Rapid Way Mobile Application in Wireless Sensor Network: A Practical Research in Transportation System

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***Abstract*— Mobile solutions give businesses a unique opportunity to re-think the way they interact with customers, employees and partners. We propose a new method called rapid way application on the mobile devices to handle and control the connection of the mobiles with GPS while mobile devices or sensor has mobility. This paper explores the relationship between the five depends and independent variable on Rapid Way mobile application such as Perceived usefulness, perceived ease of use, time saving, cost saving and intention to use Rapid Way application in Wireless sensor network for managing the sensors. A sample of 100 respondents is selected using a purposive sampling method whereby all segments of society to be included in the survey. A structured, self-administered as hard copy questionnaire is used to find data from these respondents. The findings indicate that the perceived usefulness (β = 0.307, p<0.002) perceived ease of use (β = 0.176, p<0.080) and time saving (β =0.019, p<0.000) is positively related to intention to use Rapid Way application while cost saving is not significantly related to intention to use Rapid Way application (β =0.408, p<0.849). Besides attention to result of this paper, it shows that there is a significant level of intention to use Rapid Way application, also, time saving (β =0.019, p<0.000) as a new variable has the highest significant.**

Keywords- Wireless Sensor Network; Traffic and Transportation System; Network Routing; Rapid Way application; time/cost saving.

I. INTRODUCTION

Nowadays, traffic jam can be a significant frustration for most drivers in a large city, and may cause physical and mental distress. The social costs are high because of delay and air pollution issues. Besides, mobile application and traffic information do not works online, for example, if one road is blocked, it will not be shown in members application, or if the roads are closed by police, fire department, or road repairs, then current available mobile application, are unable to detect the block roads and suggest low traffic roads for the users ([1, 2, 3]), therefore, this issue is one of the concerns of researchers to propose various techniques to inform mobile drivers such as GPS [2].

Many drivers use GPS application to find the shortest road for going their desired destination but one limitation of GPS application is that they cannot show the roads which are blocked by governmental agenesis. The aim of this paper is to solve this problem via a new mobile application called *Rapid Way application*. New applications have contacted with these organizations and get reports from them in regards to which road is closed with details such as date, time and period of closure called Rapid Way Application The new application that is introduced in this paper, works by contacting organizations, which may block the roads. If any road is blocked, they can suggest another road to users, this application works by wireless sensor network (WSN). Because of the advantage of WSN rather than other technology for measuring traffic, it is preferred to use WSN. To improve traffic monitoring, the economic method by using new technology is how can employ Rapid Way application in traffic application [4]. Uniqueness of this application compare to recent ones is that, the new application works online and has contact with all departments that could be able to close the road. For instance, in case that police block the ways for a heavy accident or other events for few hours, the new application does not show blocked way to their members and suggest optimized way [1]. At last, several recent works concentrates on routing protocol by applying metaheuristic approaches in wireless sensor networks to decrease cost and time of routing in these networks such as [5, 6, 12, 13] and find proper way by transmitting information to less hops regarding mobility of the clients. Specifically, authors in [5, 6] use learning automata in routing in wireless sensor networks for the client's requests. There are some other WSN works done in controlling the traffic in mobile devices [7-11].

The rest of the paper is organized as follows. Section 2 presents related methods that uses in behavioral intention to use. Section 3 defines a system model for Rapid Way Application and describes the proposed research framework (approach) in detail; section 4 compares it with related methods using several combinations of parameters by Questionnaire Sources and finally section 5 summarizes and concludes the paper and future works.

II. RELATED WORK

The social psychology science was the first area in which the first model that defined the acceptance of technology grew. It refers to the years from 1918 to 1970. At this time, scientists were seeking a way to show the effect of attitude on one's behavior. However, what they found were some conflicting results about attitude and behavior. The point is

that attitude has direct or indirect result on behavior and it is a multidimensional element or a non-dimensional element [4].

