1. Introduction

Communications and services through wireless telecommunication networks that interface with mobile devices are becoming increasingly popular on a global scale. Wireless communications and services are enabled by the convergence of two technologies – the Internet and wireless technology such as mobile phones and personal digital assistants (Coyle, 2001). Abundant information has indicated that the proliferation of wireless Internet via mobile devices (WiMD) is also creating unparalleled opportunities for e-commerce to leverage the benefits of mobility. It allows consumers and businesses to build connectivity by transcending time and place, increasing accessibility, and expanding their social and business networks (Palen, 2002). This proliferation will provide the ubiquity, convenience, localization, and personalization for users participating in mobile communications and service activities (Clarke, 2001).

While there has been an increasing amount of wireless mobile activity, little attention has been given in the literature to user acceptance of WiMD. Research on WiMD user acceptance, therefore, will be extremely worthy in providing useful information, especially at this early stage of WiMD development and implementation.

The purpose of this study is to develop a conceptual framework that examines and explains the factors influencing user acceptance of WiMD. We first review the literature on technology acceptance. We then propose a technology acceptance model for wireless Internet via mobile devices (TAM for wireless Internet) that depicts the determinants of user acceptance of WiMD based on the literature review. Theoretical propositions are, in turn, derived from the framework to promote and facilitate future research. Finally, we discuss the design and procedures to operationalize TAM for wireless Internet and the related implications.

2. Literature on technology acceptance

In the last two decades, a number of studies have provided some theoretical frameworks for research in the acceptance of information
technology and information system (IT/IS) (i.e. Ajzen, 1985, 1991; Davis, 1989; Davis et al., 1989; Mathieson, 1991; Moore, 1987; Taylor and Todd, 1995). Among them, the technology acceptance model (TAM) is believed most robust, parsimonious, and influential in explaining IT/IS adoption behavior (Davis, 1989; Davis et al., 1989; Igbaria et al., 1995; Mathieson, 1991).

TAM was rooted in the theory of reasoned action, a model concerned with determinants of consciously intended behaviors (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975). Theory of reasoned action proposes that beliefs influence attitudes, which in turn lead to intentions, and then generate behaviors. TAM assumes that beliefs about usefulness and ease of use are always the primary determinants of IT/IS adoption in organizations. According to TAM, these two determinants serve as the basis for attitudes toward using a particular system, which in turn determines the intention to use, and then generates the actual usage behavior. Perceived usefulness is defined as the extent to which a person believes that using a system would enhance his or her job performance. Perceived ease of use refers to the extent to which a person believes that using a system would be free of mental effort (Davis, 1989). A key purpose of TAM is to provide a basis for discovering the impact of external variables on internal beliefs, attitudes, and intentions. The TAM model is provided in Figure 1.

Throughout the years, TAM has received extensive empirical support through validations, applications, and replications for its power to predict use of information systems (i.e. Davis, 1989; Davis et al., 1989; Davis, 1993; Davis and Venkatesh, 1996; Mathieson, 1991; Taylor and Todd, 1995; Venkatesh, 1999; Venkatesh and Davis, 1996; Venkatesh and Morris, 2000; Horton et al., 2001). On the other hand, researchers have also recognized that the generality of TAM fails to supply more meaningful information on users' opinions about a specific system. There is the need for TAM to incorporate additional factors or integrate with other IT acceptance models for improvement of its specificity and explanatory utility (i.e. Agarwal and Prasad, 1998; Hu et al., 1999; Mathieson, 1991).

Apart from examining determinants of IS adoption, a second line of research has examined the adoption and usage of information systems from the perspective of innovation diffusion (Rogers, 1983). Compared to TAM, this line of research pays more attention to specific settings and external factors that influence technology adoption. A typical example is the theory of planned behavior (TPB) developed by Ajzen (1985, 1991). It was proposed that in addition to attitudes toward use, subjective norms, and perceived behavioral control such as skills, opportunities, and resources needed to use the system, also influence behavior. TPB provides more specific information that can better guide development (Mathieson, 1991). Taylor and Todd (1995) further extended and integrated TAM and TPB by establishing a decomposed TPB. This model incorporates additional factors that are not present in TAM, but have been shown to be important determinants of behavior. The decomposed TPB is seen as implementing TAM and providing a more complete understanding of usage (Taylor and Todd, 1995).

Meanwhile, Davis and his colleagues (i.e. Davis, 1993; Davis and Venkatesh, 1996;
Venkatesh and Davis, 2000) have been validating and extending the TAM model under different situations to make it more explanatory. A number of modified TAM models were also proposed recently by other researchers to suit new technologies including Internet, intranet and World Wide Web (i.e. Agarwal and Prasad, 1998; Chau, 1996; Chau and Hu, 2001; Horton et al., 2001; Hu et al., 1999; Jiang et al., 2000). The literature reviewed so far is more or less related to the model to be developed in this paper. Table I summarizes the important studies concerning TAM. Studies are selected based on close relationship to TAM, additional contributions, and frequent citations in the literature.

