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Factors that Influence the Sustainability of IoT Usage for Smart Living

[1]A.H. Mahadi, [2]K. Norliah, [3]S. Safiah, [4]M. Shahrulanuar and [5]A. Muhamad Afzamiman
[1,2,3,4] Centre of Languages and Human Development,
[3,5]Institute of Technology Management and Entrepreneurship,
[1,2,3,4,5]Innovative Software System & Services (IS[3]), C-ACT,
Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100
DurianTunggal, Melaka, Malaysia.
mahadi@utem.edu.my[1], norliah@utem.edu.my[2],
safiahsidek@utem.edu.my[3], shahrulanuar@utem.edu.my[4],
afzamiman@utem.edu.my[5]

Abstract

IoT has enabled a wide range of Internet applications to be used especially in industry and academic field by offering people unprecedented levels of convenience, comfort and enjoyment. However, there is still a lack of attention on the suitable usage of the technology for smart living. In addition, awareness among users and society on how important the IoT usage is still worrying. To this extent, this study aims to identify the factors that influence the sustainability of IoT usage among society for smart living. This study adopted a quantitative research. 150 questionnaires were distributed to community in Cyberjaya and only 126 responded to the survey. The data were analyzed using SPSS 20.0 using Pearson and multiple regression analysis. It showed that there are significant positive relationship between the performance effort, effort expectancy, social influences and facilitating conditions with the sustainable of IoT usage in Cyberjaya. The combination of all the three factors contributes 54.5% variance in the criterion variables (sustainable usage of IoT).However, effort expectancy is excluded from the regression due to the low value of beta in in the excluded variables tables. Thus, the importance of supporting IoT usage through infrastructure, individual and others perception towards IoT will influence the sustainable use of IoT. The findings of the research serve as guidelines for responsible management authority and provider to improve the products and services in order to sustain the IoT usage among society.

Key Words: Internet of Things, sustainability, usage, smart city.

1. Introduction

Internet of Things (IoT) is an integrated part of future internet enables a wide range of internet applications in order to gained more attention in academic and industry (Ghaffarianhoseini et al., 2013). Furthermore, recent advances in computer and communication technologies have offered people unprecedented levels of convenience, comfortable, and enjoyment. This will give immediate access to information about the physical world and the objects in it leading to innovative services and increase in efficiency and productivity (Bandyyopanhyay & Sen, 2011). Malaysia has rolled out its National IoT strategic Roadmap, with expectation that the implementation of IoT would contribute RM9.5 billion to country's gross national income (GNI) by 2020, and RM 42.5 billion by 2025. It is also expected that IoT implementation will generate a total 14270 high-skilled employment opportunities by 2020, as stated by Minister of Science, technology and Innovation, Dr Ewon Ebin (Digital News Asia, 2015).

IoT also expected to offer promising solution to transform the operation and role of many existing industrial system such as transportation and manufacturing system, as for example, when IoT used in intelligent transportation system, authority will be able to track each vehicle's existing location, monitor its movement and predict the possible road traffic (Xu et al, 2014). Unquestionably, the main strength of the IoT vision is the high impact it will have on several aspects of everyday life and behavior of potential users. The example of possible applications scenarios in which the IoT implemented are assisted living, smart home and offices, e-health, enhanced learning (Bandyyopanhyay & Sen, 2011).

Although the development of new technology related to IoT has been rapid and varied, there is still a lack of attention on the suitable usage of the technology to the Smart living overall. In addition, the awareness among users and society on how important the IoT usage is still worrying. To this extent, this study are going to see to what extent IoT are used or implemented in everyday life and consequently will help to understand how the users will respond to the changes in term of internet evolution occurred. Thus, this study aims to identify the factors that influence the sustainability of IoT usage among society in Smart Living. The ability of individual or an organization to transform the environment into smart living will empowers them to compete with other developing countries.

Considering less number of study being conducted on exploring the factors that influence the sustainability usage of IoT in Smart Living , this is the right time to determine the factors that is highly critical in affecting the usage of IoT among community in Smart Living. This study has been structured according each of section: 1) introduction, 2) literature review, 3) methodology, 4) discussion and lastly will be a conclusion.