Authors in [14] attempted to expand a theory with the ability to forecast, define, and effect on individual's behavior. They presented the theory of reasoned (TRA) action, however after that their theories improved and changed repeatedly. The foundation of this theory is that rationality is one quality of any individual. Therefore, they have the ability to create a system to employ the information. The matter is that before involvement in any behavior people examine the meaning of that performance.

Technology Acceptance Model (TAM) was proposed by Davis [17] and the diagram of the original TAM model is shown as Figure 1. To find the level of attitude, we should explore three factors, and namely, external variables, perceived usefulness, and perceived ease of use are very important. First, modify in TAM model applies in [17].

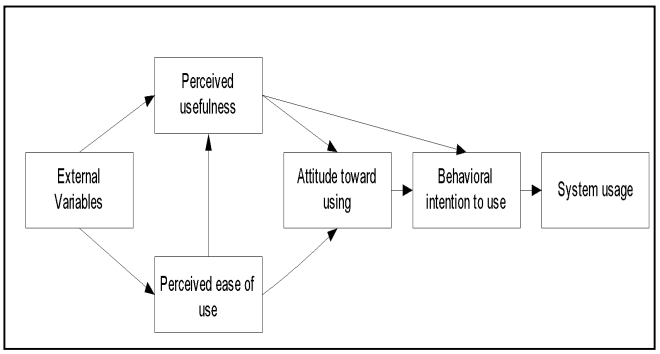

Figure 1. TAM Model.

Additionally, some previous surveys about behavioral intention to use in email, voice mail, word-perfect, lotus 123 and Harvard graphics reported perceived usefulness and perceived ease of use according to the TAM model made consistency in predicating and explaining system adoption [1]. TAM model had some limitations in explaining the reason for which a person would perceive a given system useful, and for resolving these limitations, they proposed TAM 2 (TAM version 2). In this model, some variables add as antecedents to the perceived usefulness variable in TAM model. Besides, recently several approaches try to modify the MAC layer behaviors to enhance the neighbors' discoveries in terms of RFID devices such as [18, 19].

To measure the level behavioral intention to use in a new product two factors, namely, perceived ease of use and perceived usefulness that are important when the survey is questionnaire-based [20]. TAM has some limitations that include these items: (1) it depends on respondents' report to measure the usage and it is based on the matter that the reported usage by respondent includes the real usage. (2) The type of respondents this model selects is problematic since sometimes it chooses a university student and sometimes a professional user. This matter prevents to have generalization [21].

The theory of diffusion of innovation (DOI) offers some concepts that can be applied to the study of technology evaluation, adoption, and implementation. Then it can evaluate the degree of diffusion of a technology and it can help recognize the elements, which assist or prevent technology adoption and implementation [14-16]. These elements are: (1) the innovation-decision process, (2) attributions of the innovation, and (3) innovators' characteristics. Innovation-decision process itself contains five levels that are knowledge, persuasion, decision, implementation, and confirmation. In innovation-decision level, [22] believed that people are not able to understand when they finish one level and starts another level. It means that there is no special line between these levels. Attribution of innovation also has some factors that are relative advantage, compatibility, complexity, trainability, and observability. Along with these factors, it also includes some variables such as type of innovation, communication channel, nature of social system, extent of change agents' promotion effort. In innovator's characteristic part, five elements have to be considered that are innovators, early adopters, early majority, late majority, and laggards.

Perceived attributes of an innovation that offered by Roger have been used as the base of various studies particularly those researches in the field of potential user's perceptions of information technology innovation and the influence it has on adoption. Among those who were interested in this field were [23, 24]. They planned an instrument to estimate the users' perceptions of IT innovations. Therefore, researchers added two other factors that are voluntariness of use and image. The definitions they offered were based on the perception of innovation; therefore, they made some changes in the offered definition by Rogers [22] and they changed the name to perceived characteristics of innovation (PCI). They searched for scales in order to assess them according to their reliability and validity. In their research, they found a scale with seven items that are compatibility, relative advantage, visibility, result demonstrable, and ease of use, trainability, and image.

