise with the world. Smart governance contains political

participation to serve the netizens in transforming ways that public services are delivered. Smart mobility is technologies that able people to move around in efficient way with a wide range of transportation. Smart environment describes as the natural conditions in taking care of surrounding by efforts towards environmental protection. Lastly, smart living involves in numerous aspects improving quality of life such as health, safety, housing and tourism.

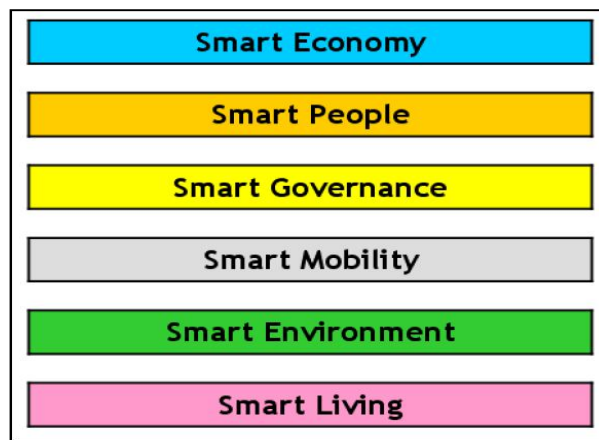


Figure 2: Six Characteristics of Smart City [11]

According to United Nations, the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100 [12]. The rise of population has led to urbanisation planning in order to improve the quality of life in terms of economy, lifestyle, health, infrastructure and society.

The #SmartME project [13] is one of the initiatives towards smart city in Italy. The #SmartME project is an IOT service ecosystem for smart cities by using low cost sensor-powered devices as the middleware. Figure 3 shows the four layers model of smart cities [13]. Bruno *et al.* [13] mentioned that in a smart city, infrastructure made out of sensors and actuators are needed to manage properly as it is the fundamental of a smart city. In this project, various applications has been implemented to manage resources and infrastructure such as #SMARTME Parking which aims to solve parking problems with use of artificial intelligence (AI) algorithms; #SMARTME Lighting to find solution in having low-cost lighting systems and #SMARTME Energy to reduce amount of energy use and cost-saving. The last layer is stakeholder, as this project is a crowd-sourced project, the contributions from citizens, public or private sector is important in order to make it possible for the smart city realization.

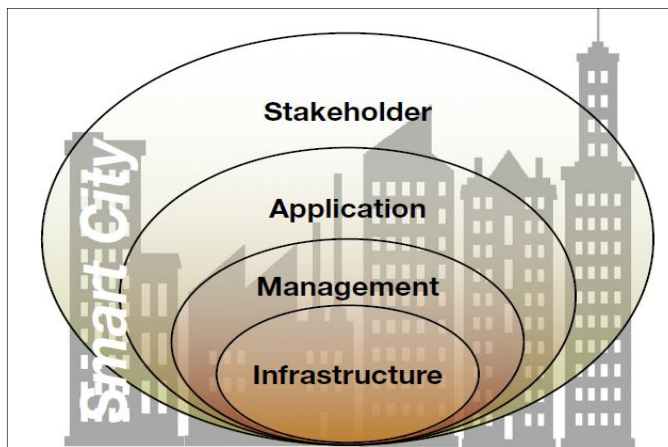


Figure 3: A 4-layer model of smart cities [13]

In building a smart city, government plays a vital part in nurturing smart cities, which focusses on connecting infrastructure for better insights with the goal of improving quality of life by integrating technology with the built environment. Governments, industries and academia globally attracts to the concept of smart city. The aim to enhance city security, improve data driven city governance and optimise city processes and usage of scarce resource has led to governance invest on modern smart city technologies. The phenomenon of smart city has been a trendy in this decade but call to mind that each city has its own particular needs and perspective. To assists cities and their stakeholders to accomplish the aims, Hamalainen et al. [14] introduced a Smart City Conceptual Model (SCCM) that consists of four primary dimensions, which are strategy, technology, governance and stakeholders.

