

WI-FI USAGE FACTOR ANALYSIS USING A HYBRID MODEL

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Abstract: Today, Wireless Fidelity (Wi-Fi) access is an essential technology for education. The University of the Thai Chamber of Commerce (UTCC), one of the most famous private universities in Thailand, adopted the iHybrid learning system that requires high quality Wi-Fi coverage throughout the campus. Therefore, it has become imperative to understand the critical factors that affect students' use of the UTCC Wi-Fi. The results from an analysis of these factors could be used to improve the network infrastructure on campus. This study aims to measure the acceptance and quality of the UTCC Wi-Fi network and is divided into two parts. The first part analyzes the factors that influence students' intention to use UTCC Wi-Fi by employing a proposed hybrid model. The hybrid model integrates two well-established models, the Technology Acceptance Model (TAM) and the Expectation Confirmation Model (ECM), along with two additional factors of security and attitude. Data from 411 UTCC students were collected and analyzed in accordance with the variables established in the hypotheses. The second part explores the signal strength and efficiency of the Wi-Fi performance of each area in the campus. The collected survey data includes 1,320 observations of signal strength, download speed, and upload speed, along with the location, day, time, and devices. The analysis results and discussion indicate that the hybrid model is a suitable tool for factor analysis of UTCC Wi-Fi usage.

Keywords: Technology acceptance model, Expectation-confirmation model, Wireless Fidelity, Security

I. INTRODUCTION

The University of the Thai Chamber of Commerce (UTCC) is one of the most famous private non-profit universities in Thailand. It has 11 schools offering 46 undergraduate programs, 23 graduate programs, and 11 research centers. UTCC and Apple Inc. founded a regional training center in Thailand to reinforce the use of education technology with UTCC staff and students. The teaching and learning system developed through the cooperation of Apple Inc. and UTCC is called UTCC iHybrid. This system is based on the use of the iPad and iTunes U. Course material for many courses have been uploaded to iTunes U and can be accessed by UTCC students using the iPad through Wi-Fi (Wireless Fidelity). Currently, there are 20,000 students with access to this system. Hence, Wi-Fi is a major factor in the success of the system. All students are given new iPads to facilitate a variety of academic activities including course registration, downloading course material, submitting homework, etc. For this reason, high quality Wi-Fi coverage needs to extend throughout the entirety of the UTCC campus to maximize connectivity for all students. To accomplish this task and improve the intention of UTCC Wi-Fi usage, network administrators must find and analyze many factors that affect the network and impact students using the network. Identifying these factors will enable administrators to make the best decisions for hardware upgrades and feature implementation improving the overall effectiveness of the network.

This research aims to assist in identifying and analyzing the factors that impact students' use of the UTCC Wi-Fi. Standard MIS models, Technology Acceptance Model (TAM) and Expectation

Confirmation Model (ECM), were used to analyze user acceptance patterns. The study is separated into two parts. The first part explores factors that influence students' intention to use UTCC Wi-Fi. The TAM and ECM models were chosen for this part in order to measure the perceived usefulness and perceived ease of use as they relate to user intention [1]. From these models the paper proposes a hybrid model combining these two models along with other key factors. The majority of the paper is dedicated to this topic. The second part of this study measures signal strength across the UTCC campus from site surveys. These surveys can reduce cost when installing a number of physical infrastructure components such as access points, Wi-Fi controller modules, optical fiber paths, and security devices. The results of this technique explore the signal strength of each area and efficiency of the Wi-Fi performance.

The paper focuses on factor analysis toward Wi-Fi user retention as the basis to improve wireless network services. The remaining part of the research is organized as follows. The Background and related work section outlines the basic knowledge concerning the study. The Methodology section explains the hybrid model and research design. The Results section shows the factors leading to the intention of UTCC Wi-Fi usage. Final analysis is given in the Conclusion.

II. BACKGROUND AND RELATED WORK

2.1. Wireless Fidelity (Wi-Fi)

The 802.11 standard functions in the physical and datalink layers of the OSI model. There are many types of Wi-Fi encoding and frequencies at the physical layer resulting in many categories such as

802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, and 802.11ad. The datalink layer is divided into two sublayers namely the Media Access Control (MAC) and the Logical Link Control (LLC). The LLC obtains an IP address, control, and information which are encapsulated in a frame. Then, each frame is passed to the MAC sublayer. This layer changes their address, control, and information to ensure the proper form for the physical layer. Wi-Fi is a broadcasting technology dependent on signal frequencies and encoding. Wi-Fi Protected Access (WPA) encryption algorithm is a popular security standard widely used nowadays.

