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Research Article
Understanding Individuals' Intention to Use Mobile Cloud Services: Cognitive and Security Perspectives

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Abstract

Background and Objective: The use of mobile cloud services continues to grow and attract considerable attention. The purpose of this study was to develop a research model that helps the IT community understand the determinants motivating individuals to adopt mobile cloud services. The proposed research model suggests several variables, including control, comfort, trust, vulnerability and unauthorized access, that affect an individual's intention to use mobile cloud services. **Materials and Methods:** A total of 427 responses from mobile cloud users were collected to test the proposed model. First, the measurement model was evaluated by performing a confirmatory factor analysis along with Cronbach's alpha for testing reliability. Covariance-based structural equation modeling using AMOS 22.0 was then used to test the proposed hypotheses. **Results:** Findings indicated that three cognitive factors: Intimacy, control and trust and two security factors: Vulnerability and unauthorized access had a significant impact on intention to use mobile cloud services. The most influential variable was intimacy but the security-related variables, particularly vulnerability, were also found to be important to users. **Conclusion:** This study revealed various factors that should be considered not only in academic research but also in mobile cloud service development for service providers.

Key words: Mobile cloud service, individual factor, intention to use, technology acceptance model, cognitive factors

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Research on cognitive and security factors for using mobile cloud services plays an important role in activating these services for both users and providers[1]. With the advancement of information technology, individuals and organizations have used various information technologies in a rapidly changing environment. In particular, as customers' needs change and business environments become more difficult to predict, many organizations must cope with a rapidly changing enterprise Information Technology (IT) environment. Thus, those companies dedicate resources for developing innovative smart or mobile devices to ensure user convenience[2]. Recently, user interest in mobile cloud computing technology has been growing. Changes in the concept of document storage space led to the development of mobile cloud computing technology, along with consumer awareness of the mobile cloud, which allows users to open files anytime and anywhere[1]. Thus, mobile cloud computing technology often ensures user convenience. A user can access stored information through a server that is connected to the Internet via a personal computer or portable device.

At the individual user level, mobile cloud computing services have gradually expanded and various synergies are required with services combining cloud computing and smart devices[2]. As such, mobile cloud computing is recognized as an important trend in the IT field both domestically and abroad and is considered an important factor in changing the perception of difficulty in using information resources. In addition, interest in mobile cloud computing has led to the expansion or establishment of businesses that target individual users. However, despite the awareness of the convenience of mobile cloud computing, there is still a lack of clear conceptualization in terms of understanding user behaviors regarding mobile cloud computing adoption[3]. Most research on mobile cloud computing stems from technical and engineering perspectives; however, research on the user perspective is very limited[4]. For this reason, empirical research for understanding the psychological behavior of mobile cloud service users is meaningful and necessary.

Despite the many advantages of mobile cloud services, there are several vulnerabilities, including privacy invasion, possibility of personal data disclosure and lack of identity protection. For example, in 2014, Snapchat's photo text messaging service was exploited by a hacker to launch a denial of service (DoS) attack. Given such high-profile data breaches, it is questionable that mobile cloud services remain popular and heavily used. Therefore, this study was conducted to shed light on the unchanged behaviors of individuals despite the potential risks of mobile cloud services or the perception there of. This study seeks to find empirical answers to two research questions. First, do individuals' behavioral control factors positively influence their intention to use cloud-based services? Second, do factors associated with privacy concerns negatively impact individuals' intention to use cloud-based services?

Therefore, this study developed a research model incorporating variables of the Theory of Planned Behavior (TPB) and other factors such as trust, vulnerability and unauthorized access from relevant research[5] to explain individual behavior regarding mobile cloud services. The 427 responses collected from mobile cloud service users were analyzed using the structural equation model to test the proposed hypotheses. Hypotheses were developed based on the results of the study. The findings provide academic and practical implications for mobile cloud services.

According to the TPB[6], the intention of individual behavior is a function of related information and psychological processes, connecting beliefs to behaviors. The TPB includes several distinct variables such as subjective norms, attitude and perceived behavioral control that can be used to predict an individual's behavioral intentions[6]. Prior studies reported that attitude, subjective norms and perceived behavioral control have a significant positive impact on an individual's behavior regarding technology use[3]. Each variable is represented by subcategorized factors, which include personal motivation for attitude, encouragement for subjective norms and familiarity and self-efficacy for perceived behavioral control. This study expected these factors to play an important role in predicting an individual's intention to use a mobile cloud service.