While acceptance of IT/IS has received fairly extensive attention from previous research, the literature reveals no rigorous effort exploring the factors that influence user intention to accept WIMD. Further, the TAM model was originally created to examine IT/IS adoption in organizations. The suitability of the model for predicting general individual acceptance needs to be explored. The proposed TAM for wireless Internet integrates the constructs with generic technology acceptance values from the TAM model. It also includes the constructs with unique values (such as technology complexity and wireless trust environment) for identifying user acceptance of wireless Internet. Therefore, the proposed model is an attempt to fill in the gap in the IS/IT literature.

3. Conceptual framework and propositions

In the present model, user acceptance is examined by attitude toward use and intention to use rather than actual use due to the fact that WIMD is still at an early stage, characterized by limited adoption and use. At this stage, investigation of intention to use would enhance the predictive power of the present model. Since the intention construct and the relationship to actual adoption has been well discussed in the original TAM model and other related studies (e.g. Agarwal and Prasad, 1999; Chau and Hu, 2001), our proposed TAM for wireless Internet model will concentrate on the theoretical rationale for the other constructs and their causal relationships in the model.

Attitude toward WIMD

Attitude has long been identified as a cause of intention. Psychologists have discussed the theoretical construct of attitude for decades. Attitude in Fishbein and Ajzen’s (1975) paradigm is classified into two constructs: attitude toward the object and attitude toward the behavior. The latter refers to a person’s evaluation of a specified behavior. This evaluation of a specified behavior leads to certain behavioral intention that further results in certain behavioral action. Adapting this general principle, attitude toward use in the TAM model is defined as the mediating affective response between usefulness and ease of use beliefs and intentions to use a target system. In other words, a prospective user’s overall attitude toward using a given system is an antecedent to intentions to adopt (Davis, 1989). In user participation research, it is also believed that prior to system development, users are likely to have vaguely formed beliefs and attitudes concerning the system to be developed (Hartwick and Barki, 1994). For the same reason, in consumer research attitude is the construct that receives most attention and is used most widely for predicting consumers’ likelihood to adopt a new technology (Erevelles, 1998).

Pragmatically, consumers today have been exposed to a number of technology innovations. They are likely to have formed favorable or unfavorable attitude about them irrespective of whether they have actually used the product in question. Wireless Internet via mobile devices as a system innovation is still in its infancy. Large numbers of users simply do not exist in many countries and regions. Investigation of attitude toward using WIMD and identification of its relationship with intention to use is more appropriate and practically valuable for predicting usage behavior. Therefore, we postulate the following proposition: P4. Attitude toward WIMD will have a significant positive effect on intentions to use WIMD.

