10-2008

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Recommended Citation

Nickerson, Robert C. (2008) "Whither Wireless? Future Directions in Mobility," *Communications of the Association for Information Systems*: Vol. 23 , Article 19.

DOI: 10.17705/1CAIS.02319

Available at: <https://aisel.aisnet.org/cais/vol23/iss1/19>

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Communications of the Association for Information Systems

Whither Wireless? Future Directions in Mobility

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Abstract:

Wireless technology, including mobile phones, WiFi-enabled laptops, and Bluetooth-connected devices, has become entrenched in today's society, and we can expect this technology and its mobile applications to continue to evolve in the future. But what direction will this evolution take? The purpose of this paper is to look into the future and forecast where wireless is heading, recognizing full well that making such forecasts is fraught with danger. This paper first places the rise of wireless in an historical context relative to other important information technologies of the past. It then reviews mobile issues first presented in 2002 and examines where these issues stand today. The paper next looks at other views about the future of wireless. With this background the paper makes six forecasts about the future of wireless networks, mobile phones, wireless communications standards, wireless security, ultimate commerce, and the wireless market. Drawing on these forecasts, the paper describes several research questions that could yield valuable results in the wireless arena. The paper concludes with one final forecast.

Keywords: wireless, mobile, cell, phone, future, issues, forecast

Volume 23. Article 19. pp. 333-350. October 2008

I. INTRODUCTION

whither (adverb): to what place, result, or condition
(Microsoft Bookshelf 2000)

Wireless technology is firmly taking root in today's society. Mobile (cell) phones, WiFi-enabled laptop computers and PDAs, and Bluetooth-connected devices are ubiquitous, and new wireless technologies, such as WiMax, are appearing. Countries are dotted with cellular phone towers, cities are providing metropolitan-wide wireless networks, and streets are lined with cafés offering free WiFi access. Wireless mobile applications are becoming the norm and not the exception. Users not only talk on their mobile phones but also send text messages, photos, and soon videos. WAP and iMode-enabled mobile phones let users check sports scores, trade securities, purchase cinema tickets, and place bets on horse races. Business travelers with wireless laptops, PDAs, and Blackberry or similar devices have a plethora of mobile applications at their disposal.

The future of wireless technology and mobile applications is bright indeed, but forecasting where it will go is difficult. Still, it is interesting to speculate, as the definition above of wither states, on the place, result, or condition to which wireless appears to be going. The purpose of this paper is to attempt such speculation by presenting a reasoned analysis of the future of wireless technology and mobile applications so as to provide some insight that could lead to fruitful research directions. We recognize that forecasting the future is fraught with pitfalls and is likely, in the long run, to be wrong, but nevertheless we think it is useful to attempt such an exercise to spark interest in the questions that it raises.

This paper examines the future of wireless by first looking at the past and how information technology arrived at where it is today (Section II). It then reexamines issues in mobility that we presented in 2002 and discusses where these issues stand today (Section III). Next the paper discusses what other authors have said about where wireless may be heading (Section IV). This background leads us to our forecasts of the future of wireless and mobility (Section V). Finally, the paper suggests areas for research that arise from these forecasts (Section VI) before presenting the conclusion (Section VII).

II. THE RISE OF WIRELESS

To understand where wireless stands today, it is useful to examine the phases through which information technology has gone in its short history. One way of defining these phases is by the chronological decades through which the technology passed.

THE 1960S: DECADE OF MAINFRAME COMPUTERS

I think there is a world market for maybe five computers.
Thomas J. Watson, Chairman of IBM, 1943

Although preliminary work on computers began earlier, the first major computers were developed in the 1940s and the first commercial applications appeared in the 1950s. These early decades, however, were largely ones of technological experimentation and efforts to determine where computers fit in organizations. It was really not until the 1960s that computers found a major place in businesses, and this place was with large, centrally located and controlled mainframe computers.

In 1964, IBM introduced the System/360 family of mainframe computers, arguably the most successful line of computers, outside of PCs, ever sold. Along with the System/360 came IBM mainframe operating systems including OS/360. IBM had competitors, sometimes called the *seven dwarfs*: NCR, Burroughs, Honeywell, CDC, RCA, Univac, and GE, each with their own line of mainframe computers and operating systems.

Mainframe computers were big machines kept in big rooms behind locked doors and only directly accessible by those who were highly trained to run them. The rest of us had to turn in our stacks of punch cards and wait hours or sometimes days to get the results back on reams of green and white striped paper. This was batch processing at its worst. The 1960s was an era of centralized computers and organizational applications that were hard to use. We think of it as *sometime computing* and *central place computing*.

The legacy of this decade still exists today. Mainframe computers are still used, often as servers in large-scale networks. The seven dwarfs are mostly gone from the computer business, but IBM still produces the latest generation of the System/360 mainframe computer, called the System z, and its mainframe operating system, z/OS.

THE 1970S: DECADE OF MINICOMPUTERS

But what is it good for?

Engineer at IBM commenting on the microchip, 1968

The first minicomputers were introduced by Digital Equipment Corporation (DEC) in the 1960s, at about the same time as IBM introduced the System/360 mainframe. But minicomputers did not really take off until the 1970s. Popular systems were the DEC PDP/11 and the DEC VAX. Time-share operating systems such as RSTS/11 and VMS ran these machines, and Unix first appeared in this decade. Many companies in addition to DEC produced minicomputers including IBM (System/3) and HP (HP 3000). Data General, Prime, and Wang were some of the other producers of minicomputers.

Minicomputers found homes in the departments and similar units of large businesses, which led to decentralized computers and departmental applications. Batch processing gave way to online, interactive processing, much to the pleasure of users who now could get their results back in minutes rather than hours. We now had *often time computing* and *local place computing*.

Minicomputers are still used today, usually as servers in networks. DEC is gone, as are most of the other minicomputer manufacturers, replaced in many cases by former start-up companies like Dell. Unix still exists, although its stepchild, Linux, has made significant inroads.

THE 1980S: DECADE OF MICROCOMPUTERS

There is no reason anyone would want a computer in their home.

Ken Olson, President, Chairman, and founder, DEC, 1977

The Altair 8800, the first microcomputer widely sold to the public, was introduced in 1975. Shortly afterward came the Apple II, the Radio Shack TRS 80, the Commodore PET, and various other microcomputers. It was not until the 1980s, however, with the introduction of IBM PC in 1981 and the Apple Macintosh in 1984 that the microcomputer era really took off. Operating systems like MS DOS and the unnamed-at-the-time Macintosh operating system were interactive and designed for a single user. The first version of Windows, not really an operating system but rather a shell around DOS, appeared during this decade. Graphical user interfaces became the norm, and WYSIWYG entered the vocabulary. IBM used off-the-shelf technology and so clone manufacturers sprung up quickly, but Apple vigorously protected its proprietary technology.