III. PROPOSED APPROACH

Attention to previous study and TAM model, we proposed a framework as a model. This model includes Perceived Usefulness (PU), Perceived Ease of Use (PEoU), Time Saving (TS) and Cost Saving (CS) that these are independent variables and intent to use Rapid Way application as dependent variables.

We take Perceived Usefulness (PU) and Perceived Ease of Use (PEoU) from [17] and two other items: Time Saving (TS) and Cost Saving (CS) are proposed here is related to the benefit of Rapid Way application. There are some mobile applications for controlling traffic that are showing the ways to drivers to reach their destination such as Nokia OVI map, but, all applications that are available today are unable to show the ways that are blocked by previous coordination or emergency closure.

Also recent applications are unable to servicing online, because, they do not have any contact with organizations within the city and out of the city that have power to block the ways such as Police office, fire department and Maintenance department. New applications have contacted

with these organizations and get reports from them in regards to which road is closed with details such as date, time and period of closure called Rapid Way Application. Fig. 2 shows overview of Rapid Way Application. In Fig. 2, after choosing destination by users, application prioritized roads attention to shortest path and if the shortest road is block, it will suggest the second shortest road. The sensors (speedometer sensors) that is installed on the roads that send speed of vehicles to control centre, can detect which way has lowest traffic.

The process of suggesting a suitable road to users based on Fig. 2 can see as follows:

- Police or any other organizations that block the road, report the date, time, and period of closure. If the road is closed by each organization, the shortest path is suggested to users, until it opens again while it will be deleted from user's list of choice.
- Application search the distance of other roads between vehicle and destination by Dijkstra Algorithm [25] and sensors sense speed of vehicles in each road.

Regarding to the speed of vehicles, distance and time of arrival can be found by equation (1):

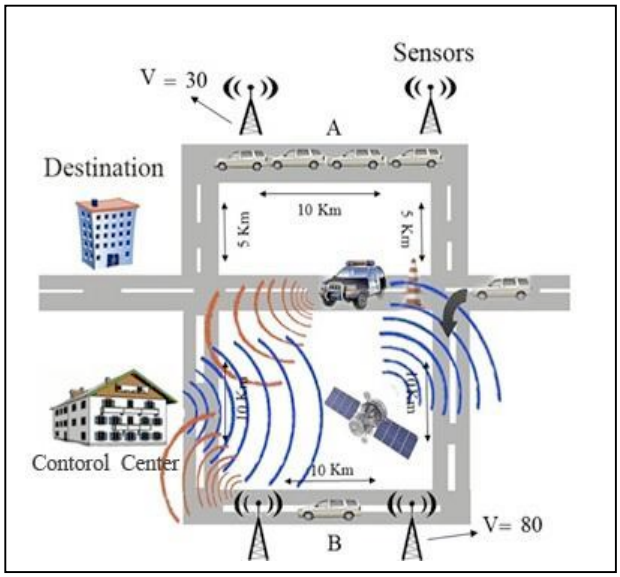

Figure 2. Overview of Rapid Way Application

$$X=V.T \rightarrow T=X/V. \quad (1)$$

According to Fig. 2, in equation (2) and (3) show that the distance of the road A is less than the road B but heavy traffic in the time of arrival to destination by the road A is more than the road B.

$$\text{Road A: } \frac{20\text{km/h}}{30\text{km/h}} = 2/3\text{h} = 40\text{min.} \quad (2)$$

$$\text{Road A: } \frac{30\text{km/h}}{80\text{km/h}} = 3/8\text{h} = 22.5\text{min.} \quad (3)$$

The research methodology model of our proposed model shows in the Fig. 3. In Fig. 3, first, this research starts with the literature study on several models. We use TAM model for research hypotheses. Second, questionnaire is conducted paper survey tool to survey on the users' acceptance behaviors as well as defines the measures of the questionnaire. Finally, it is the results evaluation, which is to measure on the results gathered from the questionnaire. Sample of measure and the variables shows in Table I. Fig. 4 shows our proposed model all in detail.