Perceived short-term and long-term usefulness of WIMD

Perceived usefulness in the TAM model, originally referred to job related productivity, performance, and effectiveness (Davis, 1989).
<table>
<thead>
<tr>
<th>Studies</th>
<th>Research purposes</th>
<th>Sample</th>
<th>Factors/constructs developed/ tested</th>
<th>Results</th>
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</table>
| Davis (1989) | Develops and validates perceived usefulness and perceived ease of use | 152 industrial users of four application programs | 1. Perceived usefulness  
2. Perceived ease of use  
3. Self reported system usage | Both usefulness and ease of use were significantly correlated with usage. Perceived usefulness had a significantly greater correlation with usage behavior than did ease of use. Perceived usefulness strongly influenced intentions; perceived ease of use had a small but significant effect on intentions; attitudes only partially mediated the effects of these beliefs on intentions. Both TAM and TPB predicted intention to use an IS quite well. TAM is easier to apply, but only supplies very general information. TPB provides more specific information that can better guide development. |
| Davis et al. (1989) | Predicts people's computer acceptance from a measure of their intentions, and explains intentions | 107 full-time MBA students | 1. Intention to use  
2. Attitudes  
3. Subjective norms  
4. Perceived usefulness  
5. Perceived ease of use | The results in Davis' study (1989) were confirmed. The relationship between usefulness, ease of use and usage is influenced by whether the use is mandatory or voluntary. Perceived usefulness was 50 per cent more influential than ease of use in determining usage. Design choices influence user acceptance. |
| Mathieson (1991) | Comparing TAM with TPB | 163 senior and junior students | 1. Ease of use  
2. Usefulness  
3. Attitude  
4. Subjective norms  
5. Behavioral control  
6. Intention to use | |
| Adams et al. (1992) | To replicate Davis' study on the relationship between ease of use, usefulness, and system usage | 118 respondents from 10 organizations | 1. Usefulness  
2. Ease of use  
3. Usage | |
| Davis (1993) | System characteristics, user perceptions and behavioral impacts | 112 professionals and managerial employees | 1. System design features  
2. Perceived usefulness  
3. Perceived ease of use  
4. Attitude toward using  
5. Actual system use | All TAM, TPB, and the decomposed TPB performed well in terms of fit and roughly equivalent in their ability to explain behavior. The decomposed TPB provides a fuller understanding of behavioral intention by focusing on the factors likely to influence systems use through use of both design and implementation strategies. |
2. Peer influence  
3. Superior's influence  
4. Self efficacy  
5. Resource facilitating conditions  
6. Technology facilitating conditions  
7. Perceived usefulness  
8. Ease of use  
9. Attitudes  
10. Subjective norms  
11. Perceived behavioral control  
12. Behavioral intention  
13. Usage behaviors | The tested model confirms the effects of individual, organizational, and system characteristics on perceived ease of use and perceived usefulness, confirms the influence of perceived ease of use on perceived usefulness, and the effects of perceived usefulness on perceived usage and variety of use. |
| Igbaria et al. (1995) | Develop and test an integrated conceptual model of computer usage | 214 part-time MBA students | 1. User training  
2. Computer experience  
3. Organizational support  
4. End user support  
5. System quality  
6. Perceived ease of use  
7. Perceived usefulness  
8. Perceived usage  
9. Variety of use | (continued) |
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<tr>
<th>Studies</th>
<th>Research purposes</th>
<th>Samplea</th>
<th>Factors/constructs developed/testedb</th>
<th>Results</th>
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<tbody>
<tr>
<td></td>
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<td>administrative</td>
<td>2. Long-term usefulness</td>
<td>Perceived long-term usefulness also exerted a positive, but lesser impact. No significant, direct</td>
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<td></td>
<td></td>
<td>staff</td>
<td>3. Ease of use</td>
<td>relationship between ease of use and behavioral intention.</td>
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<td>4. Behavioral intention to use</td>
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<tr>
<td>Agarwal and</td>
<td>Examines relationship between innovation characteristics and perceived Web</td>
<td>73 MBA students</td>
<td>1. Innovation characteristics (including relative advantage and ease of use)</td>
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<td>Prasad (1997)</td>
<td>voluntariness, and acceptance behavior</td>
<td>with access to</td>
<td>2. Perceived voluntariness</td>
<td>Innovation characteristics are related to adoption behavior. User perceptions are</td>
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<td></td>
<td></td>
<td>World Wide</td>
<td>3. Current use</td>
<td>instrumental to substantial proportion of variance in current use and future intentions to use.</td>
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<tr>
<td>Agarwal and</td>
<td>Proposes a new construct, personal innovativeness in the domain of IT</td>
<td>175 business</td>
<td>4. Future use</td>
<td>Ease of use did not appear to be an important determinant of current use</td>
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<td>Prasad (1998)</td>
<td></td>
<td>professionals in a part-time MBA program</td>
<td>5. Intentions</td>
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<td>1. Relative advantage</td>
<td>The construct of personal innovativeness was validated to identify early adopters of IT/IS when</td>
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<td>2. Ease of use</td>
<td>resources are limited</td>
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<td>3. Compatibility</td>
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<td>4. Personal innovativeness</td>
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<td></td>
<td>5. Computer playfulness</td>
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<td></td>
<td>6. Intention to use</td>
<td></td>
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<tr>
<td>Agarwal and</td>
<td>Examines relationship between individual differences and IT acceptance</td>
<td>230 users of an IT innovation</td>
<td>1. Individual differences</td>
<td>Individual level of education, prior similar experience, training, and role with technology</td>
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<td>Prasad (1999)</td>
<td></td>
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<td>2. Perceived usefulness</td>
<td>have significant influences on TAM’s beliefs</td>
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<td>3. Ease of use</td>
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<td>4. Attitude</td>
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<td></td>
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<td></td>
<td>5. Behavioral intentions</td>
<td>TAM is a valuable tool for predicting attitudes, satisfaction, and usage from beliefs and external</td>
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<tr>
<td>Al-gahtani</td>
<td>Tests and develops TAM model</td>
<td>329 final year</td>
<td>1. Course</td>
<td>variables. Relative advantage of the system contributed most to attitudes and satisfaction</td>
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<td>and King (1999)</td>
<td></td>
<td>university students in UK</td>
<td>2. Computer experience</td>
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<td>Hu et al.</td>
<td>The applicability of the TAM model in explaining physicians’ decisions to accept</td>
<td>421 physicians</td>
<td>3. Training</td>
<td>Perceived usefulness as a significant determinant of attitude and intention. Perceived ease of use</td>
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<td>(1999)</td>
<td>telemedicine technology</td>
<td>from Hong Kong hospitals</td>
<td>4. Support</td>
<td>was not. Need for incorporating additional factors or integrating with other IT acceptance models</td>
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<td></td>
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<td>5. Image</td>
<td>to improve TAM’s specificity and explanatory utility.</td>
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<tr>
<td>Jiang et al.</td>
<td>A modification of a TAM model to describe usage behavior</td>
<td>335 students from USA, Hong Kong and France</td>
<td>6. Compatibility</td>
<td>Utilization of the Internet positively related to perceived near and long-term usefulness, prior</td>
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<td>(2000)</td>
<td></td>
<td></td>
<td>7. System rating</td>
<td>experience, and facilitating conditions. The external factors had more substantial impact on</td>
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<td></td>
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<td>8. Relative advantage</td>
<td>utilization of the Internet</td>
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<td>9. Enjoyment</td>
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<td>10. Ease of use</td>
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<td>11. Attitude</td>
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<td>12. Satisfaction</td>
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<td>13. Usage</td>
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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Chau and Hu (2001)</td>
<td>Compare TAM, TPB, and a decomposed TPB models</td>
<td>400 physicians in public tertiary hospitals in Hong Kong</td>
<td>1. Behavioral intention &lt;br&gt; 2. Attitude &lt;br&gt; 3. Subjective norms &lt;br&gt; 4. Perceived behavioral control &lt;br&gt; 5. Perceived usefulness &lt;br&gt; 6. Perceived ease of use &lt;br&gt; 7. Compatibility</td>
<td>TAM and TPB have limitations in explaining technology acceptance by individual professionals. Instruments repeatedly tested in previous studies among end users in business settings may not be equally valid in a professional setting</td>
</tr>
<tr>
<td>Horton et al. (2001)</td>
<td>Application of TAM in explaining intranet usage</td>
<td>466 employees from two UK companies</td>
<td>1. Perceived usefulness &lt;br&gt; 2. Perceived ease of use &lt;br&gt; 3. Intention to use &lt;br&gt; 4. Self-reported usage</td>
<td>Perceived usefulness, perceived ease of use, and intention to use were implicated as being predictive of intranet use. TAM more suitable for modeling intranets in organizations with constrained information requirements and a structured work organization</td>
</tr>
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</table>