In the 1980s, microcomputers came to be used everywhere. Everyone wanted one on their desk at work and another in their home. Personal applications such as WordStar, Lotus 1-2-3, and dBase IV drove this demand. Now we had *anytime computing* and *user's place computing*.

Today, of course, microcomputers are everywhere, not just in the office and at home, but in the car, in the classroom, and at the airport, among other places. IBM no longer makes the PC, having lost its battle with the clone makers, but Apple comes out with new Macs regularly. Windows is a true operating system, and Apple's operating system is now called Mac OS. MS Word, Excel, and Access have replaced earlier software.

THE 1990S: DECADE OF NETWORKS

The network is the computer.

Sun Microsystems slogan

With millions of mainframe computers, minicomputers, and microcomputers, the 1990s was ripe for the proliferation of interconnectivity. Networks had been around in one form or another for several decades, but by the 1990s there was so much data on so many machines, the computing world needed widespread communication among machines. Ethernet became the de facto standard for proliferating LANs, and proprietary corporate WANs spanned the globe. Years before, ARPANET started to evolve into the Internet and TCP/IP made it all work together. The communications company Cisco became as well known as the computer company IBM.

Data and applications were now spread among clients and servers in networks, and distributed applications became common. E-mail was the killer application for the end-user. And then the World Wide Web struck, and with it everyone, everywhere could be connected. It was still *anytime computing* but now we had *many place computing*.

The trend in networks continues today. The Internet is part of nearly everyone's lives, both at work and at home. Web 2.0 has become a buzzword with social networking as one of its mainstays. Software-as-a-service (SaaS) may eventually replace in-house computing in organizations and cloud computing may become the norm for everyone.

THE 2000S: DECADE OF WIRELESS

The mobile phone has arguably evolved into the first truly personal computer.
Sirkka Jarvenpaa and Karl Lang, 2005

Where do we stand today? We maintain that the 2000s is the decade of wireless. The technologies that are having the most influence today are those that connect users to systems by wireless transmissions. On the client side we find mobile phones, portable computers, Blackberry devices, and more. On the server side are variations of the technology that we see in the wireline world: Web, application, and database servers. But between these are the wireless connections of cellular, WiFi, Bluetooth, and similar technologies.

Perhaps the most important wireless technology for most end users is the mobile phone, which is a computer with its own operating system (often Symbian) and Web browser (often Openwave's Mobile Browser). With it the user has an individual computer that is uniquely theirs. The opening quote in this section by Jarvenpaa and Lang [2005] clearly expresses this idea. The user can use this personal computer wherever and whenever he or she wants. We now have true *anytime computing* and *anyplace computing*.

The mobile phone, however, goes beyond this simple step from the previous technologies, for it adds two additional characteristics that are truly unique and that make it a significant leap forward in computing. These are *location-based computing* and *identity-based computing*. A mobile phone belongs to one individual and is almost always with that individual. Through GPS technology or cellular triangulation, the service provider can locate the user. In addition, the service provider can identify the user from the phone's SIM code. Although questions of privacy exist, it is possible with this technology to customize the offerings to the user based on the user's location and identity. Such customization was not possible with previous technologies, and it makes the mobile phone truly unique in the computing world.

Table 1 summarizes the brief history of computing to show where wireless fits into the scheme of things.

Table 1. Summary of the Main Characteristics of the Computing Decades						
Decade	Technology	Common computers	Common operating systems	Applications	Time of computing	Place of computing
1960s	Mainframe computer	IBM System/360	IBM OS/360	Centralized, organizational, batch	Sometime	Central place
1970s	Minicomputer	DEC PDP/11, VAX	RSTS, VMS, Unix	Decentralized, departmental, online/interactive	Often time	Local place
1980s	Microcomputer	IBM PC, Apple Macintosh	MS DOS, Windows	Personal, GUI, WYSIWYG	Anytime	User's place
1990s	Network, Ethernet, Internet	Servers	Unix, Windows Server	Distributed, email	Anytime	Many place
2000s	Wireless communication, WiFi, Bluetooth	Mobile phone, laptop, PDA, Blackberry	Symbian	Individual	Anytime	Anyplace

III. MOBILE COMMERCE ISSUES REVISITED

In 2002, we proposed 34 major issues in mobile commerce [Tarasewich, Nickerson, and Warkentin 2002]. By an issue we meant "an idea, topic, problem, or other matter that is open to discussion or dispute or a question to be disputed or decided." Table 2 lists these issues organized into five categories: mobile client issues, communications issues, technology issues, application issues, and global issues.

Table 2. Mobile Commerce Issues

Mobile client issues:
<ul style="list-style-type: none"> • Ultimate form(s) of mobile client devices • Control of personalization of information presented on mobile client • Design of user interfaces for mobile client devices • Design of applications for use on different mobile client devices • Creation of resident software for limited mobile client devices • Acceptance of protocols or systems for mobile client device communication
Mobile commerce communications issues:
<ul style="list-style-type: none"> • Efficient use of limited bandwidth • Difficulties with mobile devices interfacing with multiple communications environments • Spectrum availability • Interference among technologies • Addressing compliance with current and future mobile phone standards and speeds • Willingness of businesses to pay the high cost of establishing new wireless infrastructures
Mobile commerce technology issues:
<ul style="list-style-type: none"> • Need for seamless transfer between locations and devices • Method of charging for wireless connection • Security of data traveling over wireless networks • Virus management • Identification verification • Control of data related to device location
Mobile commerce application issues:
<ul style="list-style-type: none"> • Determination of tasks users want to do without regard to temporal and spatial constraints • Method of providing support for desired tasks through wireless applications • Communication between different messaging services • Appropriate use of devices and applications in social settings • Security of data used in wireless applications • Identifying the best revenue generation technique • Safety while using wireless devices in vehicles • Protection of user privacy in location-based applications • Addressing the lack of integrity of data from multiple data sources • Storage of data for use and access by mobile applications • Ensuring the integrity of synchronized data among multiple devices • Development of complex, robust organizational applications within device limitations
Mobile commerce global issues:
<ul style="list-style-type: none"> • Addressing the lack of global standards • Planning for the disparity in adoption of wireless technologies and applications around the world • Identifying desired wireless services around the world • Impact of access-pricing variations around the world on wireless service use

Today, about six years later, enough time has passed that we can evaluate the current status of these issues. Have some been resolved? Are others still waiting for resolution? Are some not important any more? Have new issues arisen? We examine each of these issues in the sections that follow.

