Communications of the Association for Information Systems

Volume 8 Article 3

January 2002

Issues in Mobile E-Commerce

Peter Tarasewich
Northeastern University, tarase@ccs.neu.edu

Robert C. Nickerson
San Francisco State University, rnick@sfsu.edu

Merrill Warkentin
Mississippi State University, mwarkentin@acm.org

Communications of the Association for Information Systems

ISSUES IN MOBILE E-COMMERCE

Peter Tarasewich
College of Computer Science
Northeastern University
tarase@ccs.neu.edu

Robert C. Nickerson
College of Business
San Francisco State University

Merrill Warkentin
College of Business & Industry
Mississippi State University

ABSTRACT

Though many companies are still just beginning to grasp the potential uses and impacts of the Web and e-commerce, advances in technologies and their application continue. These advances often present various managerial and technological issues for individuals, companies, governments, and other entities. One significant area of technological advancement is the development of mobile e-commerce, which encompasses interactive business activities and processes related to a (potential) commercial transaction conducted through communications networks that interface with wireless devices. These systems provide the potential for organizations and users to perform various commerce-related tasks without regard to time and location (anytime from anywhere). This emerging mobile e-commerce environment presents a new set of issues. This paper identifies and categorizes some of these issues so that researchers, developers, and managers have a starting point for focusing their activities within the emerging m-commerce domain. Our examination finds categories that include technological (both client and infrastructure) issues, application issues, and areas for future research.

KEYWORDS: mobile, wireless, e-commerce, m-commerce, e-commerce environment issues

I. INTRODUCTION

While electronic commerce (e-commerce) continues to impact the global business environment profoundly, technologies and applications are beginning to focus more on mobile computing and the wireless Web. With this trend comes a new set of issues specifically related to *mobile* e-commerce. The purpose of this paper is to examine some of these issues so that researchers, developers, and managers have a starting point for focusing their efforts in this new domain.

Many definitions of mobile e-commerce, such as the one found in Mueller-Veerse [1999], focus on enabling business transactions through wireless devices. We apply a broader definition of e-commerce, found in Turban et al. [2002] and Adam et al. [1998], which encompasses a wide range of interactive business processes that occur before and after actual sales transactions. Electronic commerce is the electronic exchange (delivery or transaction) of information, goods, services, and payments over telecommunications networks. E-commerce activities include establishing and maintaining online relationships between an organization and its suppliers, dealers, customers, strategic partners, regulators, and other agents related to (or in support of) traditional delivery channels. [Warkentin, et al., 2001] Other activities include:

- product searches and comparisons by consumers;
- product information presentation and promotion by manufacturers and retailers;
- post-purchase customer support;
- communication between seller and shippers or banks; and
- other activities that are not directly related to the transaction itself.

DEFINITIONS

Mobile e-commerce (also called mobile commerce or m-commerce) is defined as all activities related to a (potential) commercial transaction conducted through communications networks that interface with wireless (or mobile) devices.

Mobile Devices are those devices that are used to connect the to mobile services. Current wireless devices include

- wireless phones,
- wireless-enabled handheld computers (so-called pocket, palmtop, and tablet computers),
- laptop computers,
- vehicle-mounted technologies, and
- personal message pager devices.

Mobile e-commerce can also be conducted using portable non-wireless mobile devices, such as

- personal digital assistants (PDAs) and
- laptop computers

that can interface with other devices and networks through wired synchronization, often using wired cradles or infrared “beaming.” We do not consider this form of mobile e-commerce in this paper principally because it is likely to be replaced by a (non-infrared) wireless form in the future. Our focus here is on mobile commerce conducted by means of wireless devices.

By an **issue**, we mean an idea, topic, problem, or other matter that is open to discussion or dispute [*American Heritage Dictionary of the English Language, 3rd ed.*], or a question to be disputed or decided [*Webster’s New World Dictionary of the American Language*]. An issue may be resolvable by conducting research processes or by other exploratory means, or it may be future-directed and, therefore, only resolvable with the passage of time. Thus some issues lead to research studies and others lead only to speculation.

GOAL OF THIS PAPER

The goal of this paper is to present and categorize a number of possible issues in mobile e-commerce that others can investigate or on which others may speculate. We do not claim that our list of issues is exhaustive; indeed, we hope that it will lead to investigations that may result in new issues being identified. In addition, we do not claim that all the issues in our list are of equal importance; some may be determined to be very important while others may be deemed to be of little significance in the future. We are planning future research to investigate the exhaustiveness of our list and the relative importance of the issues in the list. Furthermore, we do not attempt to

present extensive insights into the resolution of the issues. Indeed, meaningful discussion of such insights could legitimately constitute an entire paper for each of the issues we present.

The methodology that we use to identify issues is a review of the nascent literature of mobile e-commerce found in both academic and trade publications. E-commerce itself became of practical importance in the mid-1990s, although it has produced an extensive body of literature. M-commerce started to show itself in a limited way in the late 1990s. Some research articles in academic journals related to m-commerce appeared recently, and many trade magazines "jumped on the bandwagon" and published practitioner-oriented articles related to this topic. We reviewed many of the relatively small number of academic articles and some relevant trade articles in preparing this paper.

VISIONS OF WIRELESS

An important starting point for our discussion is the *a priori* perspective on the mobile phenomenon. The two visions for wireless use of the Internet [Waters, 2000] to engage in e-commerce are:

1. Mobile devices belong to one category of the many points of access to the existing Web and Internet. Proponents of this perspective suggest that wireless technologies present an alternative way to interact with a traditional Web site, albeit in a different format or on a more limited or constrained basis.

2. A more radical vision says that wireless use of the Internet is something completely new and fundamentally different. The interaction style is unique (due to the constraints of smaller screen sizes, lack of color, limited or nonexistent keyboards, and other limitations of the devices) and the content of the communication is also unique (due to the current bandwidth constraints imposed by public frequency limitations).

Because mobile devices, by their nature, are better suited for bandwidth-limited applications, such as sending text e-mail and requesting stock quotes, than for more demanding applications, their usage patterns differ from those of traditional desktop computers. Furthermore, their nearly ubiquitous availability enables direct software support and information access for many new business functions in real time that were previously unsupported by IT because these tasks were performed remotely. Many portals, brokerage firms, and other organizations seem to be adopting this second vision over the first, as evidenced by a proliferation of text-only applications that possess streamlined or limited communication and interaction capabilities. These applications are usually provided through specific service-providers, or through special wireless-enabled servers divorced from an organization's traditional (wired) Web presence.

Ubiquitous computing technologies are also part of the emerging wireless environment [Tarasewich and Warkentin, 2002]. Ubiquitous computing systems place computing devices everywhere; they will be so prevalent that they will blend into the background. Technology for sensing, processing, and presenting information will be embedded in many everyday devices, such as home appliances and building materials [Estrin et al., 2000; Warkentin, 2001]. Sensors will be able to transmit data constantly from anywhere, while global positioning systems and proximity detection technologies will enable the tracking of devices as they move. In some instances, these embedded sensors will automatically respond to changes in their environment, a concept known as proactive computing [Tennenhouse, 2000]. In this vision, device-to-device communication networks [Warkentin, 2001] will use wireless and other technologies to link traffic systems, appliances, and countless other devices into a highly complex, real-time network that will rationalize the systems that support all our activities. This vision is also called "transparent computing" [Charny, 2000].

ORGANIZATION OF THIS PAPER

This paper is organized as follows. Section II reviews the literature related to our research. Section III defines wireless technology issues, including those related to mobile devices and communications infrastructures that are currently used for mobile e-commerce. Section IV examines issues related to applications used to solve specific mobile e-commerce problems.

Section V looks at issues relevant to the global use of m-commerce. The final section provides additional discussion on the issues and questions for future research endeavors. Appendix A lists the companies mentioned and their URL's.

II. RELATED RESEARCH

A number of papers review various aspects of mobile e-commerce. Among others, Mueller-Veerse [1999] provides an extensive review of m-commerce technologies and applications, and Varshney et al. [2000] examine m-commerce applications in detail. These papers, however, as well as others cited in the remaining sections of this paper, discuss what exists or is planned but do not discuss mobile commerce issues.