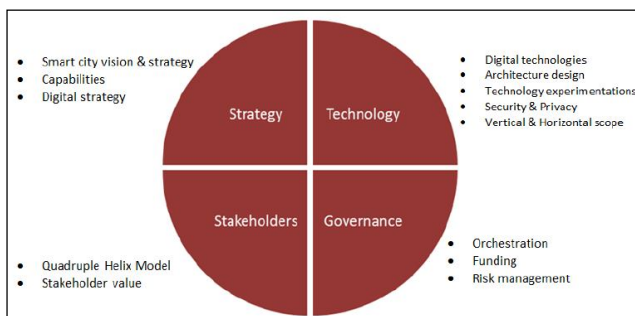


Figure 4: Smart City Conceptual Model [14]

Similarly, Gaur et al. [2] proposed smart city architecture by using multi-level system design. Each day, a huge amount of data being generated across variety of domains. A new method using semantic web technologies and Dempster-Shafer theory has been introduced in [15]. Figure 5 shows the Multi-Level Smart City Architecture that contains four levels.

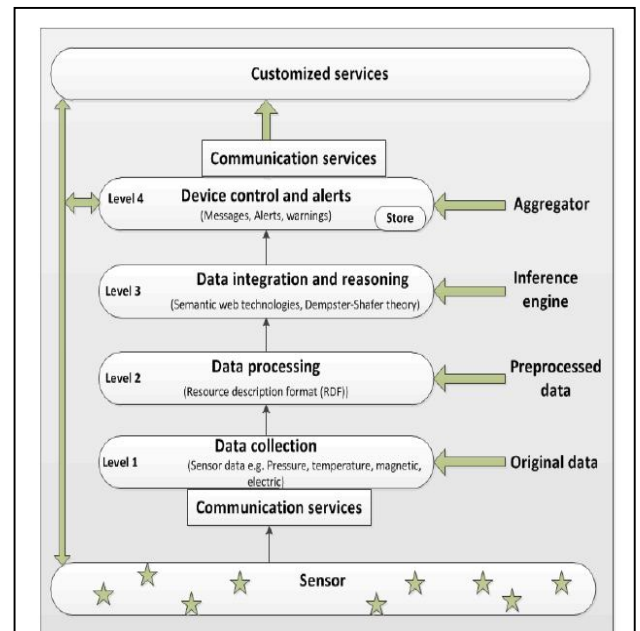


Figure 5: Multi-Level Smart City Architecture [2]

By gathering data and on-site survey for six months in London, Stockholm and Montreal, Ben [15] presented a SMART model that aims to clarify how to design and implement strategies for development of smart cities as shown in Figure 6. Ben [15] suggested that in order to transform the city, private and public stakeholders must collaborate together. In Montreal, major ICT focus on health and transportation as it populates with older generation. While in London, it emphasises in transportation and mobility due to the city attractiveness.

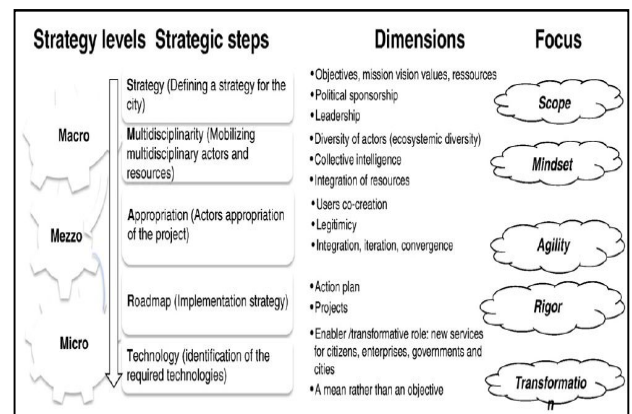


Figure 6: The SMART model [15]