MOBILE CLIENT ISSUES

Ultimate Form(s) of Mobile Client Devices

In 2002, we found many types of devices used as mobile clients: mobile phones, PDAs, laptop computers, vehicle mounted devices, etc. We asked how these diverse types of devices might evolve in the future and what types may ultimately dominate. Today we have the same variety of devices, perhaps even more. What changed, however, is an ever-increasing functionality in these devices. No longer is the mobile phone just a telephone. Today it is also a text messaging device, a camera, an organizer, and often an e-mail client. At the same time, many PDAs include WiFi or cellular communication (or both), turning them into small laptops and/or large mobile phones. Virtually all new laptops come standard with WiFi providing anyplace connectivity to the Internet and all that it offers in addition to the common office applications. Vehicle-mounted devices not only have GPS, but also provide capabilities such as map display, navigation, and remote diagnostics. Although clever new devices can appear at any time, we are likely in the future to see many of the same devices as we have today, only with more and more capabilities.

Control of Personalization of Information Presented on Mobile Client

Previously we asked whether users should have control of personalization of information presented by organizations on their mobile devices. In recent years user-controlled personalization (or customization) of information has become commonplace in the wireline Internet and is common in many Web 2.0 environments. User-controlled personalization of information is likely to become the norm on future mobile devices too, although screen size limitations will impact what can be done. As more mobile phones such as the iPhone from Apple provide Internet access with larger screens and easier navigation, users will expect functionality similar to that available to them with the wireline Internet including the ability to personalize the information they receive.

Design of User Interfaces for Mobile Client Devices

The user interface of mobile phones is arguably the major obstacle to the widespread adoption of these devices for functions beyond voice communication. Small screens and limited keyboards create many problems for user interface designers. In 2002, we asked if new user interface design principles are needed for mobile devices. While some studies of small device user interface design have been conducted [for instance, Gong and Tarasewich 2005; Adipat and Zhang 2005], and clever new devices such as the Apple iPhone and the like have started to reach the market, more work needs to be done in this area. We expect this work to move forward with new approaches for user interaction with small devices appearing every few years.

Design of Applications for use on Different Mobile Client Devices

Many types of mobile devices existed in 2002 and many more types can be found today. Previously we wondered whether applications could be designed to function similarly on different devices. The answer to this question is even more complex now because of the proliferation of devices. In addition, with new mobile phones arriving on the market regularly, and users changing mobile phones every few years (one report indicated that consumers get a new mobile phone on an average of every 18 months [Environmental Literacy Council 2008]), the problem is even more complex. Part of the solution to this problem may come as technology converges in the future, which we discuss later in this paper.

Creation of Resident Software for Limited Mobile Client Devices

With the limited devices available in 2002, we were concerned about the ability of developers to be able to create function-rich software for these devices. During the intervening years, the processing power and memory found in mobile devices has steadily increased. For example, in 2002 Hitachi announced a 133 MHz processor for mobile phones with 128 KB of memory [Hitachi 2002]. Today the Apple iPhone is reported to have a 620 MHz processor [Block 2007] and has as much as 16 GB of memory. With such increasing processing power and memory, it becomes easier to create sophisticated software. We expect that this trend will continue into the future and thus this issue will gradually die away.

Acceptance of Protocols or Systems for Mobile Client Device Communication

Previously we noted that WAP and iMode were two common communications protocols for mobile devices. We asked whether one of these protocols or some other might ultimately dominate for mobile communications. We also noted a number of markup languages in use at the time (e.g., cHTML, WML, HDML). Today WAP and iMode are

even more entrenched, although in newer versions, and XHTML Basic is a standard markup language for limited devices.

MOBILE COMMERCE COMMUNICATIONS ISSUES

Efficient Use of Limited Bandwidth

When mobile service providers first started thinking about applications beyond voice communication, bandwidth was a serious concern. Even second-generation GSM phones only operated at 9.6 Kbps, which created a severe limitation on what could be downloaded. Thus, in 2002, we asked if applications could be designed so that they worked effectively with limited bandwidth. Today this problem is much less of a concern. 2.5G and 3G phones are much faster and able to handle large amounts of data, albeit still not as much as the wireline Internet with high-speed connections. 4G phones have the potential for even greater speeds. For example, NTT DoCoMo [2007] has demonstrated mobile phone technology with a speed of 5 Gbps. In the future we do not think that this issue will be relevant.

Difficulties with Mobile Devices Interfacing with Multiple Communications Environments

A wide variety of wireless communications environments existed in 2002: IEEE 802.11b, Bluetooth, and various 2G cellular technologies (TDMA, CDMA, GSM). We wondered if mobile devices could be created that would function with different, incompatible communications systems. Even more communications environments exist today. IEEE now offers 802.11g and 802.11n. Cellular technology is in even more disarray with different standards for 2.5G (GPRS, EDGE) and 3G (WCDMA/UMTS, CDMA2000, TD-SCDMA). WiMax (IEEE 802.16) is making inroads. The problem of creating devices that will function seamlessly in multiple communications environments is even more daunting today than it was previously. Hope may come with a universally accepted 4G standard, but, given past experience, that is unlikely.

Spectrum Availability

In previous years, availability of adequate frequency spectrum for new services seemed like a potential problem. Over the years, however, governments have made new spectrums available for use by the mobile industry. Assuming this trend continues, we do not see that spectrum availability will be a limiting factor, at least in the near future.

Interference among Technologies

With different wireless technologies using the same frequency range, the potential exists for interference among the technologies. This problem existed in 2002 and may be more severe today with the increased use of wireless devices. Even microwave ovens and other common electrical devices in office environments can create interference problems [Cisco 2007]. Tools are available for organizations to locate potential interference. End-users, however, must rely on the technology provided to them. This problem is likely to persist in the future.

Addressing Compliance with Current and Future Mobile Phone Standards and Speeds

In 2002 three 2G mobile phone standards dominated (GSM, CDMA, TDMA) and 2.5G and 3G standards such as EDGE and UMTS were starting to appear. We wondered how applications could be designed to function with all these different standards, many operating at different speeds. Today we still have the older standards, EDGE is common, and 3G has become more complex with WCDMA (UMTS), CDMA2000, and the Chinese standard TD-SCDMA. Creating applications that will function across all these systems is still a problem today, and it may take some time to resolve this issue in the future.