2. Literature Review

The evolution of internet brings our economy and society highly depends on Internet of Things. Many industrial projects have been conducted in areas such as agriculture, food processing industry, environmental monitoring and security surveillance. With the rapid increasing in term of momentum, IoT brings millions of objects and devices into the connected world and it lead to the changing ways of managing assets, operation and living (Uden and He, 2017). The basic idea of IoT is to allow autonomous and secure connection and exchange of data between real world devices and applications (Lin et al., 2010). IoT also will links the real life and physical activities with virtual world (Bodhuin et al., 2006).

Moreover, IoT will play a leading role in future by assisted living, e-health, enhanced learning and more other example of possible applications scenarios. From the perspective of business users, the most apparent consequences will be equally visible in fields such as automation and industrial manufacturing, logistics, business or process management, intelligent transportation of people and goods (Agarwal et al., 2016). IoT in Smart Home able to support user-centered personalized healthcare and it offering to enhance the quality of life for people at home (Chen et al, 2009). Sun et al, (2006) stated that IoT help in increasing awareness and monitoring of children. It could also have potential in the care of the elderly. Dohr et al (2010) describe IoT technologies to support telemonitoring and assistance.

Many have claimed that the usage of Internet of things among society are contributed to positive feedback which involved improving people's everyday lives, new businesses are spawn, new building are built and make the city and transport smarter, give rise to new opportunities for the Information and Communication (ICT) sector, improve the functioning of the process undertaken in companies (Ziegeldorf et al, 2014), (Miorandi, 2012), (Alarcon et al, 2016).

Unforgettable, there are many challenging issue still need to be addressed such as trust, privacy and security that will influence the acceptance of IoT implementation by society. As we create new technologies, the challenge is to understand the personal effects of the technology in order to make it better serve our human purpose (Turkle, 2003). When technologies are perceived to be useful and easy to use, users are more likely to accept it (Davidoff et al., 2006). It is consistent with findings from William et al, (2015) where results on usefulness, ease of use, avoiding design which share detailed and personal information without clear purpose were predictive of accepting the technology in home. Moreover, privacy concerns will present a challenge in the acceptance of IoT technologies (Davidoffet al., 2006).

Other challenges that related to IoT are privacy and security that includes the concealment of personal information as well as the ability to control what happens with this information (Law et al., 2016). Guarantees in term of system-level confidentiality, authenticity and privacy are essential that will lead to the acceptation of IoT solution by the stakeholders on a large scale (Miorandi et al, 2012). Several security and privacy requirements are described as following; resilience to attacks, data authentication, access control, and client privacy. Privacy threat limiting the success of IoT vision when not implemented correctly (Ziegeldorf et al, 2014).

Privacy in IoT is the threefold guarantee to the subject for awareness of privacy risk imposed by smart things and services surrounding the data subject, individual control over the collection and processing of personal information by the surrounding smart thing and lastly is awareness and control subsequent use and dissemination of personal information by those entities to any entity outside the subject's personal control sphere (Ziegeldorf et al, 2014). There are 7 categories of privacy threats which are identification (Miorandi et al, 2012), tracking and profiling, privacy-violating interactions and presentations, lifecycle transitions, inventory attacks and information linkage arise. Meanwhile according to Miorandi et al, (2012) security in IoT consists of data confidentiality, privacy and trust.

Through the implementation of IoT in people's living, it brings a number of benefits such as increasing quality of life, life satisfaction, safety and security and also enhances innovativeness among society. Smart living will helps individual or society to compete in this digital era where almost everything is interconnected and brings towards the life's sustainability.

3. Methodology

This research use quantitative method using survey questionnaire to collect the data and information from respondents. This section focused on the selection of research design, population and sampling, research context, instrument, data collection and data analysis.

Research Design

Based on the literature review, a research design will be developed considering the sustainable usage of IoT and factors that influence the sustainability of IoT usage among community in Smart Living. This research includes four factors that influence IoT usage such as performance expectancy, effort expectancy, social influence and facilitating conditions. Respondents in this research consist of workers and students in the Smart Living. Research framework is as stated below:

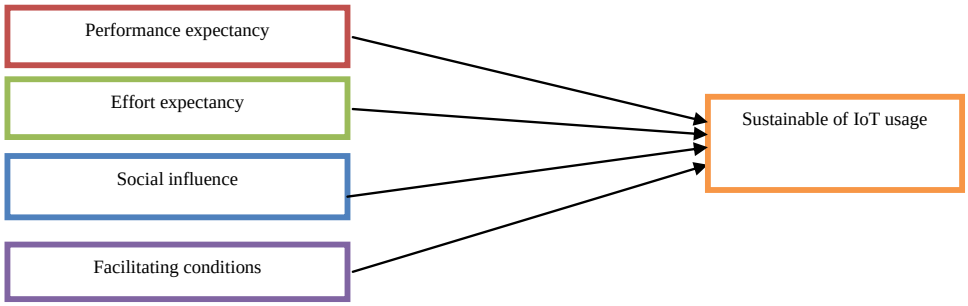

Figure 1: Research framework of factors that influence the sustainability of IoT usage

Research Location

We chose Cyberjaya that represent Smart City in Malaysia. The selection of Cyberjaya is due to its status as the earliest chosen as Smart City. Moreover, they are few institution located at Cyberjaya such as Multimedia University, Kirkby International College and Cyberjaya University College of Medical Science. Cyberjaya is also equipped with good, conducive and interconnected ecosystem that suitable for the development of residential area such as Tamarind Suites SoFo, and Gardenview Residence. Cyberjaya is also launched as a fully integrated city and Malaysia's pioneer tech hub. Thus, it is vey a good idea to choose Cyberjaya as location for this study.

Population and Sampling

The population focused on the communities in Cyberjaya, Malaysia. The total population for the purpose of this study is identified as 150 respondents from different age's group and background. Data collection process started on September 2017. To explore the significant level of dependents and independents variables, sufficient sample size is needed. From total of 150 distributed questionnaires, 126 questionnaires were responded.

Research Instrument

The research questions were designed to answer the research question and gain information from the communities regarding the factors that influence the sustainability of IoT usage. We adopted and developed the item construct for this research from previous study according to the suitability of this research. Likert Scale was used in the questionnaire due to its easiness to understand by the respondents and analyses of the data collected.

The questionnaire developed consists of three sections: The first section aims to obtain respondent's background information including their education and working background together with their understanding level towards IoT. The second section aims to gain information regarding the sustainable usage of IoT and it is consists of 9 questions. The last section

which is the third section is to identify the factors that influence IoT usage among community based on four factor which are effort expectancy with five questions, performance expectancy with four questions, social influence with three questions and facilitating conditions with seven questions. We used a 5-point Likert Scale to measure the item in the questionnaire and to collect detailed data about sustainable usage and the factor that influence IoT usage. The Likert Scale range from (1) which is 'strongly disagree' to (5) 'strongly agree'. All questions consist of 37 questions.

Data Collection Procedure

The questionnaire was developed and being improved through few processes and will be validated by the experts' person on quantitative method and SPSS to enhance the item in questionnaire. Additionally, this is to ensure that the questionnaire is clear and will able to answer the research questions. Data collection is expected to start on middle of September and will collect on early October 2017.

The questionnaires were distributed to a total of 150 respondents and they were given 15 minutes to answer the questionnaire. A short briefing regarding research's purpose and respondents were advice to answer the questions honestly. All of the information given are private and confidential. After the data collected, it will be analysed using SPSS version 20.0.

Data Analysis

The data collected were analysed using statistical method by using SPSS version 20.0. We analysed the respondent's background by using descriptive analysis that consists of frequency, mean, standard deviation and percentage. Other than that, Pearson Correlation that indicates the direction, strength, and significant relationship between the variables was also used to analyse the relationship between the factors that influence IoT usage and sustainable usage of IoT among communities in a Smart City. Multiple regression analysis helps to determine whether effort expectancy, performance expectancy, social influences and facilitating conditions are significant predictors of sustainable usage of IoT. A standard multiple regression was performed first by grouping all the four constructs as independent variables and the sustainable usage of IoT as dependent variables. The result was used to test the causal relationship hypothesis in this research. Correlation and regression were used to test the hypothesis and the answers for the research questions.

4. Result and Discussion

The purpose of the research was achieved by identifying the factors that facilitate or limit the IoT usage among community. The purpose is achieved by analyzing the relationship between the identified factors with the sustainable usage of IoT.

Respondents Background

The city of Cyberjaya was selected as research location and represents Smart City in Malaysia. The characteristics of the respondents are based on their background and understanding level of IoT, as presented in Table 1 and 2.