Intimacy is defined as the degree of previous experience or knowledge of an individual about something that serves as important internal information[7]. In addition, intimacy can reduce the resources (e.g., time and effort) used for acquiring knowledge about a given subject, technology or service, thereby reinforcing the intention to adopt while reducing uncertainty and perceived risk[7]. In this context, when individuals are familiar with mobile cloud services, they are more likely to adopt them. Hence, hypothesis 1 proposes that "Intimacy is positively associated with the intention to use a mobile cloud service".

In this study, control is the degree to which individuals believe that information about themselves can be controlled while sharing it with other people even if they are unaware of when, where and for what purpose their information is shared. On this aspect, Phelps *et al.*[8] claimed that individuals want to have control over their information. Without such control, they

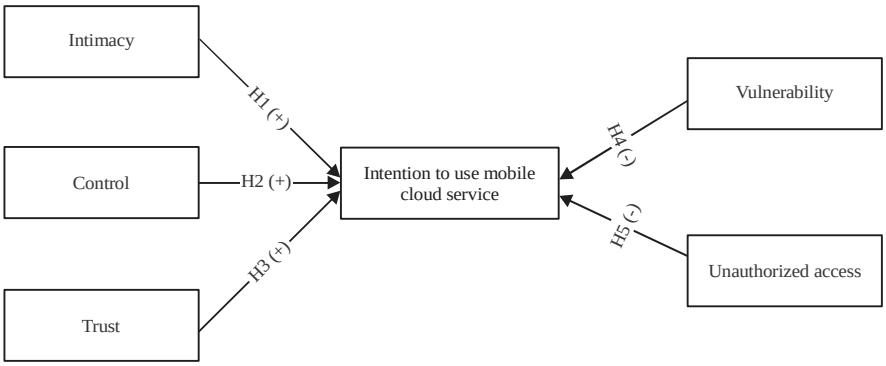

Fig. 1: Proposed research model

tend to be concerned about using mobile services. With mobile cloud services, service providers often hold control and users of their services remain vulnerable. Liu *et al.*[9] report that even if cloud service providers offer new features that increase users' concerns regarding their own information, users are pacified as long as they can control that information. Thus, when users of a mobile cloud service have more control over their own information, they are more likely to intend to use the service. This leads to the second hypothesis, "Control is positively associated with the intention to use a mobile cloud service".

Trust is defined as an individual's belief and expectation regarding the integrity and ability of the actor providing the service[10]. Rousseau *et al.*[11] defined trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another". In a social environment where it is difficult to regulate by means of rules and customs, individuals make decisions about their behavior through trust[12]. Thus, trust can be an important mechanism through which individuals can make decisions in complex and highly variable ways. Similar logic can be applied to mobile cloud services in which users must trust service providers to act in an ethical, socially desirable manner. Prior studies have claimed that trust helps increase intention to purchase from electronic commerce (e-commerce) websites[13]. Furthermore, Pavlou and Chai[14] found that customers who trust online retailers have confidence in the retailers' behavioral actions. Therefore, hypothesis 3 proposes that "Trust is positively associated with the intention to use a mobile cloud service".

In this study, vulnerability is defined as the extent to which an individual experiences a harmful situation caused by a specific behavior[15]. According to the protection motivation theory, an individual's behavior is determined by the evaluation of vulnerability and the ability to deal with potential threats[16]. That is, if mobile cloud services are considered to increase user vulnerability, individuals will not use the service to avoid threats. In contrast, if mobile cloud services leave individuals with little to no feelings of vulnerability to an actor, they are more likely to use the service, leading to hypothesis 4, "Vulnerability is negatively associated with the intention to use a mobile cloud service".