Willingness of Businesses to Pay the High Cost of Establishing New Wireless Infrastructures

The proliferation of mobile phone standards just described creates a problem for telecommunications companies that want to provide new services as new technologies become available. The cost of building the necessary infrastructure to support these technologies can be significant. We noted this previously and asked whether businesses will pay the necessary costs associated with each new standard. In the intervening years we have seen the impact of this concern with the slow implementation of 3G infrastructure. For example, in the early 2000s a 3G auction frenzy took place with companies in some countries paying huge sums for their right to use the allocated 3G spectrum; the UK auction, for one, was 22.5 billion British pounds [Binmore and Klemperer 2001]. The infrastructure necessary to provide 3G services in many countries, however, has been slow to arrive and is often limited to just the largest metropolitan markets. We still do not know if businesses will make the necessary investment to provide each new wireless service on a widespread basis.

MOBILE COMMERCE TECHNOLOGY ISSUES

Need for Seamless Transfer between Locations and Devices

The ability of a mobile user to move from one location to another without losing a wireless connection seems axiomatic to the concept of mobility. Yet, such seamless geographic transfer is only partially realized with mobile phones, as evidenced by the frequent “dropped call,” and not even possible with WiFi. In addition, moving from one device to another (such as from a mobile phone to a laptop) without terminating and restarting a common application is still a dream. Previously we asked how such transfer could be provided; today we still ask this question.

Method of Charging for Wireless Connection

A number of different methods of charging for wireless connection existed in 2002 and even more exist today. Some services charge by the minute, others by the packet, and still others provide limited or unlimited service for a fixed fee with many options. The situation does not just apply to mobile phones but also to WiFi service, which may be free in one café or hotel and costly in the next. Such variations in charging confuse consumers and make it difficult for business customers to budget. Although we can hope that some order will eventually be put into the various charging plans we do not see this happening soon.

Security of Data Traveling over Wireless Networks

Security of data traveling over wireless networks was a critical concern in 2002. The wireless medium made it that much easier to pick up signals, and users often did not adopt security measures. We asked how users and organizations can be assured that data is secure when transmitted over wireless networks. Little change occurred in this issue in the intervening years; security is still a critical concern today. WiFi security exists but users do not always enable it. The same applies to Bluetooth security. WAP 2 is more secure than WAP 1, but it is not available on all mobile phones. Security will continue to be a problem until communications becomes universally secure and security measures become transparent to the user.

Virus Management

Viruses are endemic to computers, whether connected to the Internet by wireline or by wireless. They have also appeared on mobile phones. Some examples are Cabir, Commwarrior, and Beselo [F-Secure 2008]. Viruses can spread on mobile phones in a variety of ways, including through a Bluetooth connection, by e-mail, or by downloading a game. Previously we asked how viruses can be controlled on mobile devices. With the proliferation of mobile phones, this question is even more important today. At the same time, however, we expect that this problem will be addressed with mobile phones, just as it has with stationary devices.

Identification Verification

Positive user identification is important in many transactions. The problem of how to identify a user without undue intrusion existed previously and still exists today in both the wireline world and the wireless one. Biometrics are available with some computers, both desktop and laptop. They are not common with mobile phones, however, although some early phones, such as the Pantech phone in 2004 [Pilato 2004], included some form of biometric identification. Other methods of positive user identification, such as through smart cards, also have not gained acceptance. This problem of positive user identification is just as severe today as it was previously.

Control of Data Related to Device Location

In 2002, we recognized the potential for an increase in the availability of location data for mobile devices through means such as GPS and cellular triangulation. We noted that access to this data may invade an individual's privacy, and we asked who should control such access. Although location data is not being widely used even today, the potential is still there for abuse as more and more phones incorporate GPS capability. In 2006, 43 percent of respondents to a Forrester Research survey felt that location-based data services would be a threat to their privacy [Redknee 2006]. As concern about privacy in general continues to rise, the question of location data control is even more important.

MOBILE COMMERCE APPLICATION ISSUES

Determination of Tasks Users Want to Do without Regard to Temporal and Spatial Constraints

In 2002, we listed many existing and potential mobile applications, including mobile banking, mobile advertising, mobile auctions, and mobile entertainment. But we did not know what applications users wanted to use anytime from anywhere. Today, we still cannot answer this question. Mobile entertainment is one of the largest applications, with music downloads to wireless devices reaching USD 6.7B in 2006 [Gibson 2006]. Mobile financial applications such as mobile banking and brokering, which were so promising in the past, declined in popularity and represent only a

small part of the total today. Location-based services have had only limited acceptability except in vehicle-mounted devices. The future is uncertain, although new applications such as mobile dating keep appearing, and mobile social networking is starting to arrive. One way of dealing with new applications might be to classify them along with other mobile applications in a concise, yet comprehensive, taxonomy, thus identifying their best use and locating potential areas for other applications [Nickerson et al. 2007].

Method of Providing Support for Desired Tasks through Wireless Applications

Previously, we asked what methods and metaphors are best for applications that interface with mobile devices. While today's devices are clearly more sophisticated than those of the past, the question still remains. New products such as the Apple iPhone and similar devices present new methods, such as the ability to zoom in or out on a web page display with the tap of a finger, that have gathered much attention. Whether these approaches are revolutionary or simply evolutionary is open to debate. It may take the introduction of an entirely new metaphor, analogous to the introduction of the graphical user interface first widely popularized with the Apple Macintosh (although it was found on a number of machines before the Macintosh), to really provide the necessary support for mobile applications.

Communication between Different Messaging Services

The future of mobile messaging services was unclear previously, and so we wondered how different services would communicate with each other. Today, SMS (texting) is arguably the non-voice "killer app" on mobile phones. E-mail, the "killer app" for the wireline Internet, is also becoming widely available on handheld devices. Services even exist that allow a text message to be sent from a phone to an e-mail address (SMS to email gateway) and an e-mail to be sent to a mobile phone as a text messages (e-mail to SMS gateway). The connection is not seamless but it is there. One day, perhaps, all text (and non-text) communication will merge into what is sometimes called unified communications.

Appropriate Use of Devices and Applications in Social Settings

Mobile devices, especially mobile phones, can be used in locations where they could bother collocated people. Examples of these locations are restaurants, theaters, churches, classrooms, public transportation, sidewalks, and other social settings. In 2002, we wondered whether cultural barriers might limit the use of mobile phones in such situations. Since then, we have studied this issue in a multinational study and presented the results in several papers such as Nickerson et al. [2008]. One conclusion from this research is that national culture does affect social norms related to mobile phone use; what is acceptable in one country may not be acceptable in another. The question, however, needs further study to identify when, where, and for what purpose the use of mobile devices is appropriate.