Table 1: Respondent's background

Background		Total	Percentage (%)
Gender	Male	52	41.3
	Female	74	58.7
Age	<20 years	19	15.1
	20-24 years	65	51.6
	25-29 years	14	11.1
	30-34 years	11	8.7
	>35 years	17	13.5
religion	Islam	88	69.8
	Buddha	24	19.0
	Cristian	6	4.8
	Hindu	6	4.8
	Others	1	0.8
Race	Malay	85	67.5
	Indian	8	6.3
	Chinese	29	23.0
	Others	4	3.2
Education level	Masters or PhD	8	6.3
	First degree and diploma	103	81.7
	Certificate	3	2.4
	Secondary school	7	5.6
	Primary school	3	2.4
	None	0	0
	Others	2	1.6
Working status	Students	84	66.7
	Unemployed	4	3.2
	Self employed	2	1.6
	Working with the government	0	0
	Working with private sectors	36	28.6
Citizenship	Citizenship	125	99.2
	Non citizenship	1	0.8

A total of 126 respondents in Multimedia University, Cyberjaya took part on this survey. Based on the table, there is a slight non-equal distribution between genders in which 41.3 % for male and 58.7 % for female. Moreover, the majority of the respondents were within 20-24 years with a total of 65 respondents (51.6%), while the least were respondents that is within 30-34 years with 8.7%. The majority of the respondents were Islam with 69.8%, followed by Buddha 24%. Christian and Hindu have the same percentage of respondents, which is 4.8%, and the least is other with the percentage of 0.8%. With respect to race, it is found that the Malay shows the highest percentage with 67.5% followed by the Chinese 23.0%, the Indian 6.3% and others 3.2%. Most of the respondents have their first degree and diploma. 81.7% and none of them were school dropout. With respect to working status,the majority of the respondents were students with 66.7%, followed by respondents that working with private sector with total 28.6%. However, none of the respondents were working with government. Almost all of the respondents were from Malaysia with percentage of 99.2% and only 0.8% was non-Malaysia.

Furthermore, respondents were also asked to choose the most frequent technologies used that including smart phones, tablets, smart television, laptop and desktop. Result shows that the majority of respondents used both smart phones and laptop with the percentage of 38.1%, and smart phones only with the total percentage of 37.3%. Moreover, only 0.8% used desktop in their everyday life compare to laptop 2.4%. This might due to the compatibility of laptop that makes them easier to handle and bring it everywhere.

Figure 4.2 shows the percentage of understanding level towards IoT. From the total of 126 respondents, 52 respondents or 53.6% shows that they have high level of their understanding. However, 12.4% claim that there is very low understanding towards IoT. While 22.7% respondents vote themselves as having a moderate understanding towards IoT. This means that this group of respondent is unfamiliar with the term 'IoT' or Internet of Things.

Relationship between Factors that Influence IoT Usage with Sustainable Usage of IoT

This section describes the analysis of relationship between the factors that facilitate and hinder IoT usage towards sustainable usage of IoT. The factors involved in the analysis are performance expectancy, effort expectancy, facilitating conditions and social influence. The strength of the relationship between independent variables (factor that facilitate and hinder IoT) and dependent variables (sustainable usage of IoT) consists of three level which is low, high and moderate (Cohen,1988).The analysis shows the relationship between thefactors that influence usage of IoT and sustainable usage of IoT among community in Cyberjaya as shown in Table 2.

Table 2: Analysis Relationship between Factors that Influence IoT Usage and Sustainable Usage of IoT among Community in Cyberjaya

		Performance expectancy	Effort expectancy	Social influences	Facilitating conditions
Sustainable usage	Pearson Correlation	.635**	.645**	.677**	.624**
	Sig. (2-tailed)	.000	.000	.000	.000
	Type of relationship	Strong	Strong	Strong	Strong
	N	126	126	126	126

**Significant level p<0.01

Based on the analysis above, results shows there are strong positive relationship between all four factors that influence IoT usage and sustainable usage of IoT among the community. Person correlation for performance expectancy, effort expectancy, social influences and facilitating conditions, r for the variable is ranged from 0.624 to 0.677, this proves that this four factors have influences on sustainable usage of IoT among community in Cyberjaya. The significant level that below 0.01 shows that the confidence level for the item is 99.99 percent, shows that there is strong relationship between performance expectancy, effort expectancy, social influences and facilitating conditions and sustainable usage of IoT. Overall, analysis shows that there are positive relationships between all factors with the sustainable use of IoT. Performance

expectancy, effort expectancy, social influence and facilitating conditions show strong relationship with sustainable usage of IoT. Next, multiple regression analysis were performed in order to identify the r influence between independent variables (Performance expectancy, effort expectancy, social influence and facilitating conditions) and dependent variables (sustainable usage of IoT). Result for regression analysis is presented on table 3 below.

