

## Research Article

### A Study of the Users' Attitudes and Intentions toward 4G WiMax

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**Abstract:** With the rapid development of telecommunication technologies, various high-speed wireless broadband standards have been proposed in recent years. Based on the Technology Acceptance Model and the Innovation Diffusion Theory, this study investigates the attitude of general users toward using and intending to use 4G WiMAX. Research data are collected from a survey administered to people with experience using WiMAX. Based on research results, we suggest WiMAX operators pay additional attention to the compatibility of WiMAX with other networking technologies and continue to offer services that are practical to users to influence their attitude toward WiMAX and thus their intention to use it. Moreover, WiMAX operators should accelerate their cooperation with roaming and continue to offer free trials of WiMAX to enhance the perceived usefulness of WiMAX and the users' intention to use it. This study aims to provide some references on future development for related service operators.

**Keywords:** 4G WiMAX, innovation diffusion theory, technology acceptance model

## INTRODUCTION

Due to advancement of the Internet and liberalization of telecommunications, new telecommunication technologies are developed one after another and those concerning mobile networking are particularly attracting public attention. The telecommunication industry in Taiwan was devoted to development of many mobile networking technologies in early years, such as Wireless Local Area Network (WLAN) and Wireless Fidelity (Wi-Fi). With the rapid development of new technologies, various high-speed wireless broadband standards have been established. In 2001, Institute of Electrical and Electronics Engineers (IEEE) released IEEE 802.16 standard, which is also called Worldwide Interoperability for Microwave Access (WiMAX). As this new mobile networking standard can offer users faster, more diverse and abundant content services, mobile telecommunication operators in Taiwan hold an optimistic outlook for the development of 4G WiMAX in Taiwan.

WiMAX operators in Taiwan will be confronted with many tests as soon as they go into operation, including users' examination and competitions from other mobile system providers. Whether WiMAX can win user support and its market be established has become an important issue. As research on current use of WiMAX is still rare, this study attempts to investigate WiMAX users' attitude and intention using a model developed on the basis of Davis's (1989) Technology Acceptance Model (TAM) and Rogers'

(1983) Innovation Diffusion Theory (IDT). The results of this study are expected to be a reference for WiMAX operators in WiMAX promotion and policy implementation.

## LITERATURE REVIEW

**Worldwide interoperability for microwave access (WiMAX):** Worldwide Interoperability for Microwave Access (WiMAX) is one of the latest international wireless broadband standards. It offers an effective solution to delivery of last mile wireless broadband access. WiMAX is colloquial term for a series of 802.16 standards authored by Institute of Electrical and Electronics Engineers (IEEE) and also the next-generation broadband standard for implementation of Wireless Metropolitan Area Networks (WMAN) (M-Taiwan, 2007).

WiMAX is a type of WMAN technology that transmits data in the microwave and millimeter wave bands. As it uses high-performance radio signal transmission and processing technologies, it can be used as a medium for accessing wireless broadband, a bridge between Wi-Fi hot spots and the Internet and a solution to delivery of the last-mile broadband to corporate and household users. According to Lo (2007), WiMAX has several remarkable characteristics and benefits, including high transmission rate, wide signal coverage, long transmission distance, high mobility, intelligent antenna technology, IP networking, Non-Line-of-Sight (NLOS), Line-of-Sight (LOS) and

Quality of Service (QoS). Taiwan has been actively engaged in promotion of WiMAX. Various service tests have been conducted around the island through M-Taiwan Project. Besides, National Communications Commission (NCC) also released WiMAX licenses to six operators in Jul. 2007.

**Technology Acceptance Model (TAM):** Technology Acceptance Model (TAM) was developed by Davis (1986) to explain users' acceptance behavior of new information systems. TAM is one of the extensions of Theory of Reasoned Action (TRA). Focusing on the information systems application context, it examines the relationship between rational factors, affective factors and actual use (Davis, 1986). TAM explains user acceptance of technology based on user perceptions. It is not only one of the models frequently adopted for studying user technology acceptance but also the most effective tool for predicting and explaining user behavioral intentions (Szajna, 1996).

Davis *et al.* (1989) propose that users' "actual system use" is affected by their "intention to use", "intention to use" is determined by "attitude", "attitude" is collectively influenced by "perceived ease of use" and "perceived usefulness" and "perceived ease of use" is also related to "perceived usefulness". "External variable" in TAM refers to latent variables that may indirectly affect users' actual use of a system.