Notes: "Sample was from the United States in no country information was given; *Factor in italics was developed the first time."

This is an important belief identified as providing diagnostic insight into how user attitude toward using and intention to use are influenced – perceived usefulness has a direct effect on intentions to use over and above its influence via attitude (Davis et al., 1989; Davis, 1993; Taylor and Todd, 1995). Incorporating concepts used in expectancy theory, Triandis (1980) proposed that an important factor influencing behavior is the expected consequences of the behavior. In the context of user acceptance, the concept of perceived usefulness is, therefore, expanded to include both near-term consequences and long-term consequences. Improvement in productivity, effectiveness, job performance or satisfaction are considered attributes of near-term consequence. Triandis' explanation for near-term consequence is equivalent to the perceived usefulness in TAM. Long-term consequence refers to consequential result in one's career prospects or social status. This definition of long-term consequence reflects the concept of image in Rogers' (1983) diffusion of innovations. Rogers argued that the desire to gain social status is a most important
motivation for adopting an innovation. Decomposing usefulness explicitly into near-term and long-term provides more insightful information in understanding user perception of usefulness.

Along this stream of thought, Chau (1996) split the construct of perceived usefulness in his modified TAM model into two parts: perceived near-term usefulness and perceived long-term usefulness. He hypothesized that behavioral intention to use a particular technology is dependent on the above two variables as well as on perceived ease of use. The empirical findings supported his hypothesized relationships between perceived near-term and long-term usefulness, and intention to use. The relationship between perceived near-term and long-term usefulness and attitude to use was not investigated here in order to simplify the model.

Based on Chau's modified TAM model, Jiang et al. (2000) developed utilization of the Internet technology model to explore user acceptance of Internet. Testing the utilization of the Internet technology model confirmed that utilization of the Internet is positively related to perceived near-term usefulness and perceived long-term usefulness. However, the utilization of the Internet technology model only investigated the use of the hardwired Internet. The research interest was centered on actual usage, rather than attitude and intention to use.

It will be interesting to see if their findings can be confirmed in the use of WIMD, and if attitude toward using is determined by both near-term and long-term usefulness. Thus, we propose the following:

P2. Perceived near-term usefulness of WIMD will have a significant positive effect on attitude toward using WIMD.

P3. Perceived long-term usefulness of WIMD will have a significant positive effect on attitude toward using WIMD.

P4. Perceived near-term usefulness of WIMD will have a significant positive effect on intentions to use WIMD.

P5. Perceived long-term usefulness of WIMD will have a significant positive effect on intentions to use WIMD.

Perceived ease of use
Perceived ease of use is another major determinant of attitude toward use in the TAM model. This internal belief ties to an individual's assessment of the mental effort involved in using a system (Davis, 1989). Perceived usefulness and perceived ease of use are distinct but related constructs. Improvements in perceived ease of use may contribute to improved performance. Since improved performance defines perceived usefulness that is equivalent to near-term usefulness, perceived ease of use would have a direct, positive effect on perceived near-term usefulness. Davis (1989) once proposed to test the generality of the observed usefulness and ease of use tradeoff and to assess the impact of external interventions on these internal behavioral determinants. The empirical research findings are, however, mixed (Davis et al., 1989; Davis, 1993; Chau, 1996; Venkatesh, 1999).

On the other hand, quite a few empirical studies confirmed the effect of ease of use on attitude toward use (e.g. Al-Gahtani and King, 1999; Lu and Gustafsen, 1994; Moore and Benbasat, 1991; Venkatesh and Davis, 1996). Venkatesh (2000) believes that for any emerging IT/IS, perceived ease of use is an important determinant of users' intention of acceptance and usage behavior. Even though Chau (1996) excluded the original construct of perceived ease of use in his modified TAM model, he also admitted that in the exploratory state of technology use, ease of use plays an important role. This point was also supported by a recent survey done in Europe. A mail survey by Embedded Solutions among 800 professionals in England in 1999 found ease of use among the top five factors in order of significance for determining use of wireless handheld devices (Clarke, 2000).