A few papers have addressed various mobile commerce issues. Kannan et al. [2001] present a series of propositions that are related to marketing and marketing research issues of mobile e-commerce. Varshney and Jain [2001] discuss several issues related to fourth generation wireless networks. Varshney and Vetter [2001] examine some issues while presenting a framework for mobile commerce applications. Siau et al. [2001] look at several m-commerce technology issues from both the device and infrastructure perspectives. No paper that we are aware of, however, provides a comprehensive list or categorization of the issues.

Issues research papers appear periodically in the information systems literature, often when a new field comes to the forefront. For example, several papers on issues related to global information systems, such as Deans et al. [1991], were published in the 1990s. A number of papers present an analysis of key issues in the information systems field in general, including Brancheau et al. [1996], Palvia et al. [1996], and Cule and Senn [1995]. None of these papers, however, addresses issues in mobile commerce.

III. MOBILE E-COMMERCE TECHNOLOGY ISSUES

Mobile e-commerce technology issues can be categorized into those related to:

- mobile clients,
- communications infrastructure, and
- other technology.

MOBILE CLIENT ISSUES

Mobile clients (sometimes called mobile commerce terminals) are those devices and their client software used by individuals to communicate with wireless communications networks. The issues related to mobile clients primarily center on hardware and software technology.

1. What physical form or forms will mobile devices ultimately take?

The devices currently used most commonly for mobile clients are mobile telephones, handheld computers, laptop computers, and vehicle-mounted devices. Hybrid devices are appearing, such as the combinations of mobile phones and handheld devices (sometimes called smartphones) under development by Sendo, using Microsoft's "Stinger" Smartphone platform, and by Kyocera, Kyocera, using Palm's operating system.[1] Another example is mobile telephones that integrate players for MP3 files, which can also stream MP3 music from servers using wireless access. Disposable mobile phones are currently available and disposable laptop computers are under development by Dieceland. Many laptops are expected to have wireless

[1]Unless otherwise noted, all products identified in this paper were available or announced in December 2001 and all firms were in business at that time. URLs are listed in Appendix A.

capabilities built into them. Companies such as France Telecom and IBM are developing wireless watches. An "atomic clock" (under $20) and atomic watches continuously receive the WWVB 60 KHz broadcast signal, controlled by the real atomic clock operated by the National Institute of Standards and Technology (NIST) with the exact time (including daylight saving time) so that the time displayed is always precisely accurate [Meissner, 2001]. Automobiles will have dash-mounted Web consoles and airplanes will have Internet access while in flight. Dertouzos [1999] suggests that convergence of these technologies will lead to generic interactive devices that will take the place of items such as televisions, pagers, radios, and telephones. How the diverse array of mobile client device types will evolve in the future and what types will ultimately become dominant are unknown.

2. How should the personalization of information presented to the user on a mobile client be controlled?

Information viewing can be personalized for the user either on a single wireless device or across multiple devices, thus giving users a consistent and familiar environment when going from one device to another. While the user can control personalization at the client, organizations may not want users reformatting data taken from their Web site before displaying it on their wireless devices. Whether to allow complete user control of such personalization or to limit it is a question that needs resolution.

3. Usability: What is the optimal design of the user interface on devices with physical limitations?

Handheld and phone devices differ from desktop and laptop computers in several ways, including smaller screen sizes and limited input capabilities. Many handheld devices display only a few lines of text and do not have traditional keyboards. Larger screens and the use of color can enhance usability but at the expense of battery life (although there is continuing research into new battery types). This classic trade-off is driving current design efforts as vendors try to offer both features – large color screens and longer battery life. QWERTY keyboards (with tiny chiclet-style keys) and traditional phone-layout keypads create further limitations to usability. Some mobile phones are beginning to appear without keypads. Voice interfaces also show potential for use with mobile clients, but currently have limitations including the need to train devices to recognize a user's voice, the relative slowness of voice versus other input means, and the exclusion of graphics or other visual information display. In addition, the dynamic nature of the m-commerce environment requires a focus on usability that goes beyond the device itself. The context of the application and the device must be taken into account [Johnson, 1998]. Some researchers are investigating sentient systems that change their behavior as their environment changes [Addlesee et al., 2001]. Whether existing principles of user interface design (e.g., Shneiderman, 1998) can be transferred to newer devices or whether new principles must be investigated is unclear [Nah and Davis, 2001]. A more detailed discussion of wireless/mobile device interface design and usability issues can be found in Tarasewich [2002].

4. Usability: How do we design applications for use on different mobile client devices?

Wireless devices differ not only from their larger counterparts but also from one another. The number of lines displayable on a screen, the availability of color screens, the keyboard format and layout (if one is even present), and the availability of special keys or buttons for screen navigation all vary considerably from one device to another. Even within a device class (such as Pocket PCs from Compaq, Casio, and HP) the differences in button function, screen resolution, and even processor manufacturer require different versions of many popular applications [Chan and Fang, 2001].

5. How do we create client software for mobile devices, such as operating systems, browsers, and e-mail software, with increased functionality?

Wireless devices force developers to carefully revisit operating systems and other types of resident software on a variety of platforms. Operating systems such as Symbian's EPOC were created to function using the limited amount of memory available in mobile phones. Other limited-function operating systems, such as Microsoft's PocketPC (formerly called Windows CE) and Palm's PalmOS, were developed for handheld devices. Symbian and Palm agreed to collaborate on technologies that could result in the eventual combination of the two operating systems. Special mobile Web browsers, such as Pocket Internet Explorer and Mobile Browser, were also created to function with smaller displays. Although current mobile device software meets some needs, its functionality is limikted. Whether functionally rich resident software can be created for mobile client devices is an unanswered question.

6. Which protocols or systems for mobile client device communication will be accepted?

The Wireless Application Protocol (WAP) enables wireless devices, such as mobile phones and handheld computers, to access the Internet [Bannan, 2000]. Many WAP-enabled devices are on the market , although, as discussed Section V, there is doubt as to whether WAP will become a globally accepted standard. Japan's wildly popular i-mode, produced by NTT DoCoMo, is a complete wireless system that includes its own protocol and services for its customers. It works only with specifically designed Web sites and does not truly access the Internet. I-mode's specialized protocols are based on compact HTML (cHTML), a subset of standard HTML. Other Web sites use Wireless Markup Language (WML), based on XML, that is not compatible with HTML and acts as a page description language within WAP [Herstad et al., 1998]. Still another language that can be used for viewing text portions of Web pages on wireless devices, but which is not based on XML, is Handheld Device Markup Language (HDML). Whether WAP, i-mode, or some other protocol or system will eventually dominate is an open question.

Table 1 summarizes the issues related to mobile e-commerce mobile client issues.

Table 1. Summary of Mobile E-commerce Mobile Client Issues

Issues:	**Relevant questions:**
• Ultimate form(s) of mobile client devices	• How will the diverse mobile client device types evolve in the future? What types will ultimately become dominant?
• Control of personalization of information presented on mobile client	• Should users have complete or limited control of personalization of information presented by organizations on their mobile clients?
• Design of user interfaces for mobile client devices	• Do existing user interface design principles apply to mobile client devices or must new principles be investigated?
• Design of applications for use on different mobile client devices	• Can applications be designed so that they will function similarly on different mobile client devices?
• Creation of resident software for limited mobile client devices	• Can operating systems, browsers, and other resident software be created that will provided increased functionality on limited mobile client devices?
• Acceptance of protocols or systems for mobile client device communication	• What protocol or system for mobile client device communication will ultimately dominate?

WIRELESS COMMUNICATIONS INFRASTRUCTURE ISSUES

The communications infrastructure necessary for mobile e-commerce is complex. Its technologies can be roughly divided into those that primarily support wireless local area networks (LANs) and those that are used for wireless telecommunications purposes. This paper does not explore all wireless communications technologies, standards, and protocols, but only those most relevant to mobile commerce. Further details on these technologies and others can be found in Varshney [1999] and Varshney and Vetter [2000].

Wireless Local Area Network Issues

1. How do we make efficient use of the limited bandwidth that is currently available?

Wireless networks lack the bandwidth of their wired counterparts. While researchers achieved some success in creating applications that can function efficiently in both mobile and stationary environments [e.g., Joseph et al., 1997], organizations still must rethink how users interact with an information system through a wireless device and its network. Applications that run well on a wired network may encounter new problems with data availability, processing efficiency, concurrency control, and fault tolerance when ported to a mobile environment. Data- and processing-intensive applications may need to be redesigned to function properly when communication speeds are limited and possibly inconsistent.