2.2. Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) was developed by Davis[1]who aimed to explore the impact of technology on user behavior. It has two main factors, namely Perceived Usefulness and Perceived Ease of Use, both of which have an impact on an individual's Intention of usage. There are several research (such as in [2], [3]) applying TAM model to investigate the factors that impact actual usage of the new technology in an educational context.

2.3. Expectation-Confirmation Model (ECM)

Bhattacharjee[4]developed an Expectation-Confirmation Model (ECM), which is a post-technology acceptance model. Bhattacharjeebelieved that the users' expectation of a technology could change after their experience. The model consists of three factors: Perceived Usefulness, Confirmation, and Satisfaction and aims to investigate factors affecting users' continuance intention of the technology they already selected and used [5].

2.4. Related Work

Several Wi-Fi network studies focus on a technique to improve efficiency [6]and new standards[7]. In the real world, network administrators need to understand user requirements and continuance network intention usage. Therefore, identifying factors that affect Wi-Fi retention are an important consideration before making network reconstructions or adjustments. Prior MIS researches identified some main factors that affect IT intention usage[1, 4]. From the conclusion of these research, it was revealed that the perceived usefulness, ease of use, confirmation, and satisfaction factors are necessary for investigate the intention of IT usage.

These factors are applied in many fields including social networks[8], and networking[9]. In[8, 9], they used MIS models to explain usage continuance intention for both wireless and social networks. These studies confirm that these factors relate to a high positive correlation to intentionof usage of their technologies. This is the reason why we include these factors in our proposed model for examining the continuance intention of Wi-Fi usage at UTCC.

However, two factors, security and attitude, were also added in the proposed model because the security factor is a necessary issue for networking [10, 11] and attitude is an important factor when dealing with human behaviors. [12].

III. METHODOLOGY

This research aims to investigate the perceived factors that affect users' intention to use the UTCC Wi-Fi network. Factors that influence users' intention are examined using two well-known user acceptance models combined into a singular hybrid model. Hypotheses are established based on the hybrid model and are tested using a statistical analysis of collected survey data.

3.1 The Proposed Hybrid Model

The proposed hybrid model combines TAM and ECM with two additional factors of security and attitude. Fig. 1 presents the hybrid model, related variables, and associated hypotheses. The definition of each variable and hypothesis are discussed in the following.

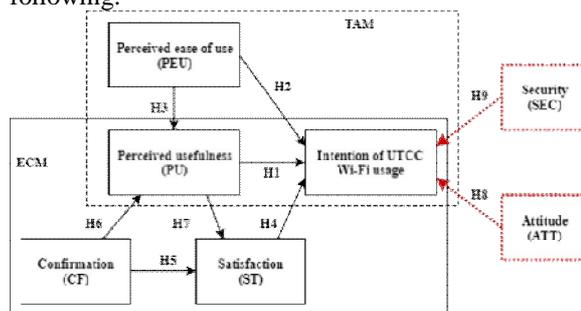


Fig. 1 The proposed hybrid model

First, the perceived ease of use (PEU) is defined as the freedom from difficulty or great effort in technology use [1]. In this study, PEU refers to the degree to which a Wi-Fi user believes that the procedure to connect to UTCC Wi-Fi is easy and widely available on campus. Second, the perceived usefulness (PU) is users' perception of the expected benefits of technology use [1]. The perceived usefulness in this study is defined as the degree to which Wi-Fi users believe that using free UTCC Wi-Fi will enhance his/ her academic experience by providing access to scholarly sources. The benefits of using UTCC Wi-Fi also include keeping in contact with people, entertainment, and other online activities. Third, Confirmation (CF) is defined as users' perception of the comparison between expectation of technology use and its actual performance[4]. Therefore, the confirmation of this study refers to the degree to which a Wi-Fi user perceives that the actual benefits of UTCC Wi-Fi will satisfy his/ her expectation. Fourth, Satisfaction (ST) refers to users' feelings about technology use[4]. Satisfaction in this study means the degree to which a UTCC Wi-Fi users feels positively about the strength

of the Wi-Fi signals, download speed, upload speed, and the coverage of the signals. Fifth, Security (SEC) is defined as the extent of users' belief that confidentiality, authentication, and message integrity are achieved within a wireless technology[13]. Security in this study refers to the degree to which a UTCC Wi-Fi user feels securely about UTCC authentication and confidentiality. Six, Attitude (ATT) is a preconceived opinion about something. In this study, attitude refers to the degree to which a UTCC Wi-Fi user is interested to use UTCC Wi-Fi, rather than other Wi-Fi networks or 4G. Last, Intention of UTCC Wi-Fi usage is users' intention to continue using UTCC Wi-Fi to enhance their daily activities.