Consequently, to better explain perceived usefulness and the attitude toward using WIMD, we propose the following propositions:

P6. Perceived ease of using WIMD will have a significant positive effect on attitude toward using WIMD.

P7. Perceived ease of using WIMD will have a significant positive effect on perceived near-term usefulness of WIMD.

System complexity
The literature has already revealed that characteristics of wireless mobile systems link
directly to issues concerning user demand (e.g. Beaulieu, 2002; Bergeron, 2001; Burnham, 2002; Coyle, 2001; Dorman, 2001). To study the impact of the typical wireless mobile technology on user intentions to accept WIMD, we propose a conceptual construct, system complexity. The impact of system characteristics has been widely recognized in system and technology user acceptance research. Davis et al. (1989), for example, proposed that system characteristics exhibit indirect effects on usage intentions or behaviors through their relationships with perceived usefulness and perceived ease of use. This impact of system characteristics has been tested and supported across a number of studies (e.g. Davis et al., 1989; Davis, 1993; Hong et al., 2001).

WIMD is a network of radio-connected devices and servers offering voice, information, and other Internet services (Beaulieu, 2002). WIMD has its own complexity that is different from what has been discussed in the technology user acceptance research. Therefore, to identify the influence of WIMD on user beliefs, its unique features need to be specified.

WIMD system complexity can be defined as the degree of integration between wireless Internet and mobile technologies supporting various communications and services. Operationally, it could be examined in four facets: efficiency of data transfer; system functionality; interface design; and mobile device capacity. Effectiveness of WIMD largely depends on efficiency of data transfer on the system (Clarke, 2000; Macker et al., 2001; Varshney and Vetter, 2001). WIMD has some unique functions that provide special Internet services of its own, in addition to supporting a variety of information services and business applications (Burnham, 2002; Coyle, 2001; Weisman, 2000). Currently, the mobile devices for accessing wireless Internet all provide small screens. The smaller the screen, the less information is displayed at any one time. The user interface, therefore, becomes central in application delivery (Bergeron, 2001; Regis, 2001). Mobile devices currently serve as entry points into the wireless Web, carrying with them their own capabilities and limitations (Beaulieu, 2002; Bergeron, 2001; Raisinghani, 2001). Each aspect serves as an indispensable part of the entire WIMD system complexity. Any aspect may have some impact on users’ satisfaction of performance and mental effort, which in the long run would shape their overall impression of usefulness and importance of WIMD. Therefore, we propose them as critical system determinants of both perceived usefulness and perceived ease of using WIMD.

Pha. Technology complexity will have a significant effect on both perceived near-term usefulness and perceived long-term usefulness of WIMD in terms of efficiency of data transfer, interface design, system functionality, and mobile device capacity.

Phb. Technology complexity will have a significant effect on perceived ease of using WIMD in terms of efficiency of data transfer, interface design, system functionality, and mobile device capacity.

Individual differences
Research indicates that the success of an IT/IS innovation implementation depends as much on individual differences as on the technology itself (Harrison and Rainer, 1992; Nelson, 1990; Zmud, 1979). The theoretical relationship between individual differences and their beliefs are also discussed in social psychology and learning theories. Prior experience has long been regarded a factor identifying individual differences in technology acceptance research (e.g. Igbaria et al., 1995, 1989; Zmud, 1979). In consumer research, it is believed that past experience of using similar technologies contributes greatly to favorable attitudes toward using a new technology and actual adoption (Dabhokar, 1992, 1996; Dickerson and Gentry, 1983; Korgaonkar and Moschis, 1987). In the MIS area, prior similar experience, such as computer or Internet use experience, was supported in several studies as strongly influencing intention to use or usage behavior of a specific system through perceived short-term and long-term usefulness (Chau, 1996; Jiang et al., 2000), and through perceived ease of use (Agarwal and Prasad, 1999). The future of wireless Internet has already arrived, but simply at different places at different points in time (Beaulieu, 2002). User experience with WIMD, therefore, varies greatly worldwide. Experienced users of mobile devices or wireless
Internet may likely be more skillful and used to WIMD. Thus, to explain user beliefs concerning usefulness and ease of use toward WIMD, prior experience has to be considered.

Personal innovativeness is another variable identified as influential on usefulness perceptions (Agarwal and Prasad, 1998). Personal innovativeness epitomizes the risk-taking propensity that is higher in certain individuals than in others. In general innovation diffusion research, it has long been recognized that highly innovative individuals are active information seekers of new ideas. They are able to cope with high levels of uncertainty, and develop more positive intentions toward acceptance (Rogers, 1983, 1995). Agarwal and Prasad (1998) defined personal innovativeness in the domain of information technology as the willingness of an individual to try out any new information technology. They postulated that individuals with higher level of innovativeness with respect to information technology are expected to develop more positive perceptions about the innovation in terms of advantage, ease of use, compatibility, etc., and therefore have higher intentions toward use of a new IT/IS. Personal innovativeness was found significantly related with perceived usefulness and intentions to use in Agarwal and Prasad's study (1998). WIMD by all means is an important IT innovation. Given the relative infancy of the technology under study, it is reasonable to assume that use of WIMD is not mandated. Potential adopters have the opportunity to use it of their own volition. Therefore, it is appropriate to include personal innovativeness as one individual variable in the current model to test its impact under new circumstances.

