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Preparing for Wireless and Mobile Technologies in Government

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IBM Endowment for
The Business of Government

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E-GOVERNMENT SERIES

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FOREWORD

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On behalf of the IBM Endowment for The Business of Government, we are pleased to present this report by Ai-Mei Chang and P. K. Kannan, "Preparing for Wireless and Mobile Technologies in Government."

The report by Professors Chang and Kannan is based on the premise that we are about to enter the third generation of wireless and mobile technologies. Chang and Kannan write, "With the advent of third generation (3G) wireless networks and broadband in the near future, wireless devices can be content rich, enabling transmittal of content-rich graphics, video, and other information at speeds up to 2Mbps." Given these expanded capabilities, Chang and Kannan argue that government must now begin to explore ways in which it can utilize wireless and mobile technologies to enhance the delivery of e-government both to government's own employees and to citizens.

There are several key messages for government leaders in the Chang and Kannan report. First, government must now begin to measure the technology readiness of its employees and begin to educate and train them on the use of mobile technologies. From its own experience in introducing previous technologies, government has clearly learned the importance of preparing and training employees to use new technologies. Second, government must now begin to plan and identify ways in which it can begin to deploy mobile and wireless technologies. Such plans should include the development of pilot projects to demonstrate the potential usefulness of such technologies, especially in reaching citizens in geographically remote areas where citizen access is important.

We trust that this report will be useful and informative to both government program managers and information technology specialists as they begin to grapple with the new challenge of putting mobile and wireless technologies to use on behalf of government. Just as government has successfully begun to tap into the potential of the Internet to dramatically improve the delivery of services to citizens at all levels of government, its next challenge will be to tap into the potential of mobile and wireless technologies.

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EXECUTIVE SUMMARY

Recently there has been much excitement about the role wireless and mobile technologies can play in e-government initiatives. Wireless and mobile technologies are diffusing at some of the fastest paces witnessed among personal technology products all over the world. As citizens and employees become comfortable using technology and as the technologies mature, much of the potential for next-generation enterprise applications and wireless-based citizen services is fast becoming a reality. Given the focus within government organizations at all levels—federal, state, and local—on e-government initiatives to make processes more effective and efficient, the excitement about wireless and mobile technologies is understandable. So is the motivation for this study.

Our study has four important goals with regard to understanding how to leverage wireless and mobile technologies for e-government applications:

- Understanding the unique characteristics of the wireless/mobile environment and wireless/mobile technology usage
- Mapping the characteristics and usage for enterprise applications based on studies of successful adoption of the technology in private-sector settings
- Understanding the role of wireless/mobile technology in e-government based on the findings of the first two goals
- Assessing the technology readiness of the government workforce for wireless/mobile applications and increasing the likelihood of technology acceptance

Understanding the unique characteristics of wireless/mobile technology and its usage is a prerequisite to a successful wireless/mobile strategy at the enterprise level. In this context, our focus of research is to understand how the characteristics drive the usage under different situations—both from a customer/citizen viewpoint and from an enterprise usage situation viewpoint. The second goal of this study is to map the characteristics of the wireless environment to application orientation in the enterprise context. This is accomplished using studies of initiatives and implementations in private-sector organizations. The focus is on identifying the underlying common factors that are related to mapping wireless characteristics with application orientations. Identification of such factors helps in a normative way in understanding what types of applications can be successful in leveraging wireless technology and under what specific usage situations. We develop a prescriptive matrix that managers can use to evaluate the application of wireless technology to specific applications.

Based on the findings of the first two parts of the research and the prescriptive matrix, the third part of the study examines emerging e-government applications and potential applications for which wireless could be leveraged successfully. The focus is on intra-governmental applications as well as upstream channel applications such as procurement and downstream channel applications such as service provision through portals