As seen in Fig. 1, the relationship between variables are based on TAM [1]and ECM models[4]. The factors of security and attitude were added to explain the intention of UTCC Wi-Fi Usage. The research hypotheses were set up as follows.

H1: Perceived usefulness has a direct and positive effect on intention of UTCC Wi-Fi usage

H2: Perceived ease of use has a direct and positive effect on intention of UTCC Wi-Fi usage

H3: Perceived ease of use has a direct and positive effect on perceived usefulness

H4: Satisfaction has a direct and positive effect on intention of UTCC Wi-Fi usage

H5: Confirmation has a direct and positive effect on satisfaction

H6: Confirmation has a direct and positive effect on perceived usefulness

H7: Perceived usefulness has a direct and positive effect on satisfaction

H8: Attitude has a direct and positive effect on intention of UTCC Wi-Fi usage

H9: Security has a direct and positive effect on intention of UTCC Wi-Fi usage

3.2 Measurement instrument

In this study, a survey questionnaire was used to investigate the factors affecting the intention of users to use UTCC Wi-Fi. The questionnaire was divided into 3 sections; (1) general information about the respondents; (2) questions related to user behaviors when accessing to UTCC Wi-Fi; and (3) questions related to the evaluation of UTCC Wi-Fi, in respect to benefits, satisfaction, and attitude. For section 3, respondents were asked to respond to each items by indicating their level of agreement using a 5-point Likert scale, where 1 meant strongly disagree and 5 meant strongly agree.

3.3 Research Participants

The population of this study was undergraduate and graduate students attending UTCC who had accessed to UTCC Wi-Fi. In 2016, the total population was about 20,006 students from 11 schools. The subjects was acquired using a stratified random sampling from

the population using the Yamane formula [14] with a tolerances of $\pm 5\%$. Of the population, 411 subjects were randomly selected from 11 schools in proportion to the number of students enrolled at each school as participants of this study.

3.4 Site survey

The second part of the study explores the signal strength of each area and efficiency of the Wi-Fi performance. The study area is about 43,708 square meters and contains twenty-three buildings including offices, classrooms, and research centers. Fourteen buildings were selected for the survey of the Wi-Fi signal strength in this research because this is where most students frequently congregate. Mobile devices with iOS and Android operating systems were used to collect signal strength data as well as download and upload speeds by the OoklaSpeedtest application [15]. Survey data was collected on Monday to Saturday during the daytime at the first floor of the fourteen buildings. Then the average values of signal strength, download and upload speeds were calculated to represent the survey data.

IV. RESULTS

Survey data from the questionnaire was collected in the first semester of the academic year 2016. To verify the causal relationship of variables, descriptive statistics including reliability tests and correlation analysis were employed using the SPSS program. The results of the data analysis are described below.

4.1 Respondents' characteristics

The respondents are 377 undergraduate students and 34 graduate students from different schools at UTCC. Therefore the respondents are predominantly younger than 25 years. Of the 411 respondents, 161 (39.17%) were males and 250 (60.83%) were females. Wi-Fi usage frequency of only 3-4 times a week was 39.41% and more than 4 times a week was 45.98%. The online activities include searching for information, social networking, E-Learning, iTunes U, e-mail, online shopping, and other activities.

4.2 Hypothesis testing

In order to measure the reliability of the survey questionnaire, we employed the Cronbach's alpha coefficient that provides an indication of the average correlation among all of the items. The value of Cronbach's alpha ranges from 0 to 1 where higher value indicates greater reliability. Our survey questionnaire has a Cronbach's alpha coefficient of 0.93 which indicates that this questionnaire is a reliable tool to measure all constructs consistently. The descriptive statistics of measurement variables are presented in Table 1. The maximum and minimum of the mean values were 3.57 and 3.67. This indicates positive responses to all measurement variables. The standard deviations for all variables

were less than 1 indicating a narrow dispersion of item scores around the mean scores.