**Innovation Diffusion Theory (IDT):** Innovation Diffusion Theory (IDT) is the foundation of most existing studies on innovation adoption and diffusion. This theory is frequently employed to explain and forecast adoption and diffusion behavior (Agarwal and Prasad, 1997). According to Gera and Chen (2003), IDT aims to explain, among many other things, the process of innovations decision process, the determining factors of rate of adoption and different categories of adopters. Also, it helps predicting the likelihood of adoption and rate of adoption of an innovation. Individuals or other decision-making units adopt innovations at different rates, depending on their perception of the characteristics of the innovations. These characteristics can be used to explain users' acceptance or adoption decision process. These characteristics include relative advantage, compatibility, complexity, trialability and observability (Rogers, 1995).

The goal of this study is to understand general citizens' attitude toward using and intention to use WiMAX primarily based on TAM. So far, WiMAX is still a new-emerging network technology for Taiwanese people. Information systems that are used only by a small number of early adopters should be viewed as innovations. Besides, perceived attributes of innovation introduced in Rogers (1983) Innovation Diffusion Theory (IDT) have been extensively applied to research of consumers' adoption of innovations. Hence, this

study will integrate the perceived attributes of innovations in IDT into TAM to enhance the explanatory power of intention to use.

## RESEARCH CONSTRUCTS AND HYPOTHESE

The research model and hypotheses are explained as follows:

**Definition of each construct:** As mentioned earlier, this study combines TAM introduced by Davis *et al.* (1989) and IDT introduced by Rogers (1983) to investigate users' attitude toward using and intention to use WiMAX. According to the research objective and characteristics, the research constructs and their operational definitions are developed as listed in Table 1.

**Hypotheses and model structure:** Lu *et al.* (2005) explore factors affecting adoption of wireless Internet services using TAM. Their findings suggest that perceived usefulness has positive influence on user adoption of wireless Internet. Findings in Wu and Lin (2011) suggest that perceived usefulness of Library 2.0 has a positive impact on college students' intention to use the system. All the above findings indicate that the more that users believe that an information technology is useful, the more they are likely to use the technology. Hence, we propose the following hypothesis:

**H1:** "Perceived Usefulness" of 4G WiMAX has positive influence on users' "Intention to Use" 4G WiMAX.

Moon and Kim (2001) focus on students' acceptance of the Internet environment. Their findings indicate that perceived usefulness has positive influence on users' attitude toward using the Internet. From a research of college students' behavioral intentions in using instant messaging software, Chiu (2008) derives a positive relationship between perceived usefulness and attitude toward use. Wu and Lin (2011) also have the same finding in her study of students' intention to use Library 2.0. She mentions that students would consider the benefits of Library 2.0 for their work and life before adopting the technology. From the above empirical results, we infer that the more those users perceive an information technology as useful or having higher relative advantage, the more positive their attitude toward using the technology will be. Therefore, we propose the following hypothesis:

**H2:** "Perceived Usefulness" of 4G WiMAX has positive influence on users' "Attitude toward Use" of 4G WiMAX.

Lin and Lu (2000) point out in a study of website users' behavioral intentions that perceived ease of use

Table 1: Definition of each construct in this research

Construct	Definition	References
Perceived usefulness	The degree to which users believe they can personally benefit from 4G WiMAX	Davis (1989) and Moore and Benbasat (1991)
Perceived ease of use	The degree to which users believe that 4G WiMAX is easy to operate and learn	Davis (1989) and Moore and Benbasat (1991)
Compatibility	The degree to which users believe that 4G WiMAX is compatible with non-4G networking technologies	Moore and Benbasat (1991) and Rogers (1995)
Trial ability	The degree to which users wish to try the functions of 4G WiMAX before adopting the technology	
Observability	The degree to which users believe that the benefits of 4G WiMAX are visible and easy to express to others.	
Attitude toward use	The degree to which users hold a positive attitude toward using 4G WiMAX	Fishbein and Ajzen (1975), Ajzen and Fishbein (1980) and Taylor and Todd (1995)
Intension to use	The degree to which users have intentions to use 4G WiMAX	Fishbein and Ajzen (1975), Ajzen and Fishbein (1980), Davis (1989) and Venkatesh and Davis (2000)

has significant influence on attitude toward use. From students with Internet experiences, Moon and Kim (2001) also find that perceived ease of use has positive effects on users' attitude toward use of the Internet. Kuo and Yu (2007) use TAM to explore consumers' intention to use mobile value-added services. Their findings suggest that perceived ease of use directly reinforces attitude toward use. Hsu *et al.* (2009) mention that lower perceived complexity of blogs leads to higher attitude toward use of blogs. We can infer from the above empirical results that the more that user perceives an information technology as easy to use, the more positive their attitude toward use of the technology will be. Hence, we propose the following hypothesis:

**H3:** "Perceived Ease of Use" of 4G WiMAX has positive influence on users' "Attitude toward Use" of 4G WiMAX.

Davis (1989) argues that perceived ease of use of a system reinforces an individual's perception of the system's usefulness, suggesting that one considers an information system as more useful if he or she perceives a higher level of ease of use of the system. Karahanna and Straub (1999) use TAM and four exogenous variables to investigate user acceptance of e-mail systems. Their findings indicate that users' actual use of an e-mail system is affected by perceived usefulness of the system, which is also affected by perceived ease of use of the system. Chiu (2008) mentions in his study of college students' use of instant messaging software that perceived ease of use is positively related to perceived usefulness. Wu and Lin (2011) derives a similar finding in her study of user adoption of Library 2.0. Users tend to perceive Library 2.0 as useful when they believe they can accomplish more tasks with the same amount of efforts and do not need to spend much time and effort on learning how to use Library 2.0. From the above empirical findings, we infer that the more that user perceives an information technology as easy to use, the more likely they are to perceive the technology as useful. Hence, we propose the following hypothesis:

**H4:** "Perceived Ease of Use" of 4G WiMAX has positive influence on "Perceived Usefulness" of 4G WiMAX.

Rogers (1983) proposes that higher perceived compatibility of an innovation leads to higher possibility of adoption of the innovation. Kuo and Yu (2007) integrate compatibility into TAM to explore consumers' intention to use mobile value-added services. Their findings suggest that compatibility of mobile value-added services directly reinforces users' attitude toward using them. Hsu *et al.* (2009) combine TAM and IDT to examine blog users' satisfaction and behavioral intentions. They find that the more users perceive a blog system as compatible, the more they are likely to have a positive attitude toward using it. The above results imply that higher perceived compatibility leads to more positive attitude toward use. Hence, we propose the following hypothesis:

**H5:** "Compatibility" of 4G WiMAX has positive influence on users' "Attitude toward Use" of 4G WiMAX.

Wu and Wang (2005) integrate compatibility of innovations into TAM to investigate user acceptance of mobile commerce (m-commerce). Their findings reveal that compatibility of m-commerce has positive influence on perceived usefulness of m-commerce. Wu and Lin (2011) mentions in her study of Library 2.0 that compatibility is positively influential to perceived usefulness. In her study, participants tended to perceive Library 2.0 as useful when they perceived the functions of the system were mutually compatible. It can be inferred from the above studies that higher perceived compatibility of an information technology leads to higher perceived usefulness of the technology. Hence, we propose the following hypothesis:

**H6:** "Compatibility" of 4G WiMAX has positive Influence on "Perceived Usefulness" of 4G WiMAX.

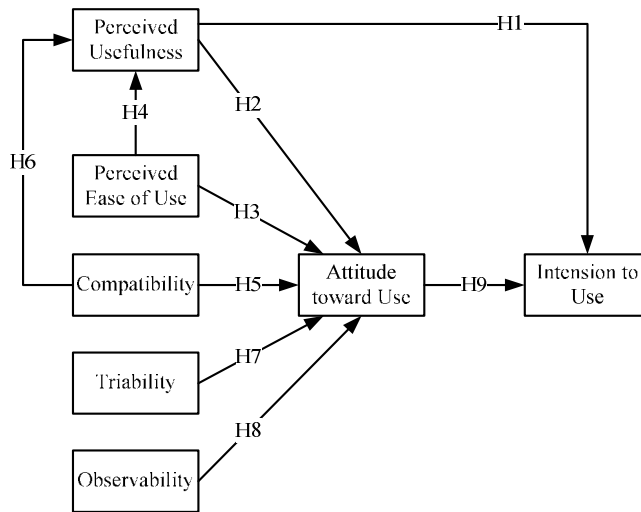


Fig. 1: Research model

Chao *et al.* (2008) explore the key factors affecting user behavior in an audit knowledge-based learning community system. Their findings indicate that reduction of time cost and uncertainties of the knowledge-based learning community system can incite positive attitude toward use of the system. Users are more likely to adopt the knowledge-based learning community system when they believe that the system can help them obtain a large amount of useful information in a shorter time and they can try it before adopting it. Wu and Lin (2011) find that trialability of Library 2.0 also has positive influence on users' attitude toward use of Library 2.0. In her research, respondents even mentioned that promotional or trail programs of Library 2.0 to increase users' adoption intentions. From the above results, we can infer that higher perceived trialability of an information technology leads to more positive attitude toward use of the technology. Thus, we propose the following hypothesis:

**H7:** "Trialability" of 4G WiMAX has positive influence on users' "Attitude toward Use" of 4G WiMAX.

Chao *et al.* (2008) mention that information sharing can be accelerated if the benefits or functions of a knowledge-based learning community system can be easily recognized and verbally expressed and increase of information sharing can further positively influence users' attitude toward using the system. Wu and Lin (2011) have a similar finding in her study of Library 2.0. The observability of the benefits of Library 2.0 has positive effects on user attitude. Users hold a more positive attitude toward using the system when they can easily learn the benefits of Library 2.0 from people around them. We can infer from the above results that higher observability of an information technology leads to more positive attitude toward use of the technology. Hence, we propose:

**H8:** "Observability" of 4G WiMAX has positive influence on users' "Attitude toward Use" of 4G WiMAX.

In research of mobile Internet services, Bruner II and Kumar (2005) and Nysveen *et al.* (2005) all point out that consumers have higher intentions to use mobile Internet services as long as they have a positive attitude toward use of the services. Wu and Lin (2007) investigate knowledge sharing behavior among IS personnel. Their findings reveal that IS personnel's attitude toward knowledge sharing directly influences their intention to share knowledge. Chiu (2008) finds that attitude toward use is most influential to behavioral intention in his study of use of instant messengers. Lin *et al.* (2009) focus on domestic bio-tech cosmetics industry to explore factors affecting consumers' intention to disseminate post-purchase opinions on corporate websites. Their results indicate that consumers' attitude toward disseminating post-purchase opinions positively affects their intention to do so. From the above findings, we can infer that positive attitude toward use of an information technology leads to higher intention to use the technology. Thus, we propose the following hypothesis:

**H9:** "Attitude toward Use" of 4G WiMAX has positive influence on users' "Intention to Use" 4G WiMAX.

Based on the above hypotheses, we develop our research model as shown in Fig. 1.

## DATA ANALYSIS RESULTS

Building on TAM and IDT, this study aims to investigate users' attitude toward using and intention to use 4G WiMAX. Through literature review, seven constructs were obtained for this research, including Perceived Usefulness, Perceived Ease of Use,

Table 2: Descriptive analysis of the sample

Basic attribute	Category	Sample size	%	
Gender	Male	126	77	
	Female	37	23	
Age	20 or under	24	15	
	21~25	77	47	
	26~30	43	26.3	
	31~35	9	5.5	
	36~40	8	5	
	More than 40	2	1.2	
Occupation	Student	96	59	
	Military and civil servant	14	8.5	
	Information industry	20	12.2	
	Professional (lawyers, doctors, and etc.)	2	1.2	
	Business	9	5.7	
	Service	15	9.2	
	Others	7	4.2	
Education	Under junior high school	2	1	
	Senior high school (vocational school)	8	5	
	College/university	99	61	
Region of residence	Graduate school or above	54	33	
	Northern Taiwan	94	58	
	Central Taiwan	27	17	
	Southern Taiwan	34	21	
	Eastern Taiwan	4	2	
	Offshore islands	4	2	
Hours of using WiMAX per week	Less than 1 h	47	29	
	2-4 h	64	39	
	5-7 h	25	15	
	More than 8 h	27	17	
WiMAX Operator	Tatung InfoComm	39	23.9	
	Far Eastone Telecom	23	14.1	
	Global Mobile	39	23.9	
	VMAX	29	18	
	Vee Telecom Multimedia	19	11.6	
	First International Telecom	14	8.5	
Primary reasons of using WiMAX (Multiple choices)	Connection quality	79	19.8	
	High-speed Internet surfing	55	13.8	
	Transmission speed	61	15.3	
	Connection stability in motion	37	9	
	Mobile connectivity	87	21.8	
	Curiosity	57	14.3	
	Price	22	5.5	
	Others	2	0.5	
	Primary purposes of using WiMAX (Multiple choices)	Checking emails	120	25.6
		Shopping	34	7.2
Browsing data		122	26	
Making friends		50	10.6	
Downloads		55	11.7	
Online games		26	6	
Work		43	9.1	
Financial transaction		18	3.8	