Gender is a neglected but important individual variable (Kwon and Zmud, 1987; Swanson, 1988). Venkatesh and his colleagues (Venkatesh and Morris, 2000; Venkatesh, Morris, and Ackerman, 2000) recently investigated gender differences in the overlooked context of individual adoption and sustained usage of technology in the workplace. They found gender an important determinant of short-term usage, and can be used to predict sustained usage behavior in individual adoption and sustained usage of technology in work places.

The literature also suggests that gaining a better understanding of age differences is important, particularly as it relates to user acceptance and usage of new information technologies. Age differences in information processing was identified as having an impact on workers' performance of computer-based tasks (Czaja and Sharit, 1998; Czaja et al., 2001). Morris and Venkatesh's study (2000) found that age has a direct effect on usefulness perceptions both the short term and long term.

Early adopters of new products are commonly thought to be young and male in most technology-led markets. According to Target Group Index (Target Group Index Europa Survey, 2000), in Germany, which has the lowest level of mobile phone ownership compared to other European countries, the market was split 60 percent men and 40 percent women. A recent survey conducted in the United Kingdom found that men spend more time on mobile phones than women (New Straits Times, 2002). This underlines the fact that less mature markets display greater bias in demographic distribution. The Italian mobile phone market was similarly male-dominated in 1999. The Target Group Index data show that most of these technophiles are between 15 and 34 years old except in Germany, where the largest proportion of early adopters was in the 35 to 44 year old age group.

Meanwhile, possible correlation between age, gender and income deserves adequate attention. In prior organizational behavior research, income has been shown to potentially confound observed gender and age differences. Specifically, older individuals are over-represented in categories of higher income, higher occupational positions, and higher educational qualifications (Morris and Venkatesh, 2000). Female gender is more related to lower income and poverty (Shaffer, 2002; Venkatesh and Morris, 2000). Even though income was not found to be a statistically significant influence of gender or age differences in technology adoption in work environments (e.g. Venkatesh and Morris, 2000; Morris and Venkatesh, 2000), the result may not be true in general individual adoption. In fact, income and social economic status have long been recognized to have a strong effect on technology adoption and diffusion. In some
rapidly developing countries and regions, stronger payment ability and higher income level is enabling more people to spend more on mobile phones (e.g. Xinhua, 2001; Hong Kong Imail, 2003). Recently, a good number of youth and teenage adopters of mobile phones found themselves unable to pay the bills (Colman, 2000, 2001) because of their lower income levels. On the other hand, a European survey in 2002 found that adult decision makers with a personal annual income of $77,240 are rapidly embracing new technology, with 26 per cent using a wireless application protocol mobile phone, 28 percent a handheld or palmtop computer and 22 percent (up from 7 percent in 2000) using a minidisc player (Crawford, 2002).

WIMD is a step further in technology than the mobile phone. Will gender and age bias identified in some studies and in mobile phone adoption in some countries repeat itself? Will income level get in the way of age and gender differences? Inclusion of these two factors in the present model will help to explore the individual differences which possibly impact user perceptions and further their attitude and intention to adopt.

P9a. Individual differences will have a significant effect on both perceived near-term and long-term usefulness of WIMD in terms of prior experience, individual innovativeness, gender, and age, controlling for income.

P9b. Individual differences will have a significant effect on perceived ease of using WIMD in terms of prior experience, individual innovativeness, gender, and age, controlling for income.

Facilitating conditions
Facilitating conditions originally provide two dimensions: resource factors (such as time and money needed) and technology factors regarding compatibility issues that may constrain usage. The argument is that when all other things are equal, behavioral intention and IT usage would be expected to be less likely as less time and money are available and as technical compatibility decreases (Taylor and Todd, 1995). In the context of workplace technology use, facilitating conditions are believed to include the availability of training and provision of support. This variable was tested in a number of technology acceptance studies, and empirical support was found for the proposed effect on perceived usefulness or perceived ease of use (Thompson et al., 1994; Taylor and Todd, 1995; Jiang et al., 2000; Venkatesh, 2000).

Facilitating conditions, however, are originally viewed as external controls related to the environment (Terry, 1993; Triandis, 1980). Behavior cannot occur if objective conditions in the environment prevent it (Triandis, 1980), or if the facilitating conditions make the behavior difficult (Thompson et al., 1994). Policies, regulations, and legal environment are therefore all conditions critical to technology acceptance. Wireless digital devices rely on radio frequency spectra allocated. Individuals who use their devices while traveling are dependent on international regulations and standardization of the physical and data-link layers of telecommunication. These have been identified as the greatest limitations at present (Zimmerman, 1999; Burnett, 2000).