Security of Data Used in Wireless Applications

Data must be secure when using wireless applications. Earlier we discussed security of data traveling over wireless networks. The question now is how can we be assured that the data used in an application, especially financial transaction data, is protected. Protecting mobile payment data is an especially difficult problem not only because of the uncertainty of the network with connections that can change from cell to cell and encryption that may not be in use, but also because of user factors. For example, entering a 16-digit credit card number is not only difficult on a small keyboard but also potentially observable by others when done in a public place. Although some solutions exist, such as PayPal Mobile and TextPayMe, they are not perfect. Encrypting critical data and storing it in a mobile device for later secure transmission is a potential solution. Small mobile devices are easily lost, however, not only exposing the user to loss of financial data but also to theft of identity and other personal data stored in the device. As none of the solutions appears perfect, the question of data security on mobile devices still remains.

Identifying the Best Revenue Generation Technique

How to generate revenue from mobile services was a concern in 2002 and remains a concern today. A number of revenue models are used including service charges, commissions, and subscription fees. iMode charges a percentage of each third-party transaction, which it can do because it controls the financial chain. The advertising model, so common on the wireline Internet, does not work well on mobile devices with limited screen size. As mobile devices become more sophisticated and mobile services more robust, new revenue models may have to be considered. It is unlikely that there will be a "best" model, but rather many good ones.

Safety While Using Wireless Devices in Vehicles

The vision of a vehicle as an integral part of a mobile system evokes a variety of interesting scenarios [Varshney 2005]. But, we wondered previously, is "browsing while driving" safe, or will it even be allowed. Many countries prohibit the use of mobile phones by drivers of cars. In the United States, California, a state that seems to live in

automobiles, banned mobile phone use while driving in 2008, but continued to allow texting. Interestingly, some states have banned texting by drivers, but not talking on a mobile phone [Governors Highway Safety Association 2008]. To our knowledge, no country or state currently prohibits the use of a GPS unit by a driver to follow a map, although such use could be distracting. Some day, full Internet access is likely to be common in vehicles, but will its use by the driver be prohibited? Safety in vehicles with increasing wireless access needs to be examined carefully as it evolves in the future.

Protection of User Privacy in Location-Based Applications

Earlier, we discussed the control of access to device location data. Assuming that location data is made available to mobile services, how will users' privacy be protected by these services? Although location-based services (LBS) have not been widely implemented despite extensive early study [for instance, Varshney 2003], someday they may be common. How can an individual's privacy be protected in applications that identify a user's location? Boston snowplow drivers, for example, threatened to strike when ordered to carry GPS-enabled mobile phones. They finally agreed under the condition that the phones were not used to calculate their working hours [Waxer 2006]. Location-based technology is becoming more common, and thus the question of protecting a user's privacy is even more relevant today than it was when we first asked it.

Addressing the Lack of Integrity of Data from Multiple Data Sources

Data for a mobile application may not come from the same source as a similar application that uses the wireline Web. A company with both mobile and fixed Internet services often has to maintain a distinct Web site for mobile applications that is derived from its main site. Over time, the sites can become inconsistent. Designing applications that ensure the integrity of data from these sources is a problem that we identified in 2002. New solutions to this problem have been developed since, an example being Web Fidelity Services [Bytemobile 2008], which transparently transforms wireline Web pages for viewing on small devices. Another solution is to provide direct access to fixed Internet services, as is done with the Apple iPhone. This solution, however, requires a device with a user interface that allows for full screen browsing. We anticipate that solutions to this problem will continue to evolve in the years to come.

Storage of Data for Use and Access by Mobile Applications

Storing data so that it is easily accessed by different mobile applications is a problem that we identified in 2002. We noted at the time that the nascent XML provided one possible solution to this problem. Today, XML has become widely accepted as the standard for storing many types of data, thus making access to the data, both for mobile and fixed applications, easier. The use of XML for this purpose is likely to continue into the future. We have also witnessed a trend toward network storage. Many of us leave our e-mails on servers for access from different devices; increasingly we also store other pieces of information on servers, including pictures, contacts, calendars, etc., which in turn can be accessed from virtually any device. We expect use and access barriers of data for mobile devices to decrease.

Ensuring the Integrity of Synchronized Data among Multiple Devices

Synchronization of data among multiple devices is a problem that has plagued IT for years. Previously we asked how synchronized data integrity on mobile devices can be ensured. As the amount of available data explodes and devices proliferate, the answer to this question becomes more complex. Just keeping one's phone book synchronized on a mobile phone, a laptop, and a PDA is not simple. Some progress has been made using open standards [Open Mobile Alliance 2008], but making the synchronization process truly transparent across many platforms is a goal that may take a number of years to realize. The concepts of cloud computing and software-as-a-service for mobile applications may help, but these are far from being fully realized today.

Development of Complex, Robust Organizational Applications within Device Limitations

Although consumer-oriented B2C applications have dominated the mobile world, mobile applications in the enterprise, both B2B and B2E, may ultimately prove to be the most economically beneficial. Planning, analyzing, designing, and implementing these applications for limited devices within a complex inter- and intra-organizational context may be difficult, however. Since first identifying this issue in 2002, we have seen only limited success in this area, with the exception of mobile e-mail access for employees, which has been highly successful. We anticipate that this issue will continue to be with us for some time, although as mobile devices become more sophisticated, enterprise solutions may become more common.

MOBILE COMMERCE GLOBAL ISSUES

Addressing the Lack of Global Standards

Earlier we noted the wide range of mobile phone standards worldwide, not just for 2G phones but also for 3G phones. How global enterprises address the various communication standards was a concern in 2002 and is more of a concern today with the increasing proliferation of standards. Previously we thought that WAP's future was uncertain and that iMode would become a standard, but neither of these has happened. WAP is well entrenched and likely to be around for a while so businesses can plan on its presence while iMode has had little success outside of Japan. But designing mobile applications for use by a company in multiple locations is still an issue, and resolution of this issue may not come for a while.

Planning for the Disparity of Adoption in Wireless Technologies and Applications around the World

In 2002, we noted Japan's lead over Europe, and Europe's lead over the U.S. in the adoption of wireless technologies and applications. A question we asked was whether businesses should plan for a continued disparity or assume that the U.S. and Europe would eventually catch up with Japan. Today not just Japan but other parts of Asia, especially South Korea, are pulling even further ahead of the Western world in wireless adoption. 3G cellular is making major inroads in Asia while appearing in only some markets in Europe and the U.S. At the same time, the U.S. leads the rest of the world in WiFi hotspots [JiWire 2008]. The answer to the question is that businesses will need to continue to plan for such disparity in their global wireless offerings in the foreseeable future.