2. How will mobile devices interface with more than one communications environment?

IEEE 802.11 and IEEE 802.11b are established wireless standards commonly used with laptops or personal computers for local wireless communications. Bluetooth is a relatively new, inexpensive short-range wireless standard that allows various devices to communicate with one another in close proximity. HiperLAN is a set of wireless LAN standards primarily used in Europe. Some companies are beginning to equip public places such as airports with the capability for Internet access when a laptop has a suitable 802.11 wireless LAN card. Bluetooth-enabled devices are also appearing in public places and HiperLAN systems are found in some locations.

3.Will needed frequency spectrum be available?

As bandwidth demand increases for new and existing network applications, there may be problems with obtaining unused “airspace.” While frequency reuse is increasing, the availability of both frequencies and bandwidth may become more limited in the future.

4. Will communications technologies interfere with one another?

Different standards, such as Bluetooth, IEEE 802.11, and other standards using the same frequency range may interfere with one another. One type of interference occurs when a channel employing “frequency hopping” (for security) interrupts another channel when it briefly “steps on” the latter channel’s frequency. Whether such interference becomes problem remains to be seen.

Wireless Telecommunications Issues

Issues related to telecommunications are important in m-commerce because of the widespread use of mobile phones (the “bandwidth cram” problem). Many of the issues with wireless telecommunications technologies are similar to those found with wireless LANs. Older generation technologies result in distinct bandwidth limitations that make it difficult to develop efficient applications for all technologies. Standards vary from country to country, making it

difficult for devices to interface with networks in different locations. (There are no phones that handle all systems.) Frequencies are becoming crowded quickly.

5. How do we address compliance with various current and future standards and speeds found in mobile phones?

Currently, the three basic second-generation (2G) digital wireless telephone technologies are:

- Time Division Multiple Access (TDMA),
- Global System for Mobile (GSM), and
- Code Division Multiple Access (CDMA).

All these technologies are circuit-switched services. A user must dial in and maintain a connection to obtain data communications. GSM is the most widely used of the three technologies, especially in Europe, but the current speed of GSM is only 9.6 kilobits per second (Kbps).

In the future, this issue will become even more complex. Wireless telecommunications continued to evolve into the current state of so-called two-and-a-half generation (2.5G) technologies, some of which are being implemented. High-Speed Circuit-Switched Data (HSCSD) is a circuit-switched wireless data transmission for mobile users at data rates up to 38.4 Kbps. Enhanced Data GSM Environment (EDGE), a faster version of GSM, is designed for data rates up to 384 Kbps to enable the delivery of multimedia and other broadband applications. General Packet Radio Service (GPRS), which promises data rates from 56 to 114 Kbps, is a continuous packet data service that is "always-on," thus allowing mobile users to access the Internet without dialing in. Redesigning applications for this generation of technology will create additional problems.

Farther in the future, Universal Mobile Telecommunications System (UMTS) is projected to be the third-generation (3G) mobile phone technology. It offers broadband, packet-based transmission of text, voice, video, and multimedia at data rates that will reach 2 Mbps and greater. Based on GSM, UMTS is the planned global standard for mobile users. Once UMTS is fully implemented, computer and phone users can be attached continuously to the Internet and have access to a consistent set of services worldwide. Europe and Asia, however, will probably benefit from 3G wireless before the United States does [Redman, 2000].

6. Are businesses willing to pay the high initial cost of establishing the necessary wireless infrastructure?

During bandwidth auctions, European telecommunications companies bid US$46.2 billion in Germany alone for 3G licenses [Brewin and Sayer, 2000]. The cost of deploying the necessary communications hardware is in addition to the licensing cost. Some companies are not waiting for updated telecommunications technologies, and are purchasing data optimization software that can increase data transmission speeds significantly by using existing wireless connections [Bruzzese, 2001]. Unless businesses (and individuals) are willing to pay all the necessary costs associated with each generation, new technology may not be implemented.

Table 2 summarizes the issues related to mobile e-commerce communications infrastructure.

OTHER WIRELESS TECHNOLOGY ISSUES

1. Will users be able to maintain continuous contact when moving between locations and devices without losing services?

Table 2. Summary of Mobile E-commerce Communications Infrastructure Issues

Issues:	Relevant questions:
• Efficient use of limited bandwidth	• How can applications be designed so that they work efficiently in limited bandwidth situations?
• Difficulties with mobile devices interfacing with multiple communications environments	• Can mobile devices be created that will function with different communications systems?
• Spectrum and bandwidth availability	• Will there be enough frequencies and bandwidth available to handle demand for existing and new mobile commerce applications?
• Interference among technologies	• Will communications technologies interfere with one another?
• Addressing compliance with current and future mobile phone standards and speeds	• How can applications be designed or redesigned so that they function with different current and future mobile phone standards and speeds?
• Willingness of businesses to pay the high cost of establishing new wireless infrastructures	• Will businesses pay the costs associated with the implementation of each new generation of telecommunications technology?

Seamless transfer of the communications linkage will be necessary when moving from location to location and from device to device. Applications cannot be allowed to terminate simply because users change places or devices; they must exhibit operational continuity, "jumping" from place to place and following the user, without the user experiencing a break in service. Research with mobile software agents indicates that they can facilitate the movement of users from one device to another (e.g., Kotz et al., 1997). This problem must be solved in general, so that users will be assured that the technology functions acceptably.

2. How will wireless communications providers charge for the wireless connection?

Given the limitations of wireless devices over their wired counterparts, alternate revenue models must be considered for mobile device access. The advertising-based Web model may not work for the wireless Web due to small screen sizes with limited graphics capabilities. Basic monthly subscription models (used in the U.S. for services such as basic phone access and cable TV) may provide a simple solution, infrastructure firms may charge for usage, or a combination of these approaches (subscription plus pay-per-use for premium services or higher bandwidth) may be the approach widely adopted. Currently, most users are charged for wireless access by the minute. NTT DoCoMo's i-mode service charges, however, are based on the number of packets of data sent and received, along with a small monthly fee. (Some applications, such as interactive graphical games or mapping, may involve far higher data transmission rates than others, such as text messaging.) Other approaches such as e-mail advertising may prevail. Companies such as Streetbeam and adAlive are investigating the use of advertising billboards with PDA interactivity. These "active billboards" may function as a network of free Internet access points for wireless devices. The various methods of charging for wireless communications links must be examined carefully to determine the best approaches.

3. Will wireless information be secure?

Organizations that use wireless LANs must realize that there are no physical boundaries limiting the flow of data on their networks and that people and devices outside the organization may have (inadvertent) access to their systems. Users and their organizations, however, will want

assurance that their sensitive wireless communications and transactions are not intercepted. Certain methods may reduce the chances of unapproved access. For example, frequency hopping can make it more difficult to intercept data communications. Encryption technologies can also help ensure that even intercepted transmissions cannot be read easily, but they will need to be made more efficient and more foolproof. One leading company in the field of mobile commerce security is Sonera, which offers public key infrastructure (PKI) for mobile phones. Sonera, Ericsson, EDS, and other companies formed an alliance called Radicchio to promote PKI as the standard for m-commerce transaction security. More such initiatives may be needed to assure users and organizations that data is secure when transmitted over wireless networks. Ghosh and Swaminatha [2001] and Miller [2001] provide additional discussions on m-commerce and wireless security concerns.

4. Can viruses be managed?

Viruses may be an even greater impending threat to wireless devices than to current wired networks. The first large-scale virus attack on wireless phones occurred in 2000 [Brewin, 2000]. What makes this issue even more problematic is that hackers could use stolen wireless devices to create and disseminate a virus, after which the devices could be physically destroyed, making it almost impossible to trace the origin of the virus or to identify its creator.

5. Can we identify users positively?

The increased use of wireless devices for e-commerce makes positive user identity verification more important, yet more difficult to ensure. Organizations will want positive user identification to validate user transactions but doing so with limited devices may be difficult. One consequence of this need is the increasing importance of biometrics [Jain et al., 2000]. Future wireless devices may include a thumbprint or retinal scanning ID device or may use smart cards to store user authentication information. Whatever technology is adopted must not unduly intrude on the user's time and privacy.

