

# LEVERAGING THE RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY IN DEVELOPING A FRAMEWORK FOR THE INTERNET OF THINGS PRODUCT

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## ABSTRACT

*This exploration paper expects to build up an estimation system for the acknowledgment variables of Internet of Things (IoT) items. Strategies/Statistical Analysis: An exploration model was built. Information from 321 Korean IoT clients was assembled and measurably prepared to determine a few components influencing on the acknowledgment of IoT item. For that reason, we administrated observational factor investigation. As the outcome, 4 elements were inferred. These components contain 4 estimated factors each. Diagnostic Hierarchical Process (AHP) technique was applied for the examination of the heaviness of the elements for acknowledgment of IoT items. Discoveries: The consequence of this paper indicated that the variables, similar to specialized issues, individual characters, natural factors, and cost factor influence the clients on the selection of IoT items. In this paper, 2 stages of the study were completed. In the main overview, 4 elements for the acknowledgment of IoT items were determined. In the second review, the heaviness of each factor was examined by the pair-wise correlation performed by 6 specialists in the field of IoT. The degree of importance of each factor was determined. As the outcome, "Cost of IoT" is the most noteworthy factor for the acknowledgment of IoT items. The factor "Client character" is the second noteworthy factor of all and this implies the "Client character" is likewise a significant factor for choosing the utilization of IoT items. Also, the following coming variable is "Condition issues". "Procedure issues" is the fourth factor. The fourth spot implies that this factor appears to be significant yet less persuasive than the other 3 factors in tolerating IoT items. The subsequent review has been directed to decide the heaviness of every factor. Enhancements/Applications: The aftereffect of this paper could be a significant reference to the IoT item organizations in arranging their business systems and showcasing their IoT items in Korea.*

## 1. INTRODUCTION

The recent developments in Information and Communication Technologies (ICT) make it possible not only to communicate between humans and computers but also to communicate between human and objects that surround us<sup>1,2</sup>. Using Radio Frequency Identification (RFID) chip, numbers of objects in our life can have unique Internet Protocol (IP) address, so that these objects can be connected to the internet world<sup>3-5</sup>. ABI Research predicts that more than 30 billion objects will get the form of Internet of Things (IoT) by<sup>6</sup> this is why we pay attention to IoT technologies. Just as the internet did, the IoT technologies will change the world<sup>7-9</sup>. The IoT technology is applicable to the field of home automation, supply chain of the materials, internet banking, environment protection, and remote healthcare service as example<sup>10</sup>. Even if there is a remarkable development in IT field,

IoT technology has still the limitation in its application and safety concerns. From the user's viewpoint, the privacy and security concerns are main barriers to buy and use the IoT product in daily life<sup>11</sup>. To promote and activate the use of IoT product in the market, it is necessary to understand user's behavioural tendency in decision for the acceptance of IoT product and identify the factors affecting IoT products adoption<sup>12</sup>. Many research works about IoT have been carried out from the viewpoint of technical issues and business application<sup>13,14</sup>. But in this paper, a study on the acceptance factors for IoT products was carry out from user's viewpoint. Because IoT is a sort of IT-related product, it is also necessary to research from the technological viewpoint<sup>15</sup>. From the technological viewpoint, it is necessary to identify which technical attributes affect user's interest in acceptance of IoT products. And it is also necessary to figure out the other factors besides technical factors, which satisfy the user in using the functions of IoT products. As we understand in general, the environmental factors, like social and cultural factors, play an important role in the acceptance of IT-product. In that sense we can regard the social and cultural factors as one of the important affecting factors in deciding to accept IoT product. At last, we should also consider the influence of the factor "cost", because the price affects mostly on deciding to buy and use of IT product in general. The price effect of IoT product is also studied, because the cost is one of the main factors influencing on user's acceptance of IoT products. As the second step, the Analytic Hierarchical Process (AHP) method has been applied to analyse these factors and measured variables according to their importance and weight, in order to decide a rank of the factors and their measured variables. This rank list explains which factor is important for the acceptance of IoT products. Many research works have focused on the basic technology for successful implementation of IoT products<sup>16</sup>. For example<sup>17</sup>, handled the problems about the security and privacy issues, while<sup>18</sup> tried to set up the concept about the IoT architecture<sup>17,18</sup>. On the other hand, few researches have carried out to understand the factors affecting on the acceptance of IoT products from the perspective of individual user. The objective of this paper is to analyse acceptance factors for IoT products of users. For that purpose, a research model as shown in Figure 1 was constructed. And the questionnaire with 5-point Likert scale and interview to the IoT experts was administrated to 312 Korean students. The data gathered from survey were statistically processed. The data validity and reliability was tested in the stage of factor analysis. And factors and variables affecting the acceptance of IoT products have been derived through several statistical approaches. As the result of factor analysis 4 major factors, i.e. technique issues, user characters, environment issues, and cost of IoT products, were derived. Figure 1. Research model In spite of lack of empirical work, this research paper aims to construct a measurement framework of factors affecting users' acceptance of IoT technology based on the analysis of the priorities according to factors' weight and significance. The result of this study could be the good reference for IoT related companies in understanding which factors entice the users' greater interest and acceptance for IoT products in the Korean market.