Figure 3. Research Methodology Model

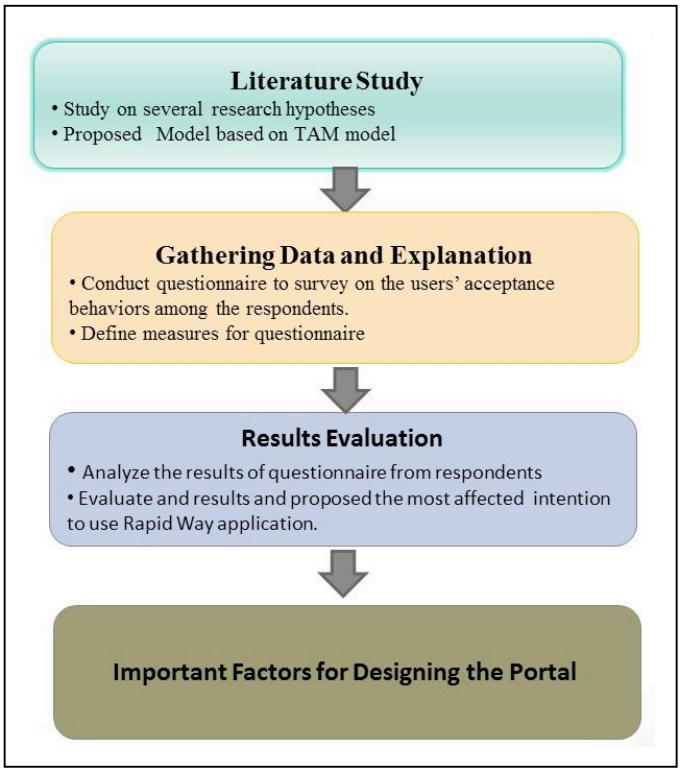

TABLE I. QUESTIONNAIRE SOURCES

Section	Sample Questions	Source
PU	Using Rapid Way application gives me greater chose my way.	[17]
PEU	Learning to operate the Rapid Way application is easy to me.	[17]
Time Saving	Finding optimum way with rapid way application is timesaving.	Researcher (proposed approach)
Cost Saving	Using Rapid Way application reduces usage of petrol.	Researcher (proposed approach)

IV. PERFORMANCE EVALUATION

Here, we used Questionnaire to simulate our proposed framework on it. Questionnaire is developed to survey on the user's acceptance towards Rapid Way application regarding

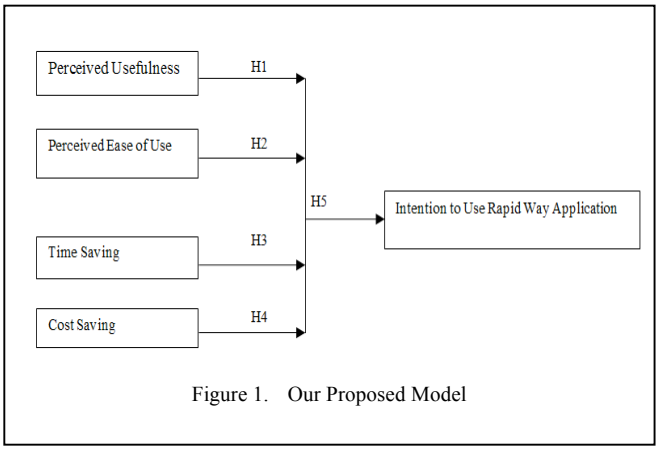

Figure 1. Our Proposed Model

to the various variables used. Questionnaires are distributed to the students from Universiti Sains Malaysia (main campus & engineering campus), public and friends.

Hence, research hypotheses and research proposed model also is tested using the data statistical software named Statistical Program for Social Sciences (SPSS). 108 responses were gathered at the end of the survey during few weeks of data collection period. Overall, 100 valid responses were chosen because some information of the questionnaires were not filled up properly by the respondents. The demographic profile of the respondents is presented in Table II and Table III.

In Table II, it can be seen that 32% of the respondents are female whereas 68% of them are male. As for ethnic composition, 38% of the respondents are Malays, 36% are Chinese, followed by 16% and 10% of Indian and others respectively. Majority of the respondents are from the 25-40 years age group (56%). In addition, 43% of respondents spend time in traffic 10 to 30 minutes every day.