Table 3: Goodness-of-fit criteria and test results

Measurement items	Results	
Preliminary fit criteria	Factor loading	Compliant
	Error variance	Compliant
Overall model fit	$\chi^2/d.f.$ (normed Chi-square)	Compliant ( $\chi^2/d.f. = 1.6878$ )
	GFI(Goodness of fit index)	Compliant (GFI = 0.82)
Fit of internal structure of model	AGFI (Adjusted goodness of fit index)	Partially compliant (AGFI = 0.77)
	RMR (Root mean square residual)	Compliant (RMR = 0.045)
	IR (Individual item reliability)	Partially compliant
	CR (Composite reliability)	Compliant
	AVE (Average variance extracted)	Partially compliant
	Parameter estimates	Compliant

Compatibility, Trialability, Observability, Attitude to Use and Intention to Use. Based on these constructs, a questionnaire was developed and then evaluated by experts. All the items in this questionnaire were designed to be measured on a Likert's five-point scale.

**Data collection and analysis:** The survey was administered to people with experience of using WiMAX in Taiwan via both online and study questionnaires. A total of 175 responses were collected and 163 of them were valid. The valid response rate was 93%. The questionnaire had a Cronbach's  $\alpha = 0.81$ , meaning that it was developed with good internal consistency. Besides, as this questionnaire was developed on the basis of Davis *et al.* (1989) TAM and Rogers' (1983) IDT and evaluated by experts from related fields, its content validity was ensured. The basic data of the respondents are shown in Table 2.

**Confirmatory factor analysis:** In this study, we performed Confirmatory Factor Analysis (CFA) to evaluate the measurement model and explore the causal relationships between research constructs. The paths between latent variables and observed variables in the model were obtained using structural equation modeling. The research model consisted of seven constructs and nine hypotheses. These constructs involved four independent variables and three dependent variables. We developed 15 items for the independent variables and 11 for the dependent ones.

In this study, the factor loading, error variance and t-value for all the items are within their respective ideal ranges. According to Bagozzi and Yi (1988), a complete evaluation of model fit should involve tests of preliminary fit criteria, fit of internal structure of model criteria and overall model fit criteria. As shown in

Table 3, except the adjusted goodness of fit index (AGFI = 0.77) which was slightly below the ideal criterion ( $>0.8$ ), all the test results complied with their respective criteria. AGFI values should better be close to 1, but 1 is not necessarily an absolute requirement for AGFI values (Hair *et al.*, 1995). The criterion for AGFI values depends on model complexity, variables and sample size. Therefore, we can infer that the goodness-of-fit of the model is good.

**SEM Analysis:** This study proposed nine hypotheses with LISREL. The path coefficient and t-value of each hypothesis is presented in Fig. 2. The data shown in Fig. 2 are analyzed as follows:

- **The effects on attitude toward use:** Our results show that "Perceived Usefulness" has significant and positive effects on "Attitude toward Use", meaning that users tend to have a more positive attitude toward using WiMAX when they perceive WiMAX as useful. However, "Attitude toward Use" is not significantly related to "Perceived Ease of Use", "Compatibility", "Trialability" or "Observability". Our explanation is as follows: If WiMAX operators expect to influence users to have positive attitude toward WiMAX, they must provide them practical services continuously. However, the current drivers of most WiMAX adaptors have not been well-designed. Users need to download drivers and necessary application software from the Internet before they can use WiMAX. This limitation has reduced the perceived ease of use of WiMAX. Besides, WiMAX is similar to other networking technologies in terms of compatibility. It is therefore harder for general