Table 3: Multiple regression analysis

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.677[a]	.459	.454	3.90959	.459	100.961	1	119	.000
2	.724[b]	.525	.517	3.67979	.066	16.328	1	118	.000
3	.738[c]	.544	.532	3.61969	.019	4.950	1	117	.028

a. Predictors: (Constant), facilitating_condition

b. Predictors: (Constant), facilitating_condition, perfomance_expectancy

c. Predictors: (Constant), facilitating_condition, perfomance_expectancy, social_influence

ANOVA[d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1543.178	1	1543.178	100.961	.000[a]
	Residual	1818.905	119	15.285		
	Total	3362.083	120			
2	Regression	1764.266	2	882.133	65.146	.000[b]
	Residual	1597.817	118	13.541		
	Total	3362.083	120			
3	Regression	1829.127	3	609.709	46.535	.000[c]
	Residual	1532.955	117	13.102		
	Total	3362.083	120			

a. predictors: (constant), facilitating_condition

b.predictors: (constant), facilitating_condition, perfomance_expectancy

c.predictors: (constant), facilitating_condition, perfomance_expectancy, social_influence

d. Dependent Variable: sustainable_usage_IoT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.786	2.285		4.721	.000
	facilitating_condition	1.017	.101	.677	10.048	.000
2	(Constant)	6.656	2.381		2.796	.006
	facilitating_condition	.707	.122	.471	5.781	.000
	perfomance_expectancy	.691	.171	.329	4.041	.000
3	(Constant)	5.273	2.423		2.176	.032
	facilitating_condition	.563	.137	.375	4.112	.000
	perfomance_expectancy	.542	.181	.258	2.989	.003
	social_influence	.597	.268	.206	2.225	.028

a. Dependent Variable: sustainable_usage_IoT

Model summary table shows that overall correlation between factors (facilitating conditions, performance expectancy and social influence) with criterion variable is r=.74. Moreover, model 1 shows the R^2 valueis .459 which means that 45.9% changes in criterion variable (sustainable usage of IoT) causes by the changes in predictor variables, facilitating conditions. Thus, facilitating conditions is the main factor that influences the sustainable usage of IoT.

Next, R^2 value for second model is .525 (r=724) shows that 52.5% changes in criterion variables (sustainable usage of IoT) is due to the changes in combination between both predictors variables (facilitating conditions and performance expectancy). This means that the combination of facilitating conditions and performance expectancy contribute 6.6% added changes in sustainable usage of IoT. Social influences contribute 1.9% variance in sustainable usage of IoT. Overall, the combination of all three factors contribute 54.5% variance in criterion variables (sustainable usage of IoT).

ANOVA test report that all the predictors variables significantly are the factor that influence sustainable usage of IoT [F (3, 117) =46.535, P<0.000]. F-test analysis shows that there are relationship between all the predictor variables with the criterion variables at p<0.05. Model 1, model 2 and model 3 are presented below.

Model 1 [F (1, 119) =100.961, P<0.000],
Model 2 [F (2, 118) =65.145, P<0.000].
Model 3 [F (3, 117) =46.535, P<0.000]

The significant result for B-value shows that all the three multiple regression model formed by predictor and criterion variable can be generalize into population.

Regression equation
$y= 5.273 + .563 X_1 + .542 X_2 + .597 X_3$
y= sustainable usage of IoT
X_1= Facilitating conditions
X_2= performance expectancy
X_3= social influence

The significant standardized coefficients for all three factors which is facilitating conditions ($\beta = .36$, $p< .05$), performance expectancy ($\beta = .26$, $p< .05$) and social influence ($\beta = .21$, $p< .05$) shows that the variables is the factors towards sustainable use of IoT. Regression equation shows a linear relationship between variables y and x. Thus, the increasing in the degree of organizational and technical infrastructure exists to support the use of IoT will also contribute to increasing sustainable usage of IoT. The degree of individuals perceives that others believe that he/she should use IoT and IoT will enhance their performance will also increase the sustainable use of IoT. However, effort expectancy did not influence or contribute towards the sustainable use of IoT among community.