A sustainable smart city with the help of Big Data and IoT ensure a sustainable environment. Sujata et al. [16] identified six pillars of smart city, which is Social, Management, Economic, Legal, Technology and Sustainability (SMELTS). Sujata et al. [16] proposed a SMELTS framework based on these six elements as shown in Figure 7. Citizens who are able to socialise and communicate with governance are the key of social in shaping a smart city. The awareness of smart city need to take into considerations, as city is all about

citizens. The management, which usually governance plays essential role in executing a smart city. Physical governance or digital governance, both are important to serve the citizens. In assure, e-governance probably helps citizens interact actively to enable greater participation in disclose data exchange, opportunities, collaboration and service integration. Major driving force of smart city, economy is crucial as core indicator to measure a city is based on its economical state. Also stated in [16], legal compliances such as councils, governments and political bodies are key aspects in organizing growth and development of a city. ICT is another significant role in developing the smart city as well as IOT. Sujata et al. [16] also highlighted that sustainability as one of the elements. The basic concept of sustainability is balancing between preserving the environment and modernizing a city. In developing a city, the carbon emission is probably higher than countryside, but with smart applications we can find other effective way to preserve it to lead a better liveable life.

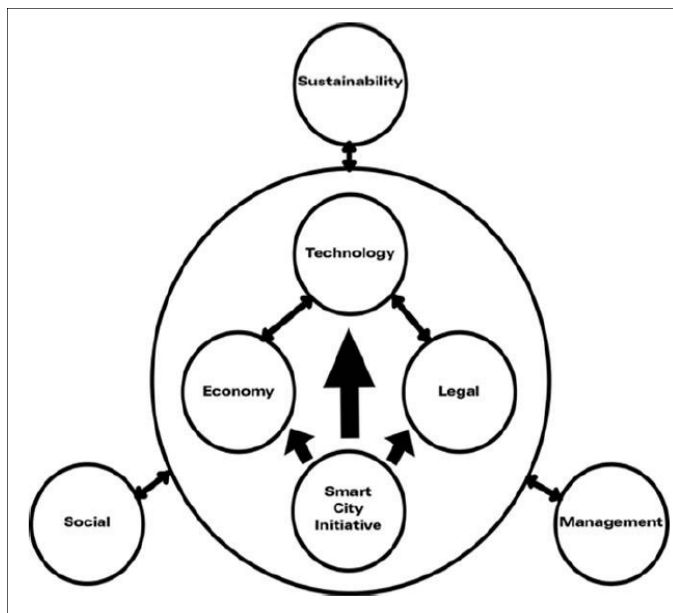


Figure 7: The SMELTS framework Initiative [16]

Khan et al. [17] proposed a Dynamic Responsive System (STDRS) framework as shown in Figure 8. The objective of Dubai smart city is to make Dubai the happiest city on earth. Dubai has made it a benchmark to countries throughout the world. The STDRS framework uses multiple levels of integration to develop a smart with happiness system. The IT platform, data and IT infrastructure are the base on integration of STDRS. Smart Tourism plays a big role in order to create an intelligent city, thus, STDRS make it possible for it [17].

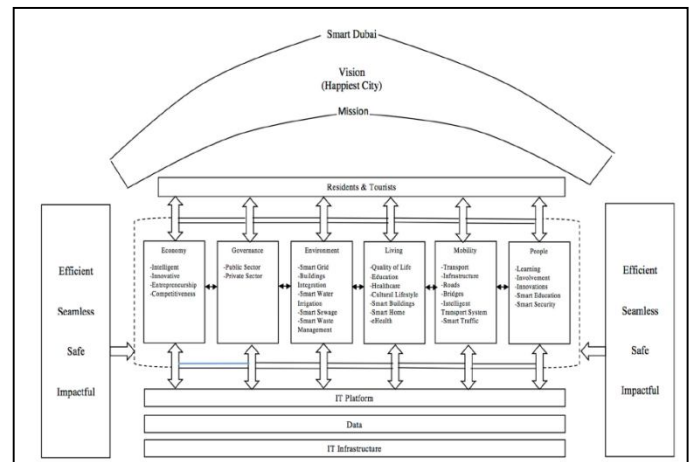


Figure 8: Smart Tourism Dynamic Responsive System (STDRS) framework [17]

Undeniably, there is a lot of smart city model research across countries. Different countries have different parameters and indicators to build an intelligent city. This study has led to Kesswani N. and Kumar S. [18] to form a new model of smart city by extensive reading on the related topics to determine the features, characteristics and dimensions proposed by other researchers. Different researchers have their own opinion on smart city parameters. For instances, Anthoupolous et al. [19] provide different smart city model with the approach of Nine Pillar model by IBM which take the human services as the main services of a smart city. Bellisent [20] classify smart city infrastructure around the globe as transportation, healthcare, education, public safety, utilities, building management and constituent services. Smart city ecosystem is an integration of technology aspects like sensing, networking and data analytics [21]. This information collected has been highlighted to get a Smart-X model for smart city as shown in Figure 9.