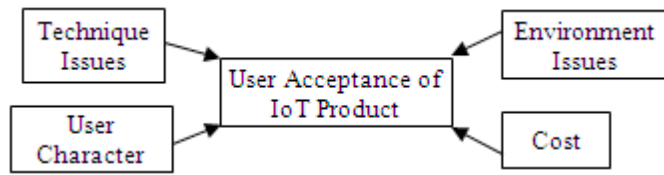


Figure 1. Research model

## 2. INTERNET OF THINGS

The Internet allows digital technologies of any kind to share and communicate the information. And internet technology had profoundly transformed our way of life. One of these big changes is “Internet of Things (IoT)” communicating and sharing the information through internet with each other. The IoT describe the physical objects that can communicate via internet. Many researchers emphasize that IoT could have revolutionary influences, if IoT can provide us very important information in our everyday life. Wikipedia’s definition about IoT is19:

IoT is the network of physical objects, devices, vehicles, buildings and other items which are embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more-direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit...”20.

This definition highlights that numbers of objects or things exchange information with each other using internet. IoT was regarded the objects that used RFID communication technology, and was applied in the area, like warehouse management, home automation, and healthcare service14. But with the advancement of IT and sensor technology, the IoT is getting smarter and smarter, so that the many sophisticated applications is to be found in business operations and smart homes. To summarize, IoT technology aims to operate, communicate and control the electronic devices at any time and any place by utilizing the internet technology.

## 3. COLLECTION AND DEFINITION OF DATA

### 3.1 Data Collection

In this paper, we formed up several categories of factors in 4 perspectives. The questionnaire surveys in 5 point Likert scale about these factors were conducted. This survey was carried out to derive the factors affecting on the acceptance of IoT products from the user’s perspective. The questionnaire was composed in 4 perspectives, i.e., technical perspective, user character perspective, environment perspective, and the cost perspective. These 4 perspectives were composed of 18 measured variables. As the result of factor analysis, these variables were grouped into 4 factors. These 4 factor scan be regarded as the factors affecting on the acceptance of IoT products. That is the technical functionality and attribute of IoT product itself, customers’ personal characters in using the new technology, safety

and privacy issues in adoption of new technology, and cost issues of new products. The contents of variables are shown in Table 1. As the second step, the analytic hierarchy process was carried out to analyse the weight-age of each factor and variable. After all we can set up rank of the all factors and their measured variables according to their weight and significance in deciding to IoT products.

### 3.2 Operational Definition of Variables

#### 3.2.1 Technical Perspective

IoT technology is the collection of all ICT, like mobile communication and software technique of various applications. In this paper, we will focus on the benefits and performances and the technical attributes of IoT product. From the perspective of the technical issues, “ease of use of IoT product”, “performance of IoT product”, “functionality of IoT product”, “state of art of IoT product”, and “safety in use of IoT product”, are predefined as measured variables.

#### 3.2.2 Environmental Perspective

The acceptance of IoT product by user could be influenced by factors, like quality evaluation or opinions of other users around them<sup>12</sup>. This kind of influence could spread very fast and extensive through social network service. We named this kind of influence as “environmental factor” for acceptance of IoT product. In this context, we have defined the variables, like “rumor about the IoT product”, “performance evaluation of other user”, “social atmosphere about the use of IoT product”, and “media’s assessment about IoT product”, as predefined measured variables for environmental factor.