Variables	Overall Sample (N = 411)	
	Mean	S.D.
PEU	3.60	0.83
PU	3.66	0.93
CF	3.57	0.82
SAT	3.59	0.83
SEC	3.62	0.80
RT	3.65	0.81
ATT	3.67	0.94

Table 1: Descriptive statistics of the variables.

According to the proposed hypotheses, the Pearson correlations coefficients (r) were calculated to measure the strength and relationship between two variables and to test the hypotheses. The correlation coefficient value lies between +1 and -1, where any value close to 1.0 or more than 0.5 shows positive correlation and any value less than 0.5 and close to -1.0 shows negative correlation. Table 2 shows the calculated correlation coefficients (r) among variables for testing each hypothesis.

Hypotheses	r
H1: PU → Intention of UTCC Wi-Fi usage	0.620**
H2: PEU → Intention of UTCC Wi-Fi usage	0.589**
H3: PEU → PU	0.551**
H4: SAT → Intention of UTCC Wi-Fi usage	0.425**
H5: CF → SAT	0.619**
H6: CF → PU	0.708**
H7: PU → SAT	0.600**
H8: ATT → Intention of UTCC Wi-Fi usage	0.627**
H9: SEC → Intention of UTCC Wi-Fi usage	0.668**

Table 2: Correlations among the variables
**Correlation is significant at the 0.01 level (2-tailed).

According to the results in Table 2, we can state that all coefficient values show positive relationships between two variables in every hypothesis which is significant ($p < .01$ for a two-tailed test), based on 411 complete observations. The positive relationship ($r = 0.551$) between perceived ease of use (PEU) and perceived usefulness (PU) indicates that the authorization process and the continuous of signal during mobility has an impact on the degree of perceived usefulness for online activities. Also, a greater level of perceived usefulness (PU) is associated with a greater level of users' satisfaction (SAT) as can be seen in the coefficient value of 0.60. Students who agreed that UTCC's Wi-Fi actual performance met their benefit expectation ($r = 0.708$) tended to show high satisfaction ($r = 0.619$). Among the five factors (PU, PEU, SAT, ATT, and SEC), they all have direct impact on the intention of

users to use UTCC Wi-Fi. We found that the Wi-Fi security is the most important factor in determining if students will continually choose to use UTCC Wi-Fi.

4.3 Site Survey Results

The collected survey data contains 1,320 observations of signal strength, download speed, and upload speed along with the collected location, day, time, and devices. We performed statistical data analysis using the SPSS program and can state the following

- There is a significant difference between the average download and upload speed for mobile devices with iOS and android OS at 95% confidence interval. In the study area, the average download speed of mobile devices with iOS is 26.89 Mbps, while Android mobile devices is 17.45 Mbps. The average download speed of mobile devices with iOS is 26.89 Mbps, while Android mobile devices is 14.67 Mbps. The average upload speed of mobile devices is 24.77 Mbps and for Android mobile devices is 14.67 Mbps.
- There is a significant difference between the average download and upload speed for different buildings at 95% confidence interval. Five new buildings in the campus have higher and better quality of signal strength and speed than the old buildings.
- There is no significant difference between the average download and upload speed for different days.
- There is a significant difference between the average download and upload speed for different time of the day at 95% confidence interval. The time of the day was grouped in to the morning, noon, and evening. The noon period (11-13) was the busiest time of the day.

CONCLUSIONS

This study was developed to assist in identifying and analyzing the factors that impact students' use of the UTCC Wi-Fi. The results of this study could be used as the basis to improve wireless network services on campus. The study contained two parts. The first part explored factors that influence students' intention to use UTCC Wi-Fi and the second part measured signal strength and Wi-Fi quality across the UTCC campus from site surveys. According to the results, the mean value of all measurement variables was approximately 3.6 out of 5.0. This indicates that subjects' opinions about the quality of UTCC Wi-Fi tended to be moderate, which corresponds with the site survey results. Some older buildings (9 out of 14 surveyed buildings) on campus are still using old network equipment (e.g., router or cable) and cannot provide high-speed internet. From the results, the satisfaction factor had the lowest coefficient value of all the other factors when predicting intention of UTCC Wi-Fi usage. The findings also included that all five factors

(PU, PEU, SAT, ATT, and SEC) have direct impact on the intention of users to use UTCC Wi-Fi. However, the Wi-Fi security factor was determined to be the most important factor in determining if students will continually choose to use UTCC Wi-Fi. This indicates that students might be concerned with privacy and keeping their data safe.

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