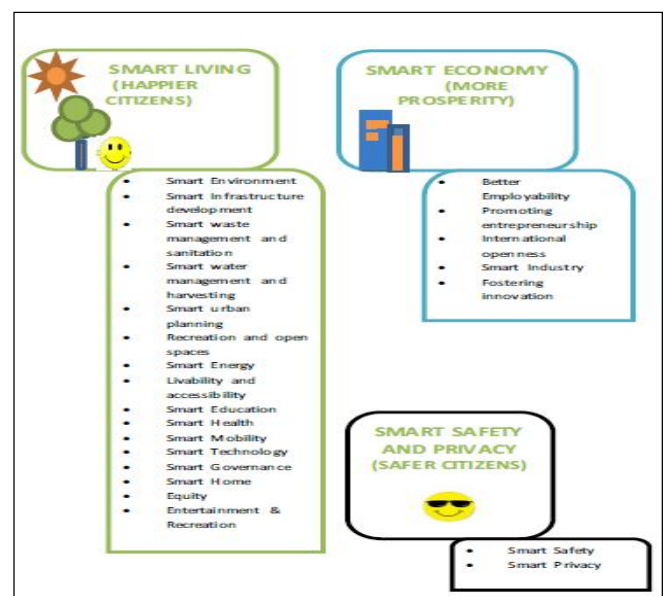


Figure 9: The SMART-X Model [18]

As smart city is still new and on-going development in Malaysia, the awareness and the impact of it might not be attentive enough to the netizens. This issue can relate with the IT adoption surveys among Malaysians that have been studied decades ago. A model of IT adoption as shown in Figure 10 is the output of this research. Parameters have been identified throughout the survey based on different perspective [22].

Figure 10 show they are two perspectives which are managerial perspective and organisational perspective with diverse parameters.

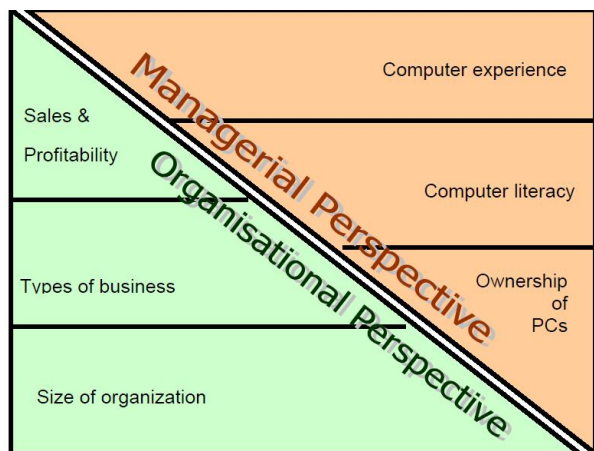


Figure 10: An IT adoption model [22]

Based on related works discussed, Table 1 summarized all the elements and components found for the smart city.

Author and Year	Method	Model
Bruneo et al., 2019 [13]	4 layer model (infrastructure, management, application and stakeholders)	A 4-layer model (Figure 3)
Hamalainen et al., 2018 [14]	4 dimensions (strategy, technology, governance and stakeholders)	A smart City Conceptual Model (Figure 4)
Kesswani et al., 2018 [18]	Extensive reading from different researchers across different countries.	The Smart-X model (Figure 9)
Khan et al., 2017 [17]	Multiple level of integrations (IT platform, IT infrastructure, environment, economy, governance and people)	Smart Tourism Dynamic Responsive System (STDRS) (Figure 8)
Sujata et al., 2016 [16]	6 elements (sustainability, social, management, economy, legal and technology)	SMELTS Framework (Figure 7)
Ben Letaifa S., 2015 [15]	4 dimensions (stakeholders, environments, transportation and resources)	Smart Model (Figure 6)