6. Who should have control over location device data?

Location technologies, especially the Global Positioning System (GPS), will play a large role in wireless communications [Djuknic and Richton, 2001; Hightower and Borriello, 2001]. In 2000, President Clinton ordered the U.S. military to stop scrambling GPS satellite signals, allowing the geographic location of anyone in the world with a GPS to be determined to within about 10 meters. Other location technologies employ algorithms to triangulate from three or more cellular towers. With these technologies, organizations can determine where users are located, but access to this information must be controlled for the privacy of the user. Who should have such control, however, must be carefully examined. [Hamblen, 2001]

Table 3 summarizes the issues related to other mobile e-commerce technology.

IV. MOBILE E-COMMERCE APPLICATION ISSUES

A number of applications of wireless technologies for e-commerce are currently constrained by technology limitations and issues described in Section III. This paper does not provide a thorough review of m-commerce applications, but only examines those papers that illustrate the issues we raise. Sources for m-commerce application examples include Varshney and Vetter [2001], Varshney et al. [2000], Schwartz [2000], and Winer [2000]. Research papers on the feasibility of specific m-commerce applications are also appearing, such as Eklund and Pessi [2001], who study WineGuide, a geographically bound WAP-based recommendation service for wine and food.

Table 3. Summary of Other Mobile E-commerce Technology Issues

Issues:	Relevant questions:
• Need for seamless transfer between locations and devices	• How can mobile systems provide capabilities for users to move between locations and devices without losing continuous services?
• Method of charging for wireless connection	• What are the best ways to charge for wireless communications links?
• Security of data traveling over wireless networks	• How can users and organizations be assured that data is secure when transmitted over wireless networks?
• Virus management	• Can technology that minimizes the impact of viruses on wireless devices and networks be provided?
• Identification verification	• How can users be positively identified without undue intrusion on their time and privacy?
• Control of data related to device location	• Who should control access to device location data?

1. What tasks will users want to perform without regard for temporal or spatial constraints?

Many mobile e-commerce applications became available recently and new ones are being planned and developed. Varshney and Vetter [2001] list some categories of mobile applications including:

- Financial services
- Advertising
- Inventory management
- Product location and shopping
- Proactive service management
- Business reengineering
- Auction and reverse auction
- Entertainment
- Information-oriented services

Wireless systems allow using applications in these and other categories at any time from almost any location, but whether users want to do so for any specific application is not known.

2. How do we provide support for the desired tasks through wireless applications?

Examining this issue involves exploring different methods and metaphors for use in mobile e-commerce. For example, services can be provided through simple applications interfacing with mobile phones or through more complex applications connected to handheld computers. The development of mobile applications is also more challenging than the development of wired applications because mobile applications are contextual, are usually used in dynamic environments, and receive more limited attention from the user [Shen and Shen, 2001]. Because a desktop metaphor with folders, icons, and tabs, so common in the wired computer world, does not necessarily work well on limited mobile devices [Kristoffersen et al., 1998], a new metaphor may need to be found.

3. In wireless messaging services, how do we provide communication among users of different systems?

Mobile instant messaging is expected to become widely used as wireless communications move toward continuous packet services, such as GPRS [Mueller-Veerse, 1999]. Messaging services, such as AOL's Instant Messenger and Yahoo! Messenger, are being integrated into phone and handheld devices. NTT DoCoMo's wireless i-mode system allows millions of Japanese to send messages to one another [Reiss, 2000]. These services are needed not only for personal messages but also for commerce-related messages between customers and organizations. Users of different systems, however, cannot necessarily contact one another.

4. How do we gain social acceptance of using mobile devices in various locations or during specific events?

Ringing mobile phones and key tapping users are not appreciated by many people in public locations, such as theaters and restaurants. The Canadian government held a 90-day public comment period on whether or not to license technology that prevents inappropriate mobile phone use [Brewer, 2001]. The Canadian National Research Council is even funding research by Cell Block Technologies on a device that diverts cell phone calls into an unused channel (thereby blocking the calls). Whether legal or cultural barriers will limit the use of mobile devices in certain situations is unknown.

5. How do we make financial and other data used in mobile applications secure?

Mobile banking allows banks to offer customer services, such as account information and transactions, without the overhead of a brick and mortar location. Services such as Fidelity's InstantBroker™ provide wireless stock trading. Wireless devices (sometimes in conjunction with smart cards) are also beginning to be used for payments to merchants and for transfer of cash between devices. Wireless devices may eventually substitute for the array of membership and affinity program cards that many people carry in their wallets, a concept known as Mobile Dynamic Information Management [Mueller-Veerse, 1999]. Someday, a mobile device might contain passport and medical information. VirtualWallet and eWallet, two applications for PocketPCs, can hold (and beam) all kinds of sensitive information, including medical, personal, and financial information. Before any of these wireless applications will be fully accepted by users, financial and other data must be made secure.

6. What are the best ways to generate revenue?

This issue can be seen in the context of wireless entertainment. Mobile betting and gambling is available through wireless devices. Hong Kong's Jockey Club permits off-track wagering using mobile phones, and Blue Square in the UK provides sports betting over WAP-enabled devices. Revenue in these cases might be obtained through service charges, sponsorships, or commissions on the gambling wagers themselves. Other companies provide multi-player games that can be played from a phone or handheld device. NTT DoCoMo's i-mode allows its users to play games with distant partners, using Java and "i-appli" technology. Wireless-enabled PocketPC users can play one another in chess and other games remotely. Stockholm-based It's Alive developed location-based mobile games that work on WAP phones and on current GSM phones in Europe. Many new games are limited by the current graphics capabilities and bandwidth of wireless devices, but several companies have been successful with more "intellectual" games, such as poker and the text-based sports game 3Play from ESPN.com. These types of games and other entertainment services on mobile devices are expected to generate significant revenues from advertisers, sponsors, subscription fees, and usage charges [Kuchinskas, 2001], although the question of which combination of these revenue-generating techniques is best for these or any other wireless services remains unanswered.

7. How do we provide safety while using wireless technology in automobiles and other forms of transportation?

Telematics, such as the OnStar system, put distressed travelers in immediate contact with assistance and direct hungry travelers to the nearest appropriate restaurant. Traffic advisory systems can guide a driver to his or her destination or warn of impending traffic jams. Automobiles will eventually be able to report potential problems to service centers themselves before they become serious. The service center might make minor adjustments to the car online or contact the driver to bring in the car. An application developed in Great Britain helps drivers find an empty parking space. Newer car-mounted devices allow regular Internet access, but users do not consider safety when “browsing while driving”.

8. How do we respect user privacy in location-based applications?

Even without GPS, location identification with m-commerce applications may become possible. One proposed technology for bringing emergency call service (called Enhanced 911 or "E-911" in the United States) to mobile phone users will use triangulation from surrounding towers to identify the location of the individual using a wireless phone or Web device. This technology could not only direct emergency personnel to the scene but could also be used for e-commerce applications, such as directions to services and merchants, pizza delivery, and appropriate traffic information. The location of users can also be used to target market customers in commercial areas, such as grocery stores and shopping malls or when they are near a restaurant [Gopal, Nair, and Tripathi, 2001].

9. How do we address the lack of integrity of mobile data from multiple sources?

Many applications do not maintain a single source of data for mobile and non-mobile applications, nor do they allow direct sharing of data among devices and applications, which can result in a lack of integrity in the data. For “wireless Web” applications, organizations are transcoding (converting the content of) their current Web sites to make them useable with wireless devices [Kaasinen et al, 2000]. Companies such as AvantGo provide ways to let organizations supply content and applications to mobile devices, but only by going through secondary servers and clients.

10. How do we store data so that it is readily usable and accessible by mobile applications?

Extensible Markup Language (XML), which tags data and puts content into context, is one possible solution to this problem. Another is Relational Markup Language (RML), which acts as an intermediate format between languages, such as HTML and WML, and allows the automatic markup of all markup languages [Saha et al., 2001]. The output is generated without regard to the initial markup language. Other solutions may also exist, or be discovered, that work better in some situations.