#### 3.2.3 User Character Perspective

The personal character of each consumer plays an important role in deciding to buy and use IoT product. For example, the users, known as “early adopter”, have tendency to buy and use new IT product, as soon as the IT product comes on to the market. In general, most of consumers have tendencies to wait and watch how the early adopter evaluates the performance of IT product. In that sense, we can define the character of each user as one of important factors affecting the acceptance of IoT product. The variables, like “readiness of acceptance of new IT product”, enjoyment in using IT product”, “learning capability in operation of IT product”, and “open mind in accept new technology”, “curiosity in new IT product”, are the predefined measured variables for the factor, “User Character”.

#### 3.2.4 Cost perspective

As we discussed before, “Cost” is one of most influential factors of the acceptance of IoT product. As we understand, customer reacts to the price of goods very sensitively in general. The term “Cost” here means money, time and effort to achieve the IoT product from the market. Therefore, we can regard the cost-benefit ratio as an important factor in deciding to buy and use of IT product in daily life. We have defined the variables, like “price of IoT product”, “time and effort to acquire the IoT

product”, and “time and effort to maintain the IoT product”, as measured variables for the factor “Cost”.

## 4. RESULT OF STUDY

### 4.1 Factor Analysis of Measured Variables

After we have predefined the variables, factor analysis was administrated to derive factors. The goal of factor analysis is the identification of relations among factors. Generally, researchers use the factor analysis to build factors for a particular research theme and to identify a set of latent construct<sup>2</sup>. The result of the factor analysis is explained in

Table 1. The Cronbach- $\alpha$  value ( $>0.7$ ) of each factor means the assurance of reliability and credibility of derived factors.

As Table 1 shows, 4 factors composed of 12 variables have been derived.

### 4.2 Analysis of Variable's Weight

The AHP method was carried out to analyse weight of measured variables and factors. The AHP is a structured method to build and analyse complex decision-problem. In 20 has developed AHP method in the 1970s<sup>20</sup>. AHP is to apply for group decision-problem in making business strategy, health care and governmental policy. AHP provides a comprehensive structured framework for quantifying decision elements and for alternative solutions. For AHP survey, we interviewed to 6 experts of IoT field. While interviewing, each factor was compared pairwise regarding to its weight. With a pair-wise examination, the heaviness of each factor is resolved and can be utilized as the multiplier for the subsequent stage. In the main review, the heaviness of each factor was dissected by the pair-wise examinations of 6 specialists. Table 2 shows the consequence of the first overview. Table 2 shows that the degree of the essentialness of each factor. These are the multiplier to decide the heaviness of estimated factors. The digits in Table 2 clarify about hugeness level of each factor. “Cost of IoT” is the most significant factor for the acceptance of IoT product. The factor “User character” is second significant factor of all and means that the “User character” is also very important factor for decision to use of IoT product. And the next coming factor is “Environment issues”. “Technique issues” is 4th factor. The 4th place means that this factor seems important but less influential than other 3 factors in accepting IoT product. The second survey has been conducted to determine the weight of each variable. As we see, the final result of AHP is explained in Table 3. Finally, the ranked list of all variables according to their weight and significance is determined. We can understand the content of Table 3 as that of Table 2. The rank of all 12 variables of each factor is displayed clearly. As the result, we find that the measured variable, “Price of IoT product”, take the first position. This means that the cost of IoT product is most important variable for the acceptance of IoT product. The next significant variables could be the “Curiosity about IoT”. The last significant variable is “Ease of use” of IoT product.



**Table 1.** The Factor loadings of factor analysis.

Factors	Measured Variables	Factor Loadings				Cronbach- $\alpha$
		Fac1	Fac2	Fac3	Fac4	
User Characters	User enjoyment with IoT	0.896	0.240	0.130	0.197	0.934
	User curiosity about IoT	0.874	0.141	0.194	0.169	
	Learning capability of user	0.859	0.291	0.121	0.249	
Environment Issues	Media assessment of IoT	0.209	0.922	0.130	0.100	0.893
	Social atmosphere for IoT	0.199	0.914	0.133	0.091	
	Rumor about IoT product	0.166	0.785	0.059	0.111	
Cost of IoT	Price of IoT product	0.167	0.019	0.891	0.151	0.902
	Acquisition cost of IoT product	0.039	0.148	0.887	0.102	
	Maintenance cost of IoT product	0.209	0.153	0.886	0.140	
Technique Issues	Performance of IoT product	0.155	0.052	0.086	0.860	0.834
	Functionality of IoT product	0.168	0.085	0.142	0.844	
	Ease of use of IoT product	0.197	0.169	0.154	0.796	
*Extracted by Principal Component Analysis.						
*Rotated by Varimax method with Kaiser Normalization						
* Converged in 5 Iterations						