Author and Year	Method	Model
Gaur et al., 2015 [2]	4 levels(data collection processing, integration and devices)	Smart City Architecture (Figure 5)
Ibrahim R. and Jacey, 2005 [22]	2 Perspective (Managerial and Organization)	IT Adoption Model (Figure 10)

3. THE PROPOSED MODEL

Based on elements and components for smart city in Table 1, a model for smart city can be formed for Malaysia perspective. A model of smart city should consist of two major elements, which are infrastructure and environment. Infrastructure can consist of any smart building such as smart hospital, smart school, smart library and recreation park. For environment, people of a smart city should have smart waste management system, renewable resource energy, sustainable energy and water supply as well as smart recycling program. In designing the smart city model, utilization of IOTs is a must. IOTs is a part of ICT which is the focal point in transforming city as ingenious, intelligent and smart. Components of IOTs include CCTV, WiFi and WSN (Wide Sensor Network). In Malaysia, various ethnics made Malaysia as a unique country. Due to this, in designing the smart city for Malaysia, culture perspective should be considered. Figure 11 shows the proposed components for smart city in Malaysia by adding culture as another component for the smart city.

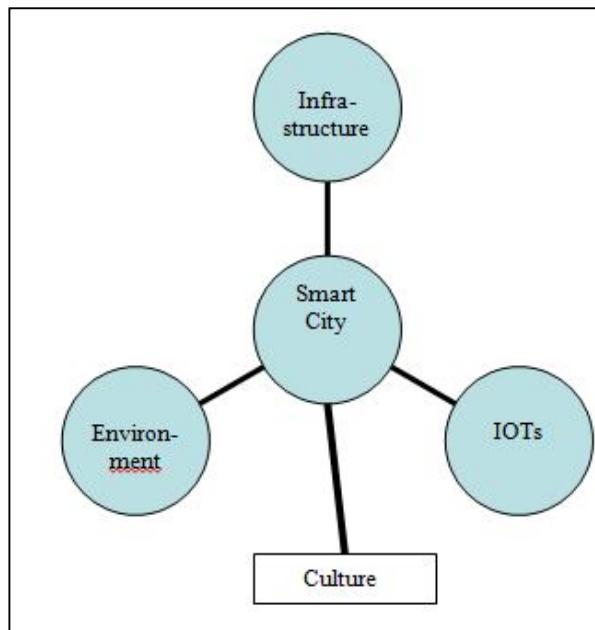


Figure 11: The Components for Smart City in Malaysia

Based from Figure 11, the proposed components for smart city in Malaysia consists of infrastructure, IOTs, environment and culture. Infrastructure and IOTs are the core elements in developing the smart city. But in order to have a sustainability city, environment elements should be taken into account as the ecological of city need to be

balance for a livable city. Our proposed model takes into consideration of culture due to Malaysia environment. Adopted from smart city conceptual model in [14], we propose the model for smart city in Malaysia as shown in Figure 12.

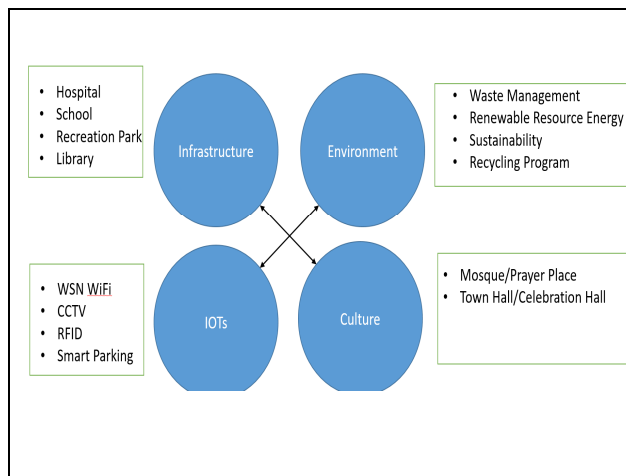


Figure 12: The Model for Smart City in Malaysia

To validate our proposed model as shown in Figure 12, we are designing the validation instrument, which is questionnaire. The questionnaire is divided by five sections which are demographic information, awareness of smart city, elements of smart city, impact of smart city and culture influence towards smart city. This instrument can be used to survey the community in order to validate the proposed model that incorporated culture as another element in the model for smart city in Malaysia.