Standardization of protocols and other regulations is still a goal to strive for in the future for the growth of wireless communication systems and digital network markets around the world (Burnett, 2000; Sanghiran and Takefuji, 2000). In a word, the possible impact of facilitating conditions on user perceived usefulness and ease of using WIMD can hardly be neglected. Thus, we have the following propositions:

P10a. Facilitating conditions will have a significant effect on both perceived near-term usefulness and perceived long-term usefulness of WIMD.

P10b. Facilitating conditions will have a significant effect on perceived ease of using WIMD.

Social influences
In Taylor and Todd’s study (1995), social influences were equivalent to subjective norm and defined as other people’s opinion, superior influence, and peer influence. Venkatesh and Davis (2000) later expanded social influences to include subjective norm and image as well. Image is derived from the research on diffusion
of innovations. Moore and Benbasat (1991) defined it as the extent to which use of an innovation is perceived as enhancement of one’s status in a social system. Davis and his colleagues (1989) believed that in some cases people might use a system to comply with others’ mandates rather than their own feelings and beliefs. Empirical support for the relationship between social norms and behavior can be found in many studies (e.g. Tornatsky and Klein, 1982; Venkatesh and Davis, 2000). Mobile users are usually in social situations. In front of another person, not only is speed important, but a sense of social image is considered critical for many. In Japan, young people treat smart-phones as new fashion items to show off in public. In China, 73 percent of the executive class in big cities owned mobile phones early in 1998 not only for their convenience but also as a symbol for social status (Samson and Hornby, 1998).

Considering the possible social influence on the WIMD users, the following proposition is developed:

P11. Social influences will have a significant effect on both perceived near-term and long-term usefulness of WIMD.

Wireless trust environment

As business marketers place greater emphasis on building long-term relationships with their customers, trust has assumed a central role (Viega et al., 2001; Garbarino and Johnson, 1999; Doney and Cannon, 1997). Trust is a complex social phenomenon that reflects technological, behavioral, social, psychological, as well as organizational aspects of interactions among various human and non-human agents. All business transactions require an element of trust, especially those conducted in the uncertain environment of electronic commerce (Lee, 1998).

There are two key ingredients of a wireless trust environment: security; and privacy. Wireless security must be seen in the broader context of Internet-based e-commerce systems to include confidentiality; authentication; and message integrity (Coyle, 2001). Compared to wired Internet, wireless Internet is exposed to greater danger of insecurity. Several things cause wireless vulnerability. The mobile devices, because of their limited computing resources, require different programming languages, protocols, encryption methods and security perspectives. Interception of wireless transmission is easier in the open air. Although the CDMA digital signals can be harder to intercept, it is not an impossible. Drive-by hackers with appropriate software can still launch an attack (Brewin, 2002). Furthermore, for a mobile user to communicate with an Internet Web site, a wireless data signal from the cell phone will eventually be converted into a wired signal. Once it becomes a wired signal, it is subject to the same interception vulnerabilities as all unencrypted communications on the Internet. Even though communications between the mobile phone and the service provider’s transmission equipment can be encrypted for confidentiality, without end-to-end encryption, wireless Internet sessions are as vulnerable as other unencrypted communications over the Internet (Lee, 2002). Note that a phone can be reprogrammed with the serial number of another phone to impersonate a genuine subscriber and consume paid services (Beaulieu, 2002).

To build consumers’ trust in the safety of using wireless devices for transactions, wireless transport layer security; public-key infrastructure, certificate authority, device independent smart card; and wireless biometric services have emerged as common solutions. Wireless transport layer security offers security features for wireless application protocols to deliver communications by using wireless devices. Public-key infrastructure uses public key cryptography to authenticate the sender of a message and to encrypt and decrypt messages to ensure security. Smart card and/or wireless biometric services provide a core authorization infrastructure to verify that only the authorized user is making the transaction.

Privacy concerns often arise with new information technologies such as the Web enabled mobile technology that supports enhanced capabilities for collection, storage, use, and communication of personal information (Webster, 1998; Milberg et al., 1995; Culnan, 1993). Recent reports of concerns about privacy on wireless Internet are
on the rise (Phillips, 2002; Green et al., 2000). According to a survey conducted by the Boston Consulting Group, nearly 75 per cent of US consumers are concerned about security and privacy in the wireless environment (Goldman, 2001). Therefore, it is impossible to translate the potential business applications of the wireless technology into viable business ventures without first setting up trustworthy online environments. In other words, wireless trust environment closely relates to long-term and near-term usefulness of WIMD. Thus, we propose the following proposition:

\[ P12 \] Wireless trust environment will have a significant effect on both perceived near-term and long-term usefulness of WIMD.

Based on the above discussions, a TAM for wireless Internet model, which depicts the relationships among the previously discussed constructs, is displayed in Figure 2. The names of the two newly invented constructs/factors are in italics.