Unauthorized access refers to the extent to which an individual is concerned about access by unauthorized individuals or other entities to his/her data[17]. Unauthorized access includes security breaches involving various types of harmful activities, such as stealing personal information, data or fraud. Although mobile cloud services provide many benefits, security concerns are perceived as a major hurdle for individuals to continue to use the services[9]. Prior studies have found that privacy concerns, including unauthorized access, have a significant impact on individuals' intention to use e-commerce services. For example, Dinev *et al.*[18] examined an individual's online purchase decisions in both the U.S. and Italy. They found that both countries showed that the fear of security, such as improper access, had an adverse effect on the intention to use e-commerce. As mobile cloud services are considered a type of e-commerce, a negative relationship has been proposed in previous studies between unauthorized access and user intention to adopt mobile cloud services. Therefore, the study proposes hypothesis 5, "Unauthorized access is negatively associated with the intention to use a mobile cloud service". The research model in Fig. 1 showed the direct effects model as well as the expected relationships between five external variables and intention to use mobile cloud service.

MATERIALS AND METHODS

Sample: Data for analysis were collected through online and offline surveys. The unit of analysis was an individual who has

used mobile cloud services for various purposes. Of the 452 responses collected, 25 were discarded due to incompletion. Therefore, 427 responses were used for the analysis. Table 1 describes the demographic characteristics of the survey participants.

Measurement: The items used to measure the latent variables included in the research model were developed based on existing research. However, each item was revised and supplemented for mobile cloud services. All of the items developed were tested for content validity for IT professionals (e.g., professors and Ph.D. candidates), thereby improving the contextual accuracy and relevance of the items. Each item assesses individuals' psychological feelings with respect to the intention to use mobile cloud services. All items were developed on a seven-point Likert-type scale, ranging from (1) strongly disagree to (7) strongly agree to answer the degree of individual agreement or disagreement related to the use of mobile cloud services.

Analysis of the measurement model: Before testing the proposed hypotheses, the measurement model was evaluated by performing a confirmatory factor analysis with AMOS 22.0. First, the overall fit of the measurement model was evaluated using several indices, such as the Normed Fit Index (NFI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Comparative Fit Index (CFI), relative χ^2 (χ^2/df) and root mean square of approximation (RMSEA). To demonstrate the overall fit, NFI, GFI and CFI should be equal to or greater than 0.90 [19], the threshold of AGFI equal to or greater than 0.8 and RMSEA equal to or less than 0.1 [20]. Finally, the value for the relative chi-square (χ^2/df) should be equal to or less than 3.0 [21]. As shown in Table 2, all indices fulfilled the thresholds, implying that the data fit well into the measurement model, indicating it could be used for further analyses.

Reliability and construct validity: After testing the overall fit of data, the reliability and validity of each latent variable were examined. Cronbach's alpha, a commonly used test method, was used to check for reliability. To demonstrate the reliability of the measurement model, the value of alpha should be 0.7 or greater[22]. As shown in Table 3, Cronbach's alpha for all latent variables exceeds the minimum requirement (0.7). Thus, the reliability of the measurement model was confirmed. Next, convergent validity was verified by three indicators: (1) Factor loadings, (2) Average Variance Extracted (AVE) and (3) Composite Reliability (CR). The factor loading for each item and the CR value of latent variables should be 0.7 or higher and the AVE should be 0.5 or higher to ensure convergent validity[23]. The results are shown in Table 3. The factor loadings of all measurement items were above 0.7 and the AVE and CR values of each latent variable were above their thresholds, confirming the convergent validity of the measurement model.

The discriminant validity was tested as the last step of the verification of the measurement model to prove that the latent variables are not related to the items to be measured and other potential variables. The discriminant validity can be examined by comparing the square root of the AVE value of each latent variable with the correlation. The square root of AVE should be larger than the correlation value in the diagonal to ensure the discriminant validity. As shown in Table 4, all values in the diagonal were greater than all correlation values; thus, the discriminant validity was confirmed.

Table 1: Demographic characteristics (n = 427)

Demographic characteristics	Frequency	Percentage
Age (years)		
19-29	67	15.69
30-39	128	29.98
40-49	150	35.13
50+	82	19.20
Gender		
Male	186	43.56
Female	241	56.44
Race/Ethnicity		
White, Non-Hispanic	90	21.08
Black	85	19.91
Hispanic origin, any race	63	14.75
Asian or Pacific Islander	189	44.26
Educational level		
Graduate high school	91	21.31
College/University	186	43.56
Post-graduate study	122	28.57
Others	28	6.56
Occupation		
Student	109	25.53
Company-employed	137	32.08
Professional	83	19.44
Self-employed	69	16.16
Others	29	6.79
Length of using Mobile cloud service		
<1 year	61	14.29
≥1, <2 years	170	39.81
≥2, <3 years	196	45.90