11. How do we ensure the integrity of synchronized data among multiple devices?

When mobile clients are synchronized with other devices (such as desktop computers), changes (to calendars, for example) within each device are sent to the other devices according to rules of precedence. The current proliferation of non-interoperable synchronization technologies creates barriers to developing robust mobile commerce systems. A consortium of global technology firms, including wireless handset manufacturers, is developing a standard for synchronizing data between mobile client devices and other platforms. SyncML, a synchronization protocol based on XML, is designed to ensure that mobile phones, pagers, and other mobile devices can synchronize their data with network applications, desktop calendars, and other locations where information is stored [SyncML, 2001]. If SyncML is established as a universally recognized standard for data synchronization, then devices and systems that do not comply will become isolated among the otherwise interoperable technologies. Firms must determine whether the data standards they employ, and the communication of their data between various mobile devices, are such that data integrity can be ensured when synchronization is used with multiple mobile devices and platforms.

12. How do we develop complex, robust inter-organizational and intra-organizational applications that work well within current (and any foreseeable) device limitations?

While most initial mobile commerce applications seem to be aimed at the business-to-consumer market, business-to-business and intranet applications are also appearing. Wireless technologies and m-commerce can facilitate the redesign of organizational activities. Companies that use a just-in-time (JIT) manufacturing approach can track inventory through wireless transmitters and can also track the location of vehicles bringing materials to be processed. Vending machines or copy machines can be networked wirelessly and can call automatically for more supplies or maintenance. Service technicians can be assigned new tasks dynamically and sent problem information while they are traveling. Sales people can go literally anywhere in the field and access product information and customer accounts, although the applications right now are still subject to the constraints of current wireless devices, such as limited bandwidth, small screens, and a lack of standardization [Scheier, 2001]. All these mobile enterprise applications are complex, however, and developing them requires careful planning, analysis, design, and implementation.

Table 4 summarizes the issues related to mobile e-commerce applications.

Table 4. Summary of Mobile E-commerce Application Issues

Issues:	**Relevant questions:**
• Determination of tasks users want to do without regard to temporal and spatial constraints	• What applications do users want to use anytime from anywhere?
• Method of providing support for desired tasks through wireless applications	• What methods and metaphors are best for applications that interface with mobile devices?
• Communication between different messaging services	• How can different messaging services interface with one another?
• Appropriate use of devices and applications in social settings	• Will legal or cultural barriers limit the use of mobile devices in certain situations?
• Security of data used in wireless applications	• How can financial and other data be made secure in wireless applications?
• Identifying the best revenue generation technique	• Which combination of revenue generation techniques is best for different services?
• Safety while using wireless devices in vehicles	• Can "browsing while driving" be made safe?
• Protection of user privacy in location-based applications	• How can the privacy of the user be maintained in applications that identify the user's location?
• Addressing the lack of integrity of data from multiple data sources	• How can applications be designed so that data integrity is maximized?
• Storage of data for use and access by mobile applications	• What data storage techniques are best for data that is used by mobile applications?
• Ensuring the integrity of synchronized data among multiple devices	• How can data integrity be ensured when synchronization is used with multiple mobile devices and platforms in an organization?
• Development of complex, robust organizational applications within device limitations	• How can mobile enterprise applications be planned, analyzed, designed, and implemented?

V. MOBILE E-COMMERCE GLOBAL ISSUES

The global use of wireless technologies and applications adds another layer of complexity to the issues in m-commerce. This complexity derives from the legal, cultural, social, political, and technical differences among countries.

1. How does a firm operate within the current lack of standardization throughout the world?

Technologies continue to evolve and change on a daily basis worldwide. Mobile phone standards vary from country to country and even within a country. The implementation of WAP devices is slower than expected in Europe, and there are doubts as to whether it will become the accepted worldwide standard [Lewis, 2000]. One reason WAP is in doubt is the popularity of Japan's i-mode. NTT DoCoMo is planning to expand i-mode into Europe and North America with help from companies such as AT&T, KPN Mobile NV, America Online, and Microsoft [Reiss, 2000]. Third generation (3G) communication technologies are not yet implemented, and researchers are already planning the fourth generation [Varshney and Jain, 2001]. How global enterprises should address the various wireless communication standards around the world is an open question, and a critical one, for achieving competitive success.

2. How do businesses plan for the disparity in the adoption of wireless technologies and applications in different regions of the world?

The United States lags behind western Europe and Asia in terms of wireless technology. Japan already implemented the first 3G technologies, although on a limited basis, and western Europe should be next. The primary reason for the U.S. lag is that the United States has not experienced the same demand for increased mobile communication capacity as Europe and Japan [Mentrup, 2000]. Fewer Americans use wireless devices than people living in Asia or Europe, and those who do use wireless devices use them less and for fewer tasks. Nonetheless, U.S. companies realize that the advanced wireless capabilities available in Europe and Japan present enormous potential for increased m-commerce activities and revenues. Many are starting to explore opportunities abroad through partnerships, direct sales, or new foreign divisions [Nelson, 2001]. Should businesses plan for the continued disparity in adoption of mobile e-commerce around the world or assume that Europe and the United States will eventually catch up with Japan?

3. How will wireless service providers identify what services are desired in different parts of the world?

Demand for wireless applications differs around the world. While Europe and Asia experience more overall use of wireless devices, it is thought that the United States is ahead of Europe in terms of the volume of commerce transactions occurring over a wireless network and in terms of sending targeted ads and promotions to wireless devices [Daugherty, 2000]. The reasoning behind this situation is that consumers in the United States are more experienced with searching for and purchasing items over the wired Internet, and this experience extends to mobile devices. Wireless handheld computers, with screens larger than mobile phones, also are expected to contribute to more m-commerce transactions in the United States compared to other countries. Revenue from advertisements on the devices is expected to be greater. In Europe, online wireless games are popular and Japan offers a wireless Web-based version of karaoke, but North Americans do not readily use wireless browsing for entertainment. Because Japanese are pressed for living and working space, smaller devices such as mobile phones seem to work better with their lifestyles than larger personal computers, laptops, or even handheld devices.

4. How do access-pricing variations contribute to global differences, and impact the use of wireless services?

In Europe and Asia, being wired to the Web is relatively expensive (ranging from US$15 per month for 20 hours of access in Europe to hundreds of U.S. dollars per month in Japan), but

wireless access costs only a few dollars per month, although NTT DoCoMo charges i-mode callers a small fee for each piece of data that they access (e.g., $0.30 for a movie review or $0.01 to send a short e-mail message). Pricing policies in the United States are just the opposite: the wired Internet is almost free in many cases, but wireless bills can sometimes reach hundreds of dollars per month in airtime costs. These pricing differences, however, are becoming less pronounced as many service providers change their pricing policies to make them more affordable to the average consumer. Whether variations in access pricing in different countries affects the use of wireless services is not known.

Table 5 summarizes the global issues related to mobile e-commerce.

Table 5. Summary of Mobile E-commerce Global Issues

Issues:	**Relevant questions:**
• Addressing the lack of global standards	• How should global enterprises address the various wireless communication standards around the world?
• Planning for the disparity in adoption of wireless technologies and applications around the world	• Should businesses plan for the continued disparity in adoption of mobile e-commerce around the world or assume that Europe and the United States will eventually catch up with Japan?
• Identifying desired wireless services around the world	• What wireless services are likely to be successful in different parts of the world?
• Impact of access-pricing variations around the world on wireless service use	• Do variations in access pricing in different countries affect the use of wireless services?

VI. DISCUSSION

In this paper we identified numerous issues related to the design, implementation, and management of mobile e-commerce systems. Our examination showed that these issues may be categorized as technology, application, or global issues, where technology issues may focus on the client itself or on the underlying infrastructure. While our list of issues is certainly not exhaustive, it represents a useful overview of the social, technical, and practical environment within which m-commerce activities will be established in the coming years and provides a foundation for further issues analysis research within this domain.

The classification system outlined in this paper can be augmented by alternative perspectives. One useful paradigm for the examination of these issues is a viewpoint containing multiple dimensions (Figure 1). Each distinct dimension—technical level, organizational level, and geographic level—represents an alternate continuum for evaluation. First, is an issue a highly technical one or is it less technical or even entirely non-technical? This technical dimension is a continuum from those issues that almost exclusively involve technical considerations to those that have little or no relationship to technology. For example, encryption algorithms, frequency hopping protocols, and the like are highly technical issues. Legal issues, such as laws governing the public use of mobile phones, are primarily non-technical issues impacted by the technology. In between are such issues as acceptance of standards that have both technical and non-technical considerations.