Identifying Desired Wireless Services around the World

Demand for different wireless services varied around the world in 2002 and continues to vary today. Asia, Europe, and the United States, in that order, have adopted mobile applications, but what is popular in one part of the world may not be popular elsewhere. As noted earlier, mobile music downloading is one of the most popular mobile applications worldwide. Other mobile applications find popularity in different countries and regions, such as mobile gambling in the UK (Holden 2007a) and mobile games in China (Holden 2007b). The question still remains: 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

In 2002, we noted the difference in pricing among countries for both wireline Internet access and mobile access. Today, those differences still exist, although some changes have taken place. In the United States wireline connections remain relatively cheap and the cost of wireless continues to be much more expensive. In Europe, by contrast, the cost of wireline connections has decreased in the intervening years while the price of wireless has remained relatively similar to what it was. Whether these variations in pricing in different countries affect the use of wireless services is not clear.

IV. THE FUTURE OF WIRELESS: OTHER VIEWS

Before we present our forecasts for the future of wireless we need to see what others have predicted. Attempts to project the future in the wireless/mobile arena have been around from the early days of the field. One early work, the often-cited Mueller-Veerse [1999] Durlacher report, presented a comprehensive overview (for the time) of the state of wireless technology and mobile applications with some projections into the future. Scornavacca et al. [2006] reviewed 235 papers dealing with mobile business published between 2000 and 2004. They found that 17 of these papers dealt with "strategic analysis," which included, according to the authors, papers that discussed the future of m-commerce. Articles from this time mostly focused on the future of specific wireless technologies or new mobile applications. For instance, Hart and Hannan [2004] examined the future of mobile device screen technology, wireless connectivity, and battery life, and Varshney and Vetter [2002] presented an extensive list of emerging mobile commerce applications.

More recent articles often continue the approach of dealing either with future wireless technology or with future mobile applications. Walker, Turnbull, and Sim [2007] discuss their view of the key trends in mobile device hardware and software including the growth of high-level operating systems, the retention of a share of the market by specialized devices, the continuing challenge of preserving battery life, the growth of storage capacity, the ubiquity of WiFi, and the enhancement of rich content services.

Mohr [2006] focuses on mobile and wireless communication and examines the trends in this area including advance of the Internet, advance of mobile communication, bandwidth evolution, convergence of digital industries, advance of e-commerce, deregulation and globalization, services and applications as key, and reduced cost/bit. Mohr also lists trends that influence the future development of mobile and wireless communications including social trends (individuality, mobility), economic trends (widespread use of the Internet, cost reduction, high-speed Internet

access), and technology trends (multimedia services, variety of devices, machine-to-machine communication). Finally, Mohr examines the work being done worldwide in systems that go beyond 3G and discusses some the projects that are underway for next generation mobile communications systems.

New wireless applications are often proposed in the literature. Varshney [2005] examines potential wireless applications in which moving vehicles are actively involved in the system, for which he coins the term vehicular mobile commerce. He sees a future where vehicles are used as mobile business tools, for mobile advertising, for location-based services, to provide wireless Internet services, for diagnostic and safety messaging, to manage highways and traffic, and to broadcast contents and entertainment services.

Unlikely the previous authors, Junglas and Watson [2006] examine the future of both wireless technology and mobile applications in describing their vision of ultimate commerce or u-commerce. They foresee a converging world of ubiquitous networks and universal devices in which users are uniquely identified by person, location, and preferences, and data and applications are in unison across multiple devices.

Some papers go beyond intuitive speculation and report on projects that are designing future systems or on empirical research into the future of wireless. Herzog et al. [2007] describes wireless research projects being conducted in the German state of Bremen in which new wireless technology and mobile applications are being implemented and tested. Shim et al. [2007] includes a report on an international research project in which users are asked questions about future wireless scenarios. The goal of this research is to understand how certain socio-cultural constructs impact user's intention to adopt new wireless technologies and mobile applications.

In addition to academic publications, trade publications publish articles that speculate on the future of wireless and mobility. One example is Haskins [2007], which reports on one industry expert's predictions that the "next big thing" in mobility may include broadband ubiquity, mobile media, location-based services, search and discovery, custom user interfaces, and mobile social networking.

Finally, many articles that deal with various aspects of wireless and mobility, while not forecasting the future, include suggestions for future research. Scornavacca et al. [2006] proposed several directions for research in mobile business including research into mobile business applications, research that gathers empirical data related to mobile business, and research that develops new theories related to mobile business.

V. WHITHER WIRELESS?

With this background we are now ready to make our forecasts about the future of wireless. We take an approach that is more general than most others, not focusing on specific wireless technology or mobile applications, or both, but instead on large themes that may have a wide impact. We must again issue the caveat that forecasts of the future are likely to be wrong, but we hope that in giving our views we spark interest that leads to fruitful discussion and research. We make six forecasts in the sections that follow.

FORECAST 1: THE NETWORK OF THE FUTURE WILL BE WIRELESS

Today we have various communication technologies for wireless networks that span wide areas, metropolitan areas, and local areas. These existing wireless technologies will continue to evolve and new technologies will be developed. Wireline technology does not provide all these network options and the development of the technology appears to have slowed.

Wireless networks are easier and less costly to install than wireline networks. With wireless networks it is not necessary to drill holes in walls and pull cables through buildings. Wireless networks are more flexible than wireline networks. They are not limited by building architecture but can connect users nearly anywhere they are located. Businesses will increasingly select wireless for their network needs. Home users have already discovered their advantage. Anyone with a wireless router for their DSL or cable connection knows that they can use their wireless enabled computer from anywhere in their house or garden. And, as pointed out earlier, WiFi hotspots are becoming universal.

The nature of the work environment changed with the advent of wireless. Employees no longer need to be tethered to a cable for their computing needs. They can work wherever they happen to be, which could be a hotel room, an airport terminal, a café, a park, or at home. These nomadic employees will continue to insist on more and better wireless communication.

All this leads us to conclude that the network of choice in the future will be a wireless one.

FORECAST 2: THE PERSONAL COMPUTER OF THE FUTURE WILL BE THE MOBILE PHONE

Although people will continue to use wireless-enabled laptop computers because of their larger screen size and easier to use keyboard, in the future the most widely used personal computer, and the one that will often be the first selected by the user, will be the mobile phone. The functionality of the mobile phone continues to increase. Today people regularly check their e-mail and surf the Web with their mobile phone while riding a bus, waiting for a friend to arrive at a restaurant, or participating in a business meeting. New functionality will be added, and business or private consumers will soon find they cannot live without an advanced mobile phone. The instant-on characteristic of a mobile phone will also be an incentive to use it; no one wants to wait while Windows boots on a laptop just to check their email, the weather report, or the latest sports scores while waiting in line for a coffee.