A. Result Setup

To do this research, at first a questionnaire-based survey performed Rapid Way Portal (With Determining Blocked & Optimized Ways): The Determinants for User's Intention to Use Rapid Way Application in Penang Island of Malaysia. According to [17] perceived usefulness, perceived ease of use, and attitude towards using rapid way application considered to measure customers' Intention to rapid way application in Penang Island of Malaysia. Two factors namely, time consuming and cost saving (which provide with using Dijkstra algorithm [25]) considered too. It includes 36 questions. The first 11 questions refer to demographic information. Questions 12 to 16 (five questions) are related to perceived usefulness and have been taken from the model; the next five questions which are 17 to 21 are related to perceived ease of use; time saving using rapid way application considered by question 22 to question 26 (five questions); Question 27 to question 31 (five questions) measure cost saving; Intention to use of rapid way application by question 32 to 36 (five questions). The researcher has prepared the questions related to time saving and cost saving while other questions derived from previous studies.

B. Result Details

The descriptive statistics for the main variables in Table 3 revealed that all dimensions charted higher than the midpoints of their respective scales. It shows that respondents are generally optimistic about the Perceived Usefulness (PU) and Perceived Ease of Use (PEoU) of find optimize road for reach to destination. Additionally, cost saving was rated slightly lower than the technological acceptance dimensions of PU, PEoU and TS. If the P value of correlation between two variables is less than 0.01, it means these variables have high correlation [26, 27]. There is a high correlation between perceived usefulness and intention to use of rapid way application because $p<0.01$. Table I shows general variables and questions between our method and others.

Table IV shows correlation between variables. Perceived Usefulness (PU) has a positive effect on intention to use Rapid Way application in mobile phone is supported with the Beta value is 0.307 and the value of significant is 0.002 in the regression analysis at Table IV. This shows that perceived usefulness is involved extensively and a positive influence on the intention to use Rapid Way application. Some previous studies [4], [28] also illustrated that perceived usefulness has positive and significant relationship with behavioral intend.

Perceived Ease of Use (PEoU) has a positive effect on intention to use Rapid Way application in mobile phone is supported with the Beta value is 0.176 and the value of significant is 0.080 in the regression analysis at Table IV. This shows that Perceived Ease of Use is involved extensively and a positive influence on the intention to use Rapid Way application. Time Saving (TS) has a positive effect on intention to use Rapid Way application in mobile phone is supported with the Beta value is 0.019 and the value of significant is 0.000 in the regression analysis. This shows that Time Saving involved extensively and a positive influence on the intention to use Rapid Way application. Cost Saving (CS) not supported with the Beta value is 0.408 and the value of significant is 0.849 in the regression analysis at Table IV. This shows that Cost Saving not supported by respondent answer on the intention to use Rapid Way application. The concern of our model is whether the variables have an influenced as hypothesized. For this purpose, MRA is used to analyze the relationship between PEoU, PU, TS and CS with Intention to use Rapid Way application. H1, H2 and H3 were found to be supported while H4 not supported. PU, PEoU and TS managed to explain 56 per cent of the variance in the intention to use rapid way application. Additionally, the impact is such that TS has the largest impact on intention to use Rapid Way application, followed by perceived usefulness and perceived Ease of use.

TABLE II. DESCRIPTIVE STATISTICS FOR VARIABLES

Question Item	Variable	%
Age	At least 25 years old	20%
	25 to 40 years old	56%
	More than 40 years old	24%
Gender	Male	68%
	Female	32%
Education level	No education	2%
	Primary level	4%
	Secondary level	6%
	College	11%
	Diploma	14%
	University level	63%
Marital	Single	64%
	Married	36%
Race	Malay	38%
	Chinese	36%
	Indian	16%
	others	10%
Car	Yes	71%
	No	29%
Spend time in traffic	No waste time	9%
	Less than 10 min	39%
	10 min and 30 min	43%
	More than 30 min	9%
Use GPS	Yes	62%
	No	38%
Kind of GPS application	Nokia ovi	32%
	Google map	44%
	Itrafic	12%
	others	11%