Second, the organizational dimension is a way in which issues can be segmented according to the level of organizational impact. Does the issue primarily affect the individual, the workgroup (or team), the department, the entire organization, multiple organizations (within or across industries), or the environment outside the organization? For example, client device interface issues and control of personalization may matter most to the individual user, while frequency crowding and virus management are issues related to workgroups and organizations.

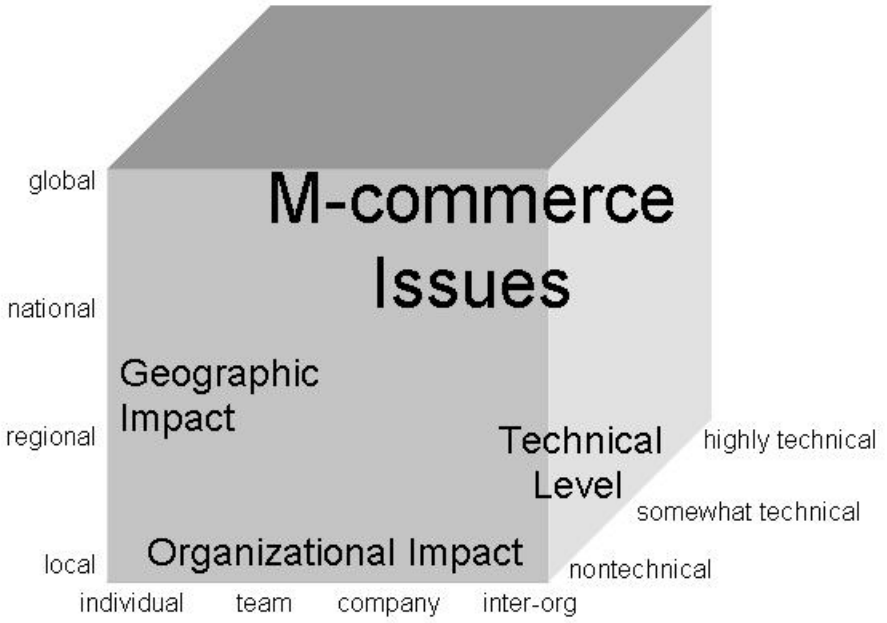

Figure 1: An Alternate Classification System for Mobile E-commerce Issues

The issue of controlling the data related to device location supersedes the organization itself and may be an industry or societal issue. Should issues related to individuals be resolved in a different manner from those that primarily focus on group interactivity or inter-organizational systems? Many organizations, both small and large, are transnational enterprises, operating within multiple legal and regulatory environments, and so this perspective is one of organizational dimension, not national dimension.

The third dimension is a way of examining issues along a continuum of geographic importance—does an issue have primarily a local impact, a regional impact, a national impact, or a global impact? For example, because wireless transmission has a limited range (extremely limited in the case of Bluetooth networks), bandwidth issues may be primarily local or regional issues. Crowded bandwidth in one part of the world (for example, Europe) would not prevent expansion into the same frequency range in another part of the world (for example, South America). To a certain extent, however, given that mobile devices are, by definition, able to move to any part of the world, all issues are global. A user with a mobile device may seek to interface with wireless systems anywhere in the world.

Growth in the use of m-commerce technologies may be inevitable, but the path this growth will follow is not. While our examination provides a useful platform for the analysis and resolution of various issues within this domain, there is a compelling need for future research into identifying and analyzing these and other issues. First, is this a complete set of issues within this domain? We welcome reaction to our examination and the identification of other key issues for consideration. We continue our analysis as we build a more comprehensive taxonomy with more refined classes of these and other issues. Second, it is imperative that researchers pursue analysis of the most crucial issues for the future of m-commerce, but which issues are relatively more important? The relative importance of these issues is a matter of opinion and is something that should be openly debated by all affected parties. In such a rapidly changing field, a careful in-depth analysis of any issue is difficult at best.

For example, has the proliferation of multiple standards for transmission, security, data representation, data synchronization, and application interfaces created an impediment to wide acceptance and growth in m-commerce? Or have technical standards served to stifle creativity and the introduction of improvements in the technologies themselves or in the ways they are utilized? There is no clear test for knowing when to cease competing and begin cooperating in the establishment of global standards. While several prominent standards are either proposed or are under development, the future is uncertain, and the landscape for m-commerce may be dominated by the resolution of these issues. Moreover, history shows that standards often change. Will further research shape the evolution of these standards? Will consortia of industry groups have the greatest impact on their eventual form? Will national or international standards be the norm?

As another example, will the issue of client hardware and software design be especially critical, given the impact of usability on adoption? If the devices and applications do not provide high-value functionality to users, groups, and organizations, then their use may not grow at the forecasted rates. In the current recession economy, technology adoption decisions face increased scrutiny as corporations seek to minimize expenditures on unnecessary systems. Should interactivity patterns for mobile end users be evaluated carefully to ensure that the design of comprehensive m-commerce systems meet their needs sufficiently? Within the global context, this also requires a careful focus on cultural and legal factors that affect adoption and use.

Many questions about systems design, implementation, and management in the wireless landscape must be addressed by individuals, organizations, and nations as we face a rapidly changing technological landscape. With an understanding of the issues presented in this paper, along with the further issues analysis research that will follow, researchers and practitioners will have a basis for evaluating and participating in the developments in this field. An appreciation of all these issues will help others pursue a more comprehensive, informed path of research and development, and greater clarity will lead to more rational decisions affecting the future of this important domain. In addition to these issues, there are also numerous concerns about the ways that wireless technologies should or will be used within our firms and within our societies.

The answer will not be simple, but in all probability new practical solutions to problems will be found, new technical standards will be established, new national and global approaches to addressing social and business issues will be instituted, and the future environment for wireless technologies and their use will evolve into a new equilibrium. This future will be determined by the parties involved in systems creation, including hardware and software vendors and developers, national governments, standards organizations, user groups, financial institutions, various consortia, and others. The resolution of these issues will have fundamental impacts on the nature of global commerce. Researchers and practitioners need to understand these issues as they unfold so that they can participate in the ongoing discussion that will help shape our wireless future.

ACKNOWLEDGEMENTS

The authors thank Henri Isaac of the University of Paris Dauphine for his feedback on a draft of this paper.

Editor's Note: This paper was fully peer reviewed. The article was received on October 21, 2001 and was published on January 30, 2002. The paper was with the authors for two weeks for one revision.

REFERENCES

EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
2. the contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
3. the authors of the Web pages, not CAIS, are responsible for the accuracy of their content.
4. the authors of this article, not CAIS, is responsible for the accuracy of the URL and version information.

Adam, N. et al. (1998) *Electronic Commerce: Technical, Business, and Legal Issues*. Upper Saddle River, NJ: Prentice Hall.

Addlesee, M., et al. (2001) “Implementing a Sentient Computing System”, *Computer*, 34(8), pp. 50-56.

Bannan, K. J. (2000) “The Promise and Perils of WAP”, *Scientific American*, 283(4), pp. 46-49.

Brancheau, J. C., B. D. Janz, and J. C. Wetherbe (1996) "Key Issues in Information Systems Management: 1994-95 SIM Delphi Results", *MIS Quarterly*, (20)2, pp. 225-242.

Brewer, B. (March 12, 2001) “Canada Considers Legalizing Cell Phone Jamming Systems”, *Computerworld,* http://computerworld.com/cwi/story/0%2C1199%2CNAV47_STO58493_NLTmw%2C00.html (current Oct. 7, 2001).

Brewin, B. (June 12, 2000) “Virus Threat Spreads to Wireless”, *Computerworld,* http://www.computerworld.com/storyba/0,5125,NA47_STO4775776.html (current January 20, 2002)

Brewin, B., and P. Sayer (August 18, 2000) "Analysts Predict Euro-telcos Will Stick Users with High Cost of Spectrum Auction", *Computerworld*, http://www.computerworld.com/cwi/story/0,1199,NAV47_STO48768,00.html (current Aug. 24, 2001).