The interviews and surveys will be conducted to community for requirements gathering. Requirements gathering are essential to fully understand what the project will deliver to its success. The possible possibilities can be found as our expected outcome may be limited. The distribution of questionnaires among community can support the validation of the proposed model. By probing questions, the study can drill-down areas that important that can be critical to the design of the smart city. In this phase residents can states the expectation of smart city, how it will done, who is going to use the facilities and the specific information included with any special requirements related to the study.

Once the data have been gathered, the data will be analysed. Two existing models of smart cities namely Brisbane [23] and Dubai [24] will be studied and used for benchmarking during the analysis of requirements. The data collected helps to determine the requirements of smart city.

IOTs have been used by many researchers such as [25] and [26]. Rae *et al.* [25] used IOTs for setting up their Wireless Sensor Network (WSN). Devi *et al.* [26] uses IOT technology for the vehicles in order to ensure the safety of the children while using the vehicles going to school. Dauwed *et al.* [27] used IOTs for setting up the framework for the health information exchange within the

hospital. They utilize the IOTs in developing the framework. For our model for smart city, we also utilizing IOTs. IOTs have been considered as major elements in developing the model for the smart city.

4. CONCLUSION AND FUTURE WORKS

In this paper, a smart city model through digital transformation has been proposed. The proposed model consists of infrastructure, IOT, environment and culture. For future work, we would like to validate the proposed model with survey instruments. We will gather the data. Once the data have been gathered, the data will be analyzed.

ACKNOWLEDGEMENT

The authors would like to thanks Ministry of Education (MOE) for supporting this study under Fundamental Research Grant (FRGS) entitled: Designing a Model for Smart City thru Digital Transformation: A Case Study of Sri Gading, under grant Vote No K043.

REFERENCES

1. Zhang K., Ni J., Yang K., Liang X, Ren J., Shen X. **Security and Privacy in Smart City Applications: Challenges and Solutions.** *IEEE Communication Magazine* 2017.
2. Gaur A., Scotney B., Parr G. McClean S. **Smart City Architecture and its Application based on IoTs.** *The 5th International Symposium on Internet of Ubiquitous and Pervasive Things* 2015. <https://doi.org/10.1016/j.procs.2015.05.122>
3. K. Tomičić-Pupek, I. Pihir, M. Tomičić Furjan. **Smart City Initiatives in the context of Digital Transformation-Scope, Services and Technologies.** *Journal of Contemporary Management Issues, Vol. 24, No. 1, pp. 39-54, 2019.* <https://doi.org/10.30924/mjcmi.24.1.3>
4. Telefonica. **Smart cities an opportunity for Europe-The city as a platform for Digital Transformation.** 2016.
5. Zunaira Saieed. **Kuala Lumpur set to become a Smart City Next Year.** *The Star Online April 25th 2019.* Retrieved from thestarcom.my.
6. Emily K. **A Planned Intelligent City.** *The Star Online May 16th 2018.* Retrieved from thestarcom.my.
7. Vijenthi Nair. **Taking Digital Steps to become Smart City.** *The Star Online December 25th 2018.* Retrieved from thestarcom.my.
8. Mazwin N. A. & Joseph K. Jr. **Dr M: Malaysia able to leverage 5G within next three years.** *The Star Online April 18th 2019.* Retrieved from thestarcom.my.
9. Carol L. Stimmel. **Building Smart Cities- Analytics, ICT and Design Thinking.** pp.6, 2016. <https://doi.org/10.1201/b18827>
10. Saraju P. M., Uma C. & Elieas K. (2016). **Everything You wanted to Know about Smart Cities.** *IEEE Consumer Electronics Magazine* 2016