Table 2: Summary of the overall fit indices for the measurement model

Model	NFI	GFI	AGFI	CFI	χ^2/df	RMSEA
Measurement model	0.927	0.920	0.901	0.943	1.86	0.047
Recommended value	≥0.9	≥0.9	≥0.8	≥0.9	≤3.0	≤0.10

Table 3: Construct loading and reliabilities of the measurement model

Variable	Items	Factor Loading	Cronbach's alpha	AVE	CR
Intimacy	INT1*	0.751	0.829	0.597	0.816
	INT2	0.805			
	INT3	0.761			
Control	CON1*	0.822	0.789	0.687	0.868
	CON2	0.859			
	CON3	0.805			
Trust	TRU1*	0.830	0.890	0.740	0.895
	TRU2	0.889			
	TRU3	0.861			
Vulnerability	VUL1*	0.775	0.914	0.670	0.859
	VUL2	0.821			
	VUL3	0.857			
Unauthorized access	UA1*	0.825	0.886	0.593	0.814
	UA2	0.748			
	UA3	0.735			
Intention To use mobile cloud service	INT1*	0.892	0.927	0.705	0.877
	INT2	0.860			
	INT3	0.761			

Items with asterisk (*) are fixed as "1" in the analysis

Table 4: Discriminant validity test by comparing the square root of AVE and correlation

Latent construct	(1)	(2)	(3)	(4)	(5)	(6)
(1) Intimacy	0.773*					
(2) Control	0.137	0.829*				
(3) Trust	0.163	0.143	0.860*			
(4) Vulnerability	0.262	0.332	0.272	0.818*		
(5) Unauthorized access	0.218	0.243	0.257	0.346	0.770*	
(6) Intention to use mobile cloud service	0.351	0.337	0.292	0.370	0.361	0.840*

*The values at the diagonal are the square root values of AVE

RESULTS AND DISCUSSION

Analysis of the structure model (Hypothesis test): Using AMOS 22.0, the hypotheses proposed in the research model were verified through a Structural Equation Model (SEM) analysis. Through the SEM analysis, the overall fit of the structural model, the standardized path coefficient (β) for each path and the squared multiple correlation (R^2) of endogenous variables can be determined. The path coefficient and t-value are used to decide whether to adopt each hypothesis. First, the overall fit of the structural model was judged based on the index used in the fit test of the measurement model. The results show that all fit indices were greater than their thresholds-NFI (0.951), GFI (0.945), AGFI (0.903), CFI (0.958), RMSEA (0.029) and the relative c^2 (1.920)-implying that the characteristics of the data collected in this study fit well with the characteristics of the structural model.

The findings provided strong support for all proposed hypotheses. Intimacy and control were significantly related to the intention to use a mobile cloud service. Moreover, Trust in mobile cloud service providers has a significant impact on the intention to use the service. Thus, H1, H2 and H3 were supported. These results are consistent with the results of previous studies[9,7] on acceptance of various technologies. In other words, individuals are more likely to use a technology or service when they have more control over their information and intimacy with the information technology they want to use. Furthermore, individuals are more likely to use the service when their trust in the mobile cloud service provider is higher. These results are also consistent with previous studies[11,12]. In other words, trust in an information technology application or service plays an important role in users adopting the application or service.

Research results show that unauthorized access and vulnerability negatively affect the intention to use mobile cloud services. Vulnerability and unauthorized access had a significant negative impact on intention to use a mobile cloud service. Thus, H4 and H5 were supported at $p<0.01$. These results are related to security concerns about mobile cloud services. In other words, unauthorized actors having frequent access to the information of mobile cloud service users creates a negative perception regarding using these services. Furthermore, if there is a weakness in the security of a mobile cloud service, individuals may be less likely to use the service.