Bruzzese, S. (2001) “No Need to Wait for 3G”, *M-Business* (September), pp. 56-58.

Chan, S. S. and X. Fang (2001) “Usability Issues in Mobile Commerce,” in D. Strong and D. Straub (eds.) *Proceedings of the Seventh Americas Conference on Information Systems*, Atlanta, Georgia: Association for Information Systems, pp. 439-442.

Charny, B. (October 27, 2000) “A2B: Eliminating the human element”, *ZDNet News*, http://www.zdnet.com/zdnn/stories/news/0,4586,2646086,00.html (current Oct. 7, 2001).

Cule, P. E. and J. A. Senn (1995) “The Evolution from ICIS 1980 to AIS 1995: Have The Issues Been Addressed,” in *Proceedings of the Association for Information Systems Annual Conference*, pp. 17-19.

Daugherty, W. (June 26, 2000) “U.S. Takes the Mobile-Commerce Lead”, *ZDNet News*, http://www.zdnet.com/zdnn/stories/comment/0,5859,2594098,00.html (current Oct. 7, 2001).

Deans, P. C. et al. (1991) "Identification of Key International Information Systems Issues in U.S.-Based Multinational Corporations", *Journal of Management Information Systems*, (7)4, pp. 27-50.

Dertouzos, M. (1999) “The Oxygen Project: The Future of Computing”, *Scientific American*, 281(2), pp. 52-55.

Djuknic, G. M. and R. E. Richton (2001) “Geolocation and Assisted GPS,” *Computer*, February, pp. 123-125.

Eklund, S. and K. Pessi (2001) "Exploring Mobile eCommerce in Geographical Bound Retailing," in R. H. Sprague, Jr. (ed.) *Proceedings of the 34th Hawaii International Conference on System Sciences*, Piscataway, New Jersey: IEEE.

Estrin, D., R. Govindan, and J. Heidemann (2000) "Embedding the Internet", *Communications of the ACM*, 43(5), pp. 38-41.

Garretson, R. (October 13, 1999) "Palm Computing, Symbian to Team" *Computerworld* http://www.computerworld.com/cwi/story/0,1199,NAV47_STO29169.00.html (current January 20, 2002)

Ghosh, A. K. and T. M. Swaminatha (2001) "Software Security and Privacy Risks in Mobile E-Commerce", *Communications of the ACM*, 44(2), pp. 51-57.

Gopal, R., S. K. Nair, and A. Tripathi (2001) "Wireless Advertising: Location-Based Targeting", in D. Strong and D. Straub (eds.) *Proceedings of the Seventh Americas Conference on Information Systems*, Atlanta, Georgia: Association for Information Systems, pp. 456-457.

Hamblen, M. (February 13, 2001) "Privacy Concerns Mount Over Wireless Location Technology", *Computerworld*, http://www.computerworld.com/cwi/story/0,1199,NAV47_STO57662,00.html (current Oct. 7, 2001).

Herstad, J., D. V. Thanh, and S. Kristoffersen (1998) "Wireless Markup Language as a Framework for Interaction with Mobile Computing Communication Devices", in C. Johnson (ed.), *Proceedings of the First Workshop on Human Computer Interaction for Mobile Devices,* available at: www.dcs.gla.ac.uk/~johnson/papers/mobile/HCIMD1.html (current Oct. 7, 2001).

Hightower, J. and G. Borriello (2001) "Location Systems for Ubiquitous Computing", *Computer*, 34(8), pp. 57-65.

Jain, A., L. Hong, and S. Pankanti (2000) "Biometric Identification", *Communications of the ACM*, 43(2), pp. 91-98.

Johnson, P. (1998) "Usability and Mobility; Interactions on the Move," in C. Johnson (ed.), *Proceedings of the First Workshop on Human Computer Interaction for Mobile Devices*, available at: http://www.dcs.gla.ac.uk/~johnson/papers/mobile/HCIMD1.html (current Oct. 7, 2001).

Joseph, A. D., J. A. Tauber, and M. F. Kaashoek (1997) "Mobile Computing with the Rover Toolkit" *IEEE Transactions on Computers*, 46(3), 337-352.

Kaasinen, E., et al. (2000) "Two Approaches to Bringing Internet Services to WAP Devices," *Computer Networks*, 33, pp. 231-246.

Kannan, P. K., A. Chang, and A. B. Whinston (2001) "Wireless Commerce: Marketing Issues and Possibilities", in R. H. Sprague, Jr. (ed.) *Proceedings of the 34th Hawaii International Conference on System Sciences,* Piscataway, New Jersey: IEEE.

Kotz, D. et al. (1997) "AGENT TCL: Targeting the Needs of Mobile Computers", *IEEE Internet Computing*, 1(4), pp. 58-67.

Kristoffersen, S., et al. (1998) "Developing Scenarios for Mobile CSCW," in C. Johnson (ed.), *Proceedings of the First Workshop on Human Computer Interaction for Mobile Devices*, available at: www.dcs.gla.ac.uk/~johnson/papers/mobile/HCIMD1.html (current Oct. 7, 2001).

Kuchinskas, S. (2001) "Game in Hand", *M-Business* (January), pp. 22-24.

Lewis, T. (2000) "Why WAP May Never Get Off the Ground," *Computer*, August, pp. 110-112.

Meissner, G. (2001) "Atomic Clocks", BEARS Newsletter, XLI(2), February 2001, p.1 http://www.qsi.net/w0ma/acrobat/feb.pdf (current January 17, 2002)

Mentrup, L. (2000) "To Thine Own: 3G Be True", *Telephony*, 238(9), pp. 44-52.

Miller, S. K. (2001) "Facing the Challenge of Wireless Security", *Computer*, 34(7), pp. 16-18.

Mueller-Veerse, F. (1999) *Mobile Commerce Report,* London: Durlacher Research, Ltd.

Nah, F. F. and S. Davis (2001) "Research Issues in Human-Computer Interaction in the Web-Based Environment," in D. Strong and D. Straub (eds.) *Proceedings of the Seventh Americas Conference on Information Systems*, Atlanta, Georgia: Association for Information Systems, pp. 1332-1334.

Nelson, E. P. (2001) "U.S. Companies Find Richer Prospects Abroad", *M-Business* (January), pp. 42-43.

Palvia, P. C. et al. (1996) "Key Information System Issues – An Analysis of MIS Publications", *Information Processing & Management*, (32)2, pp. 345-355.

Redman, P. (2000) "3G Wireless Networks: Worth the Wait?" *e-Business Advisor*, 18(7), pp. 12-16.

Reiss, M. (December 15, 2000) "Land of the Rising I-Mode", *tnbt.com*, http://www.tnbt.com/jsp/TNIP.jsp?x=1&y=0&p=TNAsset.jsp&a=49805&pnum=1&p0=39 (current Oct. 8, 2001).

Saha, S., M. Jamtgaard, and J. Villasenor, (2001) "Bringing the Wireless Internet to Mobile Devices", *Computer*, 34(6), pp. 54-58.

Scheier, R. L. (2001) "Wireless SFA: Don't Hold Your Breath", *M-Business* (February), pp. 28-31.

Schwartz, K. D. (May, 2000) "It's a Tool, Not a Toy", *Mobile Computing & Communications*, pp. 77-85.

Shen, J., and X. Shen (2001) "User Requirements in Mobile Systems," in D. Strong and D. Straub (eds.) *Proceedings of the Seventh Americas Conference on Information Systems*, Atlanta, Georgia: Association for Information Systems, pp. 1341-1344.

Shneiderman, B. (1998) *Designing the User Interface: Strategies for Effective Human-Computer Interaction, 3rd edition*, Reading, MA: Addison-Wesley.

Siau, K., E. Lim, and Z. Shen (2001) "Mobile Commerce: Promises, Challenges, and Research Agenda," *Journal of Database Management,* 12(3), pp. 4-13.

SyncML (2001), "Building an Industry-Wide Mobile Data Synchronization Protocol: SyncML White Paper" available at http://www.syncml.org/downloads.html (current Oct. 7, 2001).

Tarasewich, P. (2002) "Wireless Devices for Mobile Commerce: User Interface Design and Usability," in B. Mennecke and T. Strader (eds.) *Mobile Commerce: Technology, Theory, and Applications*, Hershey, PA: Idea Group Publishing, forthcoming.