**Table 2.** Result of AHP (factor).

Factors	Weight of each expert ( $EX_n$ )						Average	Rank
	EX1	EX2	EX3	EX4	EX5	EX6		
User Characters	0.23	0.25	0.35	0.26	0.32	0.28	0.282	2
Environment Issues	0.19	0.29	0.30	0.24	0.22	0.22	0.243	3
Cost of IoT	0.33	0.30	0.25	0.28	0.24	0.30	0.283	1
Technique Issues	0.25	0.16	0.10	0.22	0.22	0.20	0.195	4

**Table 3.** Result of AHP (measured variable).

Factor	Measured variables	Weight of each measured variables <sup>1</sup>						Ave.	R1	Wgt.	R2
		EX1 <sup>2</sup>	EX2	EX3	EX4	EX5	EX6				
User Characters	Enjoyment with IoT	0.33	0.35	0.35	0.36	0.32	0.38	0.35	2	0.10	3
	Curiosity about IoT	0.34	0.35	0.40	0.36	0.44	0.32	0.37	1	0.10	2
	Learning capability	0.33	0.30	0.25	0.28	0.24	0.30	0.29	3	0.10	7
Environ-ment Issues	Assessment of IoT	0.45	0.40	0.35	0.42	0.36	0.38	0.39	1	0.10	4
	Social atmos-phere	0.30	0.35	0.40	0.30	0.40	0.32	0.35	2	0.08	6
	Rumor about IoT	0.25	0.25	0.25	0.28	0.24	0.30	0.26	3	0.06	11
Cost of IoT	Price of IoT	0.50	0.45	0.45	0.42	0.46	0.48	0.46	1	0.13	1
	Acquisi-tion cost	0.30	0.30	0.30	0.33	0.36	0.21	0.30	2	0.09	5
	Mainte-nance cost	0.20	0.25	0.25	0.25	0.12	0.31	0.23	3	0.07	9
Technique Issues	Perfor-mance	0.30	0.35	0.35	0.32	0.36	0.38	0.34	1	0.07	8
	Func-tionality	0.33	0.31	0.36	0.37	0.39	0.24	0.33	2	0.07	10
	Ease of use	0.37	0.34	0.29	0.31	0.25	0.38	0.32	3	0.06	12
Ave.: Average weight, R1: Rank of variable in corresponding factor Wgt: Variable's weight multiplied by the factor's weight , $Ex_n$ : Experts 1-6 R2: ranked weight of variables / Weight of each measured variable , <sup>1</sup> : weight by each expert											

## 5. CONCLUSION

As discussed, IoT is the electronically embedded objects with network connectivity for exchange of data remotely. It is very apparent that IoT technology makes our life more comfortable. And IoT market is now starting and expanding very quickly to every sector. Therefore, many supports from government have invested to establish the R&D infrastructure for IoT industry. In that sense, study on factor which is influential on IoT acceptance has implication. And research about the significance analysis of these factors is important. In this paper the factor analysis and AHP method was applied to the experts in the IoT industry. As the result, a ranked list according to the priority of factors and variables. The significance rank of each variable is shown in Table 3. The limitations and constraints of this paper are as follows. First, samples size of this research not large enough. The enough sample size makes research work more reliable and credible. The sophisticated questionnaire and knowledge and experience of interviewee enhance the quality of research. Second, this research should be carried out to IoT related R&D centre or IoT hardware and software engineers. Such effort could make result of this study more meaningful. Third, this study might have focused quantitative

approach. This quantitative approach alone is not enough to have the meaningful result about the measurement of the ranked priority of factors. So, it had better to have the combination of qualitative and quantitative methodology. The contributions of this research work are as follows. First, the result of this research work might be the meaningful implication for both user and IoT business. Second, the academics can find or improve the better research methodology from this research work. Third, the result of this study could be a meaningful reference for the implementation and successful operation of IoT industry in Korea.