11. Giffinger R.. **Smart Cities- Ranking of European medium-sized Cities.** *Central of Regional Science, Vienna UT, October 2007.*
12. United Nation. **World Population Prospects: The 2017 Revision.** Retrieved from www.un.org
13. Bruneo D., Distefano S., Giacobbe M., Minnolo L. A., Longo F., Merlino G., Mulfari D., Panarello A., Patane G., Puliafito A, Puliafito C & Tapas N.. **An IoT service ecosystem for Smart Cities: The #SmartME project. Internet on Things.** *Journal of Internet of Things Engineering Cyber Physical Human Systems, 2019.*
<https://doi.org/10.1016/j.iot.2018.11.004>
14. Hamalainen M., Tyrvaainen P.. **Improving Smart City Design: A Conceptual Model for Governing Complex Smart City Ecosystems.** *31st Bled Econference: Digital Transformation: Meeting The Challenges 2018.*
<https://doi.org/10.18690/978-961-286-170-4.17>
15. Ben Letaifa S., **How to Strategize Smart Cities: Revealing the SMART model.** *Journal of Business Research (2015).*
<https://doi.org/10.1016/j.jbusres.2015.01.024>
16. Sujata J., Saksham S., Tanvi G. & Shreya. **Developing Smart Cities: An Integrated Framework.** *6th International Conference on Advances on Computing & Communications, ICACC 2016, September 2016.*
17. Khan M., Woo M., Nam K., Chathoth P.. **Smart City and Smart Tourism: A Case of Dubai.** *Sustainability, Vol. 9, Issue 12, December 2017.*
<https://doi.org/10.3390/su9122279>
18. Kesswani N. & Kumar S.. **The Smart-X Model for Smart Cities.** *42nd IEEE International Conference on Computer Software & Applications. 2018.*
<https://doi.org/10.1109/COMPSAC.2018.00112>
19. Anthopoulos L., Janssen M., & Weerakkody V.. **Comparing Smart Cities with Different Modelling Approaches.** *Proceedings of the 24th International Conference on World Wide Web, 2015.*
<https://doi.org/10.1145/2740908.2743920>
20. Belissent J.. **Getting Clever About Smart Cities: New Oppurtunities Require Business Models.** *Forrester Research Inc. 2010.*
21. Lea R.. **Smart Cities: An Overview of Technology Trends Driving Smart Cities.** *IEEE Technology Trends Paper, 2017.*
22. Ibrahim R., Jacey-Lynn M. **Usage of Information Technologies in Malaysian Business.** *Journal of Information Technology Impact Vol. 5, No. 1, pp. 5-14, 2005.*
23. Digital Brisbane. **Digital Brisbane 2.0 – Empowering residents and businesses to thrive globally-connected, digital-enabled world.** *Brisbane City Council, 2017.*
24. Salem F.. **A Smart City for Public Value: Digital Transformation through Agile Governance- The Case of “Smart Dubai.** *Dubai: Governance and Innovation Program, 2016.*
25. Rae S.V.R.K., Devi M.S., Kishore A.R. Kumar P. **Wireless Sensor Network based Industrial Automation using Internet of Things (IOT).** *International Journal of Advanced Trends in Computer Science and Engineering Vol 7, No 6, pp82-86, 2018.*
<https://doi.org/10.30534/ijatcse/2018/01762018>
26. Devi N.S, Raju K.S.R., Madhu A., Sekkhar R.R. **Safety and Security for School Children ‘s Vehicles using GPS and IOT technology.** *International Journal of Advanced Trends in Computer Science and Engineering Vol 7, No 6, pp91-95, 2018.*
<https://doi.org/10.30534/ijatcse/2018/03762018>
27. Dauwed M.A., Yahya j., Mansor Z., Hamdan A.R. **Determinants of Internet of Things Services Utilization in Health Information Exchange.** *Journal of Engineering and Applied Sciences Vol 13, No 24, pp10490-10501, 2018.*