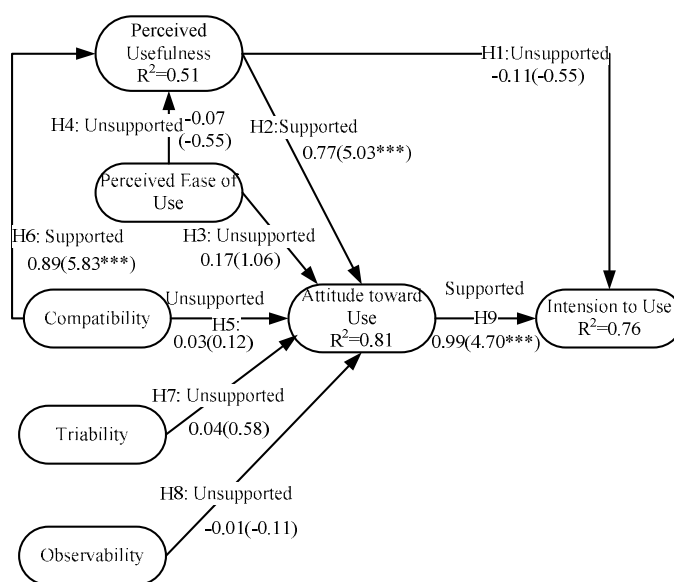


Fig. 2: Path coefficients and relationships of research variables; The Fig. 2 each hypothesis is path coefficient and the parenthesized value is t-value. \* indicates that t-value is greater than 1.96,  $p < 0.05$ ; \*\* indicates that t-value is greater than 2.58,  $p < 0.01$ ; \*\*\* indicates that t-value is greater than 3.29,  $p < 0.001$

users to perceive the unique benefits of WiMAX. As to trialability and observability of WiMAX, only one of the six licensed WiMAX operators have offered a 7-day free trial program so far. Since only a small number of people have experience of using WiMAX, it is not very easy for potential users of WiMAX to learn the benefits of WiMAX from early adopters.

- **The effects on intention to use:** The six WiMAX operators in Taiwan offer services only within their mandated regions and have not worked together to offer cross-region Internet roaming services. Therefore, no positive relationship between “Perceived Usefulness” and “Intention to Use” was observed. However, citizens’ attitude toward WiMAX is still a determinant of their intention to use WiMAX. We suggest that WiMAX operators pay more attention to users’ perceptions of WiMAX and improve their services accordingly in their promotion of WiMAX. They should influence general citizens’ attitude toward WiMAX first before they can further increase their intention to use WiMAX.

## CONCLUSION

Building on TAM and IDT, this study established a conceptual model and nine hypotheses to explore Taiwanese people’s attitude toward using and intention to use 4G WiMAX. The current WiMAX operators will be faced with users’ examination and competition from 3.5G operators as soon as they go into operation. In the present, the major barrier to development of 4G WiMAX in Taiwan is that their operations are confined to only one service region, either north or south. So far, these operators have not worked together to integrate wireless broadband resources in two regions to offer cross-region and even cross-city or cross-operator roaming services. Although some of them are planning to cooperate on roaming services in 2011 and have established a center for allocating collected service fees, the service region limitation is quite a bother for most users. Therefore, WiMAX operators should accelerate their cooperation on roaming to enhance the perceived usefulness of WiMAX in users’ job or life, which can further influence their attitude toward using and intention to use WiMAX.

So far, a considerable proportion of people still have no idea that WiMAX is a new wireless Internet access technology. Besides, most people are already very used to and dependent on wired Internet access. The benefits or services of WiMAX are not attractive enough to them. As a result, they have little intention to spend time on trying and accepting its new services. However, WiMAX indeed has some competitive advantages over existing technologies, such as transmission rates. Its various end-user devices can

become a strong incentive for many people. To gain a larger market share, WiMAX operators should endeavor to improve WiMAX connection quality and stability and continue to expand the market by offering more value-added services. While developing more WiMAX end-user devices, manufacturers can consider adding more values to the devices. For instance, they can make WiMAX USB Dongle more than a network adaptor. It can be designed to work like a USB Disk and contain drivers that automatically launch and install themselves. If people can live a better and more convenient life by using the ubiquitous Internet access and value-added applications of WiMAX, they will certainly have positive feedbacks on WiMAX and increase their intention to use WiMAX. Therefore, we suggest WiMAX operators hold more promotional activities and use various media to introduce the functions, features and benefits of WiMAX. Besides, they should launch free trial programs to increase users’ recognition of and reliance on the benefits of WiMAX and finally their intention to use it.

This study focus on general users’ attitude toward using and intention to use 4G WiMAX in the promotion stage of 4G WiMAX. Future researchers can probe into more profound issues after WiMAX enters the maturity stage where operators are cooperating to offer cross-regional services. For instance, they can explore factors affecting WiMAX adoption from the perspective other behavioral theories, examine user satisfaction or compare WiMAX application services between different operators to facilitate development of WiMAX in Taiwan.

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