The mobile phone is ubiquitous. In 2005, nearly 2.2 billion mobile phones were in service in the world [Central Intelligence Agency 2008]. Mobile phone penetration varies by country, ranging from zero in a few countries [Central Intelligence Agency 2008] to more than 100 percent in 30 countries [Wallace 2006].

Processing power and memory size will increase in mobile phones, which will allow for more complex applications. But many applications will continue to run on a mobile server. On-demand applications will find a home with mobile devices, and we may end up calling them mobile-software-as-a-service (mSaaS).

Nomadic employees will not be able to work without their mobile phones, not just for voice calls but also for checking inventory, confirming orders, tracking contacts, and other “road warrior” tasks. Among many employees text messaging is now ubiquitous and the preferred method of communication. New mobile applications will arise that will drive the demand for newer and more sophisticated mobile phones.

We conclude that in the future the mobile phone will go far beyond its current state as the first truly personal computer and become the first computer one reaches for on a regular basis.

FORECAST 3: INCOMPATIBLE WIRELESS COMMUNICATIONS STANDARDS WILL NOT MATTER

Communications standards continue to proliferate, and we do not see an end to this confusion. But we do see devices incorporating more and more standards, and software providing the transition between the standards. Multiple-band mobile phones have been available for a number of years, allowing travelers to visit other countries without worrying about which cellular technology they will encounter. Many devices now contain various combinations of WiFi, Bluetooth, and cellular communication. Fujitsu offers a laptop computer with UMTS, HSDPA, and WiFi. WiMax and other new communications technologies will be supported as they become available.

The problem with multiple communications technologies in one device is making the use of those technologies transparent to the user. Users should be able to move from one location to another with different forms of communication at each location without having to make adjustments to their devices. The solution to this problem lies in the software that recognizes which standard is used locally. It is up to the device providers to include the necessary software to accomplish this. Business users and consumers will demand this capability, however, and in the end it will be available on all devices.

Seamless transfer between communications environments will be the norm in the future.

FORECAST 4: WIRELESS SECURITY WILL IMPROVE BUT WILL CONTINUE TO BE A PROBLEM

Given the relatively poor state of wireless security, it is inevitable that security will improve, if only for competitive reasons. As older phones are replaced with newer ones, WAP 2 will replace WAP 1 (or even newer versions of WAP), thus improving security on mobile phones. Increased processing power and memory on mobile phones will also mean that more powerful security measures can be implemented on these devices. Longer encryption keys will be used and more complex encryption algorithms will find their way into mobile devices. Laptop computers and other devices will automatically set security parameters, thus making security transparent to the user.

At the same time new security breaches will be found (often by teenage hackers). The new problems will be fixed, but then other problems will appear requiring another level of security. Security requirements will continually escalate in this fashion, and everyone from government agencies to individuals will regularly expect new and better security.

As security improves, confidence in the use of mobile devices will increase. But the best security can always be broken. Users will have to accept this possibility, just as they appear to accept it with computers connected to wireline networks. Mobile service providers will have to provide financial guarantees to users in order to gain their trust, and users will have to be educated in preventing social engineering breaches of security.

Although wireless security in the future will improve, the problem will persist.

FORECAST 5: THE FOUR Us OF ULTIMATE COMMERCE WILL BE REALIZED

Junglas and Watson [2003, 2006] described four U-constructs for their view of the ultimate form of commerce:

1. ubiquity
2. uniqueness
3. universality
4. unison

With current technology we have the first two constructs. Ubiquity relates to reachability, accessibility, and portability. Today's mobile phone users can be reached by and can access mobile services with their portable devices anytime and anyplace. Uniqueness has to do with localization, identification, and portability. It is technically possible to locate a mobile phone and identify to whom the phone belongs.

The remaining two constructs are more problematic. Universality has to do with making the devices and the networks universally usable and multifunctional. We will approach this goal as devices increase in user transparent communications capabilities and as more functions are added to devices. Unison relates to integrating data across multiple devices and applications. We already have some of this capability with synchronization of data on PDAs and PDA-enabled mobile phones with desktop computer databases, but more capability will be added in the future. We can expect the address book in a mobile phone will automatically synchronize with the address book in a laptop as soon as the two devices are brought in close proximity.

Although we have a ways to go, we can see that all the U-constructs of ultimate commerce will become a reality in the future.

FORECAST 6: THE MARKET DRIVER FOR WIRELESS TECHNOLOGY AND MOBILE APPLICATIONS WILL BE CHINA

In 2006, there were over 461 million mobile phones in China, which is significantly more than the 233 million mobile phones in the United States and nearly as much as the 466 million mobile phones in the 27-country European Union [Central Intelligence Agency 2008]. China's population is over 1.33 billion people (compared to 304 million in the U.S. and 491 million in the EU), and its mobile phone penetration, although not up to that of the many countries, is rapidly growing. Its fast-paced industrialization is placing increased need for and demand on communications. At the same time, China has an inadequate wireline infrastructure, thus giving additional impetus for increased mobile phone use.

China developed its own 3G phone standard, called TD-SCDMA, which differs from the WCDMA and CDMA2000 3G standards adopted elsewhere. Although implementation has been delayed [Einhorn 2007], China's mobile phone market is large enough that it could dictate the *de facto* standard for 3G as well as other forms of wireless for the rest of the world.

In the future, wireless providers will have to consider the China market or be left behind.

VI. RESEARCH OPPORTUNITIES

Our forecasts about the future of wireless lead us to many questions, some of which could provide fruitful opportunities for research. Here we look at just a few of these questions. Many have already been investigated to some extent by others, but more can be understood about each.

HOW CAN EXISTING WIRELINE APPLICATIONS BE ADAPTED FOR MOBILE TECHNOLOGY?

As mobile devices and wireless networks become more widely accepted, it will be necessary to modify existing applications so that they are accessible anywhere. For example, ERP systems, which have become the backbone of business data processing, will need to be available from mobile devices as well as from fixed terminals. Users will demand such access and, in fact, SAP already has some mobile capabilities. CRM and supply chain management systems will also need mobile access. As another example, knowledge workers will want to retrieve information from knowledge management, business intelligence, and similar systems using their mobile devices as they move from location to location in their jobs. If our forecast that the mobile phone will be the personal computer of choice in the future becomes true, then these enterprise applications will have to be made available on mobile phones. Adapting large, complex, wireline systems for use with small mobile devices presents many challenges, and investigating paradigms for this task can result in new approaches to system design.