TABLE III. DESCRIPTIVE FOR THE MAIN VARIABLES

Variable	N	Min.	Max.	Mean	St. Deviation
Perceive Usefulness	100	1	7	5.23	1.06
Perceived Ease of Use	100	1	7	2.24	1.19
Time Saving	100	1	7	4.42	1.54
Cost Saving	100	1	7	5.04	1.31
Internet to Use	100	1	7	5.43	1.07

TABLE IV. THE CORRELATIONS OF THE MAIN VARIABLES

	PU_Mean	PEOU_Mean	CS_Mean	TS_Mean	INU_Mean
PU_Mean	1	0.636**	0.190	0.154	0.307**
PEoU_Mean	-	1	0.132	0.113	0.176
CS_Mean	-	-	1	0.147	0.019
TS_Mean	-	-	-	1	0.408**
INU_Mean	-	-	-	-	1

** Correlation is significant at the 0.01 level

V. CONCLUSIONS

The purpose of this paper is to measure scales for perceived usefulness and perceived ease of use that are taken from TAM model and two new variables time saving and cost saving that proposed by researcher to be determined intention to use Rapid Way application. According to the survey, three factors, namely, PU, PEoU and TS have significant relationship with intention to use Rapid Way application. According to this research, respondent would like to use Rapid way application because this application help them to saving time and avoid from blocked way and they accept Rapid Way application is easy to use.

REFERENCES

[1] A.D. Adams, R.R. Nelson and P.A. Todd, "Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication," MIS Quarterly, vol. 16, iss. 2, 1992, pp. 227-247.

[2] R. Agrawl and J. Prasad, "A Conceptual and Operational of Personal Innovativeness in the Domain of Information Technology," Information Systems Research, vol. 9, iss. 2, 1998, pp. 204-215.

[3] N. Cordeschi, M. Shojafar and E. Baccarelli, "Energy-saving self-configuring networked data centers," Computer Network, vol. 57, iss. 17, 2013, pp. 3479–3491.

[4] P.Y.K. Chau and P.J. Hu, "Information Technology Acceptance by Individual Professionals: A Model Comparison Approach," Decision Sciences, vol. 32, iss. 4, 2001, pp. 699-719.

[5] M. Shojafar, Z. Pooranian, M. Shojafar and A. Abraham, "LLLA: New Efficient Channel Assignment Method in Wireless Mesh Networks," Springer International Publishing, Innovations in Bio-inspired Computing and Applications, vol. 237, 2014, pp. 143–152.

[6] A. Sayyad, M. Shojafar, Z. Delkhah and M.R. Meybodi, "Improving Directed Diffusion in sensor network using learning automata: DDLA new approach in Directed Diffusion," IEEE ICCTD 2010, 2010, pp. 189–194.

[7] Hong-Chi Shih, Jiun-Huei Ho, Bin-Yih Liao and Jeng-Shyang Pan, 2013, "Fault Node Recovery Algorithm for a Wireless Sensor Network", IEEE Sensors Journal, Vol. 13, NO. 7, 2013, pp. 2683-2689.

[8] Tian-hua Liu, Si-chao Yi, and Xiao-wei Wang A Fault Management Protocol for Low-Energy and Efficient Wireless Sensor Networks Journal of Information Hiding and Multimedia Signal Processing, Vol. 4, No. 1, 2013, pp. 34-45.

[9] E. Baccarelli, R. Cusani, " Recursive Kalman-type optimal estimation and detection of hidden Markov chains", Signal Processing (EURASIP), vol.51, no.1, 1996, pp.55-64.

[10] E. Baccarelli, N. Cordeschi, V. Polli, "Optimal self-adaptive QoS resource management in interference-affected multicast wireless networks", IEEE/ACM Trans Netw vol. 21, Iss. 6, 2013, pp.1750–1759.