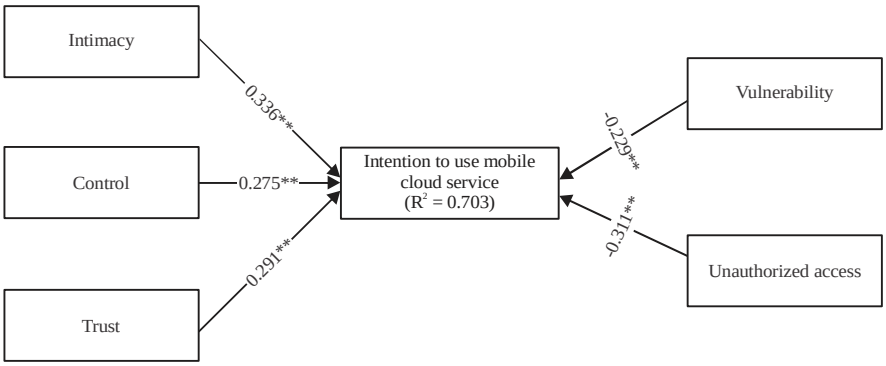

Fig. 2: Results of the structural equation model (SEM)

χ^2/df = 1.920, NFI = 0.951, GFI = 0.945, AGFI = 0.903, CFI = 0.958, RMSEA = 0.029, **p<0.01

Table 5: Hypotheses evaluation for the proposed research model

Hypothesis	Path			Std. β	t-value	Result
H1	Intimacy	→	Intention to use mobile cloud service	0.336	4.283	S**
H2	Control			0.275	3.896	S**
H3	Trust			0.291	3.312	S**
H4	Vulnerability			-0.229	-4.008	S**
H5	Unauthorized access			-0.311	-5.227	S**

**p<0.01, S: Supported

These results agree with those previously reported in the literature[15,17]. Figure 2 showed the SEM analysis and Table 5 summarized the results for each hypothesis.

The five exogenous variables (control, intimacy, trust, unauthorized access and vulnerability) proposed in this study account for 70.3% of the information regarding the intention to use a mobile cloud service. In other words, 70.3% of the information regarding the endogenous variable-intention to use a mobile cloud service-has moved in the same direction of the five exogenous variables. Based on the result of the analysis, the multiple linear regression model is given as follows:

$$Y_{(\text{Intention to Use Mobile Cloud Service})} = \begin{matrix} 0.336X_{(\text{Control})} + 0.275X_{(\text{Intimacy})} + \\ 0.291X_{(\text{Trust})} - 0.229X_{(\text{Unauthorized Access})} - \\ 0.311X_{(\text{Vulnerability})} + 3.852_{(\text{constant})} \end{matrix}$$

In the mobile environment, various cloud services are available for individual users. If existing cloud services are applied to the mobile environment, users can enjoy more features and benefits. In light of the various academic and practical implications of cloud computing research, the results of this study have some important implications. First, this study contributes to the knowledge about individuals' behaviors regarding mobile cloud services both from cognitive- and security-related perspectives. Straub *et al.*[24] claimed that two important factors of an individual's behavior in information technology are the perceptions of security and psychological aspects. This study increased the understanding of users' behaviors with regard to mobile cloud services by including these two factors. Another academic contribution of this study is related to the development and validation of the measures. In the cases in which measurement items to assess variables in the proposed research model were adopted from the literature, they were modified to suit the mobile cloud service context. Therefore, these measures can now be used in future research on mobile cloud services.

As research topics related to cloud computing are attracting considerable attention in recent years, the results of this study can be an important basis for cloud services research in the future. In particular, the results of this study indicate that mobile cloud service providers should consider important aspects of service delivery. For example, users of mobile cloud services have important psychological factors to consider, such as control of information, trust and intimacy when adopting services. Thus, based on these results, mobile cloud service providers can develop or modify their services to meet users' needs. In addition, this study shows that mobile cloud service users demand a high level of security for their personal information. Therefore, cloud service providers should ensure the security of personal information technically and politically by developing policies and regulations.

CONCLUSION

This study introduced cognitive- and security-related factors affecting the intention of individuals to use mobile cloud services. Findings indicated that three cognitive factors; intimacy, control and trust and two security factors; vulnerability and unauthorized access had a significant impact on intention to use mobile cloud services. The most influential variable was intimacy but the security-related variables, particularly vulnerability, were also found to be important to users. Despite the significant contribution of this study, more diverse perspectives on mobile cloud services are needed.

SIGNIFICANCE STATEMENTS

This study empirically analyzed the impact of cognitive (intimacy, control and trust) and security (vulnerability and unauthorized access) factors on intention to use mobile cloud services by individuals. The results of this study provide various implications for both academic and practical applications. In particular, this study will help researchers and practitioners develop new theories dealing with innovative technology from an individual perspective, as well as security features for mobile cloud services.

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