The present model is developed in the context of the innovation represented by WIMD. Based on this model, an individual’s intention to use WIMD depends on both perceived near-term and long-term usefulness and attitude toward using, which is jointly determined by perceived near-term and long-term usefulness and perceived ease of use. Perceived near-term usefulness is also influenced by ease of use. External variables such as technology complexity, individual differences and facilitating conditions help to determine both perceived near-term and long-term usefulness and perceived ease of use. External variables such as social influences and wireless trust foster the perception of near-term and long-term usefulness.

4. Discussion and conclusion

TAM for wireless Internet proposes a framework for understanding, explaining and predicting factors that influence individual acceptance of WIMD. TAM for wireless Internet builds on such constructs in the original TAM model as intentions to use, attitude toward using, perceived usefulness, and perceived ease of use, and expands to include new factors. The integration of common TAM determinants should be helpful for confirming the existing results in a new situation. Also, the results of the proposed model can be compared to other relevant
models and hopefully can add to the existing knowledge of user acceptance.

In the present model, intention to use and attitude toward using are adopted as important decision variables to defer user acceptance of WIMD. It may dig deeper into the essence of how user acceptance of WIMD might take form. Under the circumstances of early WIMD permeation among general users, this model may assume certain pragmatic value of providing implications to guide large-scale implementation of WIMD products and services. A number of prior studies also adopted a similar approach (e.g. Sheppard et al., 1988; Venkatesh and Morris, 2000; Chau and Hu, 2001).

In addition, perceived usefulness is split into two sub-constructs in the present model: near-term usefulness and long-term usefulness. This modification reflects a significant change in Chau’s (1996) model and Jiang et al.’s (2000) model. The main objective here is to test the discovered significant relationships between these two sub-constructs in a wireless environment, and to provide a more comprehensive understanding of perceived usefulness.

A major difference in the present model, compared with other TAM-related research, is the addition of two new constructs—technology complexity and wireless trust environment. Our literature review reveals that WIMD is an innovative system with strong potential to support a variety of services and applications including m-commerce. This system has its unique features mainly reflected in terms of wireless technology complexity and the wireless trust environment. Inclusion of these two constructs is expected to provide an initial framework to guide exploration of information specific to large-scale implementation of WIMD.

Inclusion of the external factors such as individual differences, facilitating conditions, social influences, and the proposed relationships also elevates the proposed TAM for wireless Internet model up to a more comprehensive level to promote and facilitate future research concerning acceptance of WIMD. However, attention should be called to the fact that the proposed model does not include all factors influencing the actual adoption of WIMD. Therefore, the proposed model can be modified and improved through studies. Empirical testing of the propositions set forth in this paper serves only as the first step.

To operationalize the proposed TAM for wireless Internet model, four recommendations are put forward for consideration:

1. The proposed model is designed to predict acceptance of WIMD among individuals in general. To test the theoretical validity and empirical applicability of the model in general, individuals with access to WIMD products or services should be the target population. The literature reveals that WIMD went into civil and commercial use earliest in some European and Asian countries. People in those countries, therefore, may have more exposure to products and applications of WIMD. Selection of research subjects in any of those countries will probably yield more meaningful data for prediction purposes.

2. A general survey research design will be appropriate for acquiring self-reported data on each of the model constructs. Available evidence suggests that despite the possible inaccuracy involved with self-reported data in an absolute sense, it is usually the best possible and most appropriate approach for investigating decisions among individuals (Davis, 1993; Hartley et al., 1977).

3. In terms of instrument selection, a number of instruments and measurement scales which have been scrutinized and which have won strong empirical support for reliability and validity in prior studies can be adopted for testing the present model. However, adequate attention should be paid to revise the instruments to suit the present research purpose. Since those instruments and scales were originally created for student samples and business users in various organization contexts, it will be also valuable to explore their appropriateness with general individual user populations. To obtain data specific to WIMD, measurement instruments on system complexity and wireless trust environment have to be developed.

4. Structural equation modeling procedures can be used to test the model fitness, and
explore the possible relationships between the model constructs. Structural equation modeling procedures aim at explaining the structure or pattern among a set of latent (theoretical) variables, each measured by a set of manifest (observed or empirical) indicators (Joreskog and Sorbom, 1986, 1989; Diamantopoulos, 1994). These procedures have gained popularity in quite a few recently published MIS studies, especially in TAM related studies for model testing (e.g. Chau, 1996; Chau and Hu, 2001; Al-Gahtani and King, 1999). They proved to be robust in discovering underlying causes of the observed variables, and the causal relationships among the latent variables.

Although it is beyond the scope of this paper, additional efforts have been made by the authors to test a few newly invented constructs. Preliminary investigation among the employed MBA students in a southern regional university in the USA revealed that system functionality, interface design, data transfer speed and mobile capability all contribute to the complexity of wireless mobile technology. The construct of wireless trust environment was also supported. No doubt, more empirical studies are needed to examine the entire TAM for wireless Internet model and in different cultural settings to establish its predictive power. Hopefully, such empirical studies utilizing the proposed model will provide adequate predictive and explanatory power for WIMD acceptance, and yield insights into improving general user acceptance.

References


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Further reading