Based on correlation Pearson and multiple regression analysis, we can conclude that all independent variables show strong relationship with sustainable usage of IoT. However, effort expectancy is excluded from the regression due to the low value of *beta in* in the excluded variables tables. Regression Analysis shows that all the factor contribute towards sustainable use of IoT among the community in Cyberjaya. Thus, the importance supporting IoT usage through infrastructure, individual and others perception towards IoT will influence the sustainable use of IoT.

5. Conclusion

The study aims to identifying the factors that facilitates the sustainability of IoT among community in smart living. The results significantly showed that IoT has enabled wide range of future Internet connection with the capability to achieve enjoyment, convenient, comfortable, etc. with the integration of this advanced technology in Smart City specially. The critical dimensions of IoT have been studied by previous researcher in different areas and dimension. Nevertheless, the study of sustainability of IoT usage among community in smart living in Malaysia is still limited. Performance and effort expectancy, social influences and facilitates condition show strong positive relationship with sustainable usage of IoT among community in Cyberjaya. Thus, it can be concluded that all these factors driven the successful of sustainable usage of IoT among community. It

does have great influences toward the innovation of IoT implementation in Smart Living. The performance and effort expectancy, social influences and facilitates condition were found to have facilitates the sustainability of IoT usage in order to brings a number of benefits such as increasing quality of life, life satisfaction, safety and security and also enhance innovativeness among society. This factor might also drove the rapid development of smart living to achieve the motto of Smart City. By combining all the factors, it will greatly enhance the transformation of Smart City fully completed with the feature of IoT solution rather than facilitated by the factor alone. This might also increase the knowledge and people awareness toward the implementation of IoT usage in Smart Living. However, this study claimed that this factor wouldn't hinder the usage of IoT among community in Smart Living as the relationship was showing the opposite direction of its negativity. Thus, this factor were actually become the most successful factors being identified that facilitate to the sustainability of IoT usage in Smart Living society. It has shown that the services convenience increases the satisfaction level of users and affects the intention of users to sustain the IoT usage. IoT technologies are supposed to achieve better adoption rates if they could facilitate the consumers' daily life.

When assessing the sustainable of IoT usage, the social context of the decision maker should not be neglected. The social context plays an important role in the decision process among users. This is particularly the case for products and services in an early stage of development or diffusion in Smart City. Here, most users lack reliable information about usage details. Thus, the relevance of the social network opinions for individual evaluation of the products increases. This is similar to facilitating conditions which describes users' perception if they have the necessary resources, capability and a sense of control in successfully performing the behavior. This study has suggested the users need to possess the basic skills to use IoT systems/devices in order to sustain the IoT usage and support the development process of the Smart City which is fully featured by IoT solution. Thus, the importance supporting IoT usage through infrastructure, individual and others perception towards IoT will influence the sustainable use of IoT.

The main contribution is it theorizes the factors that influence the sustainability of IoT technologies, from a unified perspective including technology perceptions (facilitating condition), social context variable (social influence) and user characteristics (performance expectancy and effort expectancy). It links the constructs of performance expectancy, effort expectancy, social influences and facilitating condition to the unified theory and successfully extends the unified theory in the IoT technology context, which differs from the context of other information systems. The study contributes to current knowledge pertaining to society behavior in Smart Living. The contribution of this study is more directed toward the sustainable usage of IoT among community in Smart Living of Smart City.

Practically, this research can be guidelines for responsible management authority and provider to improve the products and services in order to sustain the IoT usage among society. The study has explored the importance of IoT technology as an innovative technology in daily lives and emphasizes the contribution to the Smart Living environment. The study has revealed that the consumer are more concerned on the perceived behavioral belief to use IoT for a long term basically on the performance expectancy, social influences and the facilitating conditions of technologies. Thus, IoT practitioners need to identify the factors that stimulate the usage of IoT services so that they can serve as a reference for facilitating broad diffusion in the future.

This study has some limitations. Firstly, the study conclusive for smart city at Cyberjaya only. It is recommended that future study should expand the boundaries to investigate the sustainability of IoT in other developing countries like India, Russia, China, etc.

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