Tarasewich, P. and M. Warkentin (2002) "Information Everywhere," *Information Systems Management*, (19)1, pp. 8-13.

Tennenhouse, D. (2000) "Proactive computing", *Communications of the ACM*, 43(5), pp. 43-50.

Turban, E., et al. (2002) *Electronic Commerce 2002: A Managerial Perspective, 2/e*, Upper Saddle River, NJ: Prentice Hall.

Varshney, U. (1999), "Networking Support for Mobile Computing", *Communications of the Association for Information Systems*, 1(1), pp. 1-29.

Varshney, U. and R. Jain (2001) "Issues in Emerging 4G Wireless Networks", *Computer*, 34(6), pp. 94-96.

Varshney, U. and R. Vetter (2000) "Emerging Mobile and Wireless Networks", *Communications of the ACM*, 43(6), pp. 73-81.

Varshney, U. and R. Vetter (2001) "A Framework for the Emerging Mobile Commerce Applications", in R. H. Sprague, Jr. (ed.) *Proceedings of the 34th Hawaii International Conference on System Sciences*, Piscataway, New Jersey: IEEE.

Varshney, U., R. Vetter, and R. Kalakota (2000) "Mobile Commerce: A New Frontier", *IEEE Computer,* 33(10), pp. 32-38.

Warkentin, M. (2001) "The Next Big Thing in eCommerce", *Decision Line,* 32(1), pp. 7-10.

Warkentin, M., V. Sugumaran, and R. Bapna (2001) "Intelligent Agents for Electronic Commerce: Trends and Future Impact on Business Models and Markets", in S. M. Rahman and R. J. Bignall (eds.) *Internet Commerce and Software Agents: Cases, Technologies and Opportunities*, Hershey, PA: Idea Group Publishing, Chapter 7, pp. 101-120.

Waters, R. (March 1, 2000) "Rival Views Emerge of Wireless Internet", *Financial Times FT-IT Review*, p. 1.

Winer, A. (2000) "Handy, Dandy", *The Industry Standard's grok* (November), pp. 82-86.

APPENDIX I. WIRELESS PROVIDERS DISCUSSED IN TEXT

Table A-1 lists companies that provide wireless products.

Table A-1. Wireless Providers

COMPANY	GENERAL COMPANY URL	PRODUCT OR TECHNOLOGY	Specific Product URL (if any)
adAlive	http://adalive.com/	PDA interactive billboards	http://adalive.com/
AOL	http://www.aol.com/	instant messenger	http://www.aim.com/index.adp?promo=208992
AT&T	http://www.att.com/	3G communication	http://www.attws.com/press/3g_presskit.jhtml
AvantGo	http://avantgo.com/		
Blue Square, UK	http://www.kbluesquare.com		
Casio	http://casio.com/	Pocket PC	http://casio.com/personalpcs/
Cell Block Technologies	http://www.cell-block-r.com/	calls diversion	http://www.cell-block-r.com/
Compaq	http://www.compaq.com/	Pocket PC	http://www.compaq.com/products/handhelds/pocketpc/
Dieceland	http://www.dtcproducts.com/		
EDS	http://eds.com/	PKI	
Ericsson	http://www.ericsson.com/	PKI	http://www.ericsson.com/mobilityworld/
ESPN.com	http://msn.espn.go.com/		
eWallet	http://iliumsoft.com/wallet.htm		
Fidelity	http://www400.fidelity.com/	InstantBroker™	http://personal100.fidelity.com/products/stocksbonds/content/ib.shtml.tvsr
France Telecom	http://www.francetelecom.fr/vanglais/home/	wireless watch	
HP	http://www.hp.com/	Pocket PC	http://hp-at-home.com/gatewayPages/handhelds.htm
IBM	http://www.ibm.com/	wireless watch	
Jockey Club, Hong Kong	http://www.hongkongjockeyclub.com/english/	off-track wagering	http://www.hongkongjockeyclub.com/english/betting/ocb.htm
KPN Mobile NV	http://www.kpn-corporate.com/eng/		
Kyocera	http://www.kyocera-wireless.com/	smartphones	http://www.kyocera-wireless.com/
Microsoft	http://microsoft.com/	“Stinger” Smartphone platform	http://www.microsoft.com/mobile/phones/
Microsoft	http://microsoft.com/	Pocket PC	http://www.microsoft.com/mobile/pocketpc/
Microsoft	http://microsoft.com/	Pocket Internet Explorer	http://www.microsoft.com/MOBILE/pocketpc/columns/pie.asp http://www.microsoft.com/mobile/
Microsoft	http://microsoft.com/	3G communication	http://www.microsoft.com/MOBILE/pocketpc/columns/alphabetsoup.asp
NTT DoCoMo	http://www.nttdocomo.com/ http://www.ntt.com/ http://www.docomo-usa.com/	i-mode instant messenger 3G communication	
Palm	http://www.palm.com/	PalmOS	http://www.palm.com/software/
Sendo	http://www.sendo.com/	smartphones	http://www.sendo.com/products/products.asp
Sonera	http://www.sonera.fi/english/	PKI	http://www.sonera.fi/english/pressinfo/releases/EngSonera2002/2002/6.html http://www.sonera.fi/english/solutions/
Streetbeam	http://streetbeam.com/	PDA interactive billboards	http://streetbeam.com/
Symbian	http://www.symbian.com/ http://www.symbian.com/abo	EPOC	http://www.symbian.com/developer/techlib/documentation/er5/opl/sysdoc/opl/getstart/devprods.html

	ut/symb-os.html		
VirtualWallet	http://www.applian.com/pocketpc/virtual_wallet/		
Yahoo	http://www.yahoo.com/	instant messenger	http://messenger.yahoo.com/

ABOUT THE AUTHORS

Robert Nickerson is Professor of Information Systems and Director of the Center for Electronic Business in the College of Business at San Francisco State University. His research interests include electronic commerce, global information systems, collaborative computing, and database design. In addition to numerous research publications, Dr. Nickerson is the author of fourteen major textbooks on information systems, computers, and programming, including *Business and Information Systems*, 2nd ed. (Prentice Hall, 2001). He holds a Ph.D. in information sciences from the University of California at Santa Cruz, and an M.S. in business administration and a B.S. in industrial engineering and operations research from the University of California at Berkeley. E-mail: RNick@sfsu.edu. URL: http://online.sfsu.edu/~rnick.

Peter Tarasewich is Assistant Professor of Information Science in the College of Computer Science at Northeastern University. His research interests include eBusiness, interface design and usability of mobile/wireless systems, Web engineering, and pervasive information systems. His publications appear in journals such as *Communications of the ACM*, *IEEE Transactions on Engineering Management*, *Quarterly Journal of Electronic Commerce*, *Internet Research*, *Journal of Computer Information Systems*, *Information Systems Management*, *European Journal of Operational Research*, and *Journal of the Operational Research Society*. Dr. Tarasewich holds a Ph.D. in operations and information management from the University of Connecticut, an M.B.A from the University of Pittsburgh, and a B.S.E. in electrical engineering with a second major in computer science from Duke University. His home page can be found at: http://www.ccs.neu.edu/home/tarase/.

Merrill Warkentin is Associate Professor of MIS in the College of Business and Industry at Mississippi State University. He is the author of over 100 articles, chapters, and books. His research, primarily in eCommerce, virtual teams, and knowledge engineering, appears in such journals as *MIS Quarterly*, *Decision Sciences*, *Information Systems Journal*, *Decision Support Systems*, *Journal of Electronic Commerce Research*, *Journal of Knowledge Engineering & Technology*, *Logistics Information Management*, *ACM Applied Computing Review*, *Information Systems Management*, *Expert Systems*, and *Journal of Computer Information Systems*. His books include *Business to Business Electronic Commerce: Challenges and Solutions* (Idea Group Publishers, 2002) and Turban, et al. (2002). Since 1996, he has served as National Distinguished Lecturer for the Association for Computing Machinery (ACM). Professor Warkentin holds B.A., M.A., and Ph.D. degrees from the University of Nebraska-Lincoln. E-mail: mwarkentin@acm.org. URL: http://www.MISProfessor.com.

Communications of the Association for Information Systems

ISSN: 1529-3181