[11] E. Baccarelli, N. Cordeschi, T. Patriarca, "QoS stochastic traffic engineering for the wireless support of real-time streaming applications", Computer Networks, vol.56, iss. 1, 2012, pp. 287–302.

[12] A. Sayyad, M. Shojafar, Z. Delkhah and A. Ahamadi, "Region Directed diffusion in Sensor Network Using Learning Automata: RDDLA," Journal of Advances in Computer Research, 2011, pp. 71–83.

[13] M. Shojafar,J.H. Abawajy, Z. Delkhah, A. Ahmadi, Z. Pooranian, A. Abraham, "An efficient and distributed file search in unstructured peer-to-peer networks", Peer-to-Peer Netw Appl, pp. 1–17, 2013. DOI: 10.1007/s12083-013-0236-0

[14] R.G. Fichman, "Information Technology Diffusion: A Review of Empirical Research," International Conference on Information Systems, vol. 13, 1992, pp. 195-205.

[15] Sh. Shamshirband, A. Patel, N.B. Anuar, MLM LMKiah, "Cooperative game theoretic approach using fuzzy Q-learning for detecting and preventing intrusions in wireless sensor networks", vol. 32, June 2014, pp. 228–241. DOI: 10.1016/j.engappai.2014.02.001

[16] Sh. Shamshirband, A. Amini, N.B. Anuar, MLM Kiah, T.Y. Wah, S. Furnell, "D-FICCA: A Density-based Fuzzy Imperialist Competitive Clustering Algorithm for Intrusion Detection in Wireless Sensor Networks", Measurement, vol. 55, 2014, pp. 212–226

[17] F.D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," MIS Quarterly, vol. 13, iss. 3, 1989, pp. 319-340.

[18] D. Amendola, F. De Rango, Kh. Massri, A. Vitaletti, "Efficient Neighbor Discovery in RFID Based Devices Over Resource-Constrained DTN Networks", IEEE ICC 2014, pp. 1-6. Accepted.

[19] D Amendola, F. De Rango, K. Massri, A. Vitaletti, "Neighbor Discovery in Delay Tolerant Networking using Resource-Constraint Devices", IFIP Wireless Days (WD), pp. 1-3, 2013. DOI: http://dx.doi.org/10.1109/WD.2013.6686531

[20] T. Ramayah and J. Ignatiuse, "Impact of Perceived Usefulness, Perceived Ease of Use and Perceived Enjoyment on Intention to Shop Online," ICFAL Journal of System Management (IJSM), vol. 3, iss. 3, 2005, pp. 36-51.

[21] P. Legris, et al., "Why Do People Use Information Technology? A Critical Review of the Technology Acceptance Model," Information and Management, Elsevier, vol. 40, iss, 3, 2003, pp. 191-204. doi:10.1016/S0378-7206(01)00143-4

[22] E. Rogers, "Diffusion of Innovations," New York: Free Press, 1983.

[23] G.C. Moore, and I. Benbasat, "Development of an Instrument to Measure the Perceptions of Adopting An Information Technology Innovation," Information System Research, vol.2, iss. 3, 2001, pp. 192-222. doi: 10.1287/isre.2.3.192

[24] A. Ahmadi, M. Shojafar, S.F. Hajeforosh, M. Dehghan, M. Singhal, "An efficient routing algorithm to preserve k-coverage in wireless sensor networks," Springer, The Journal of Supercomputing, vol. 68, iss. 2, 2014, pp. 599-623.

[25] E.W. Dijkstra, "A note on two problems in connexion with graphs," Numerische Mathematik, vol. 1, 1959, pp. 269–271. doi: 10.1007/BF01386390

[26] Lund Research Ltd.: LAERD Statistics, 3-Step to Successfully Complete Your Thesis or Dissertation Statistical, 2012, Available: https://statistics.laerd.com

[27] L. Tornatzy and K. Klein, "Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings," IEEE Tran. of Eng. Management, vol. 29, iss. 1, 1982, pp. 28-43.

[28] J. Moon and Y. Kim, "Extending the TAM for a World-Wide-Web context," Information and Management, vol. 38, 2001, pp. 217-230.