HOW CAN, OR SHOULD, NOMADIC WORKERS BE MANAGED?

If, as we forecast, wireless networks becoming the norm in the future, more and more employees will not work at a fixed location. Knowledge workers, especially, already find themselves working at airport lounges, in hotel rooms, at cafés, in remote offices, and at their homes. But many more employees will find working at nontraditional locations advantageous—not only to themselves but also to their organizations. Managing these nomadic workers is different from managing static employees who work only at one company site. Assigning tasks, monitoring progress, coordinating activities, and other management functions requires new ways of thinking. Just dealing with the conflicts that arise between nomadic and static employees alone poses a challenge. These management issues become even more complex with virtual teams where members are scattered throughout many locations, often worldwide. Investigating these issues, using both a descriptive and prescriptive approach, could lead to new insights in organizational behavior.

WHAT ARE THE MOST IMPORTANT SOCIAL ISSUES RESULTING FROM MOBILITY?

Many mobile devices, especially mobile phones, can be used almost anywhere. Today it is common to see people talking on a mobile phone while walking down the street, seated in a restaurant, or waiting for a bus. As non-voice applications for mobile phones become more common in the future, the incidence of their public use is likely to increase. Checking e-mail on a Blackberry or similar device in public locations has also become common. Even the use of WiFi-enabled laptop computers at cafés or in public parks is ubiquitous. There are important questions related to the use of wireless technology in social settings. For example, in what social situations and for what purpose is it acceptable to use a mobile device? On a practical side, how should mobile service providers adapt their offerings to account for the acceptable social norms? Although, as noted earlier, some work has been done in this area, more study of actual and desired behavior of mobile device users in social settings is needed to answer these and related questions.

WHAT CHANGES NEED TO BE MADE IN MOBILE SERVICES AND APPLICATIONS FOR GLOBAL USE?

The world is much smaller today than it was 20 or even 10 years ago. Wireless communication with a colleague halfway around the world is as easy as calling your neighbor across the street, and in some cases just as inexpensive. More relevantly for us, mobile commerce technology can now connect customers to mobile service providers at distant locations, and global companies can provide mobile applications to geographically dispersed employees. But these service providers and companies must understand the cultural differences among customers and employees around the world and adapt their offerings for these differences. The size and importance of China in the wireless future makes adapting to the many diverse cultures of that country alone both important and a daunting task. Identifying those characteristics of a mobile service or application that require changes for global use and determining the best approach is a complex, multicultural problem.

HOW CAN USERS' TRUST CONCERNS BE RESOLVED IN A WIRELESS WORLD?

Gaining user trust of wireless applications is a multidimensional problem. Providing adequate security with wireless communication, which we forecast will be better but not perfect in the future, is one dimension of this problem. Protecting user privacy is another. Many applications, whether wireless or wireline, collect personal information about users. Any application must provide guarantees about the privacy of such information. Trust, however, comes from more than just a sense of security and a perception of protected privacy. Users must be assured that all interactions with the application, especially financial ones, are adequately protected. Questions such as authentication of the service provider need to be resolved to the satisfaction of the user. These questions are more problematic, at least in the user's mind, because of the wireless nature of the connection. Developing systems that engender trust in the user will require significant investigation.

HOW SHOULD WE DESIGN THE USER INTERFACES OF SMALL DEVICES?

Mobile devices are just that, mobile, and as such most are necessarily small. Their limited physical size means they use technology that at times is Lilliputian. Most mobile phones, certainly the common ones, have small screens that are not touch sensitive and keyboards with little more than enough keys for the 10 digits. Even with those mobile phones with full keyboards, it takes careful placement of a small finger to press the right key without hitting its neighbors. Devices like these were not meant for full Web screen displays and touch typing. But if mobile phones are the device of choice in the future, software engineers must develop applications that function within their physical constraints. Designing user interfaces for small devices is a challenging task that needs more investigation.

DO ESTABLISHED THEORIES APPLY EQUALLY IN THE MOBILE WORLD?

Over the years a number of theories have become well established in the IS world. The technology acceptance model (TAM) and task-technology fit (TTF) are two that come immediately to mind. But do these and other theories

apply equally well when the user is no longer tethered to a fixed system? If our forecast that the future is a mobile one is true, then this fact must be considered in our understandings of many facets of the information systems field. For example, does mobility add a new dimension that existing theories did not consider when they were proposed? How can these theories be adopted for new user behaviors in a mobile world? Reexamining established IS theories in the context of mobility can lead to new, or the same, conclusions. At the same time, new theories may come to light that were not conceived in the fixed world.

VII. CONCLUSION

We are in the decade of wireless. Mobility is common today and we predict it will be the norm in the future. Small wireless devices with voice and multiple non-voice functionalities will find their way into consumer and employee pockets and purses to the point where most people will not be able to live without them. Common problems today of network incompatibility and questionable security will disappear from view. Universally usable wireless devices, networks, and applications will be the norm, with China having a major impact on many aspects of the wireless arena.

Organizations must plan for a mobile future, not only in their technical systems, but also for their human resources. Many of the research questions we discussed are of immediate interest to organizations. Adapting existing applications for mobile use, managing nomadic employees, adjusting mobile services for global cultural differences, and resolving users' trust concerns are some of these. Researchers have many areas to explore in trying to understand these and other questions in this challenging domain.

We began this paper with a review of the chronological decades through which information technology has passed leading up to the current decade of wireless. This short history makes us wonder what the next decade will bring. We close this paper, then, with one final forecast.

FORECAST 7: THE 2010S WILL BE THE DECADE OF CONVERGENCE

What will be the dominant information technology theme of the 2010s? We expect that this decade will be one of convergence in which disparate technologies will merge into seamless systems that support organizations and users in transparent ways. We will still have anytime, anyplace, location-based, and identity-based computing. But to that we will add *any function* and *any device* computing. Users will not be concerned about what device they are using or whether they will be able to perform their desired functions with that device. Wherever they are and with whatever device they have available to them at the time, they will be able to communicate by voice, video, or text; manage their personal and work lives; complete their job tasks; and perform any of a number of other functions, some of which we can not even imagine today. It will, indeed, be an interesting future.

ACKNOWLEDGEMENTS

The author would like to thank Paul Gray and Iris Junglas for their helpful comments on this paper.

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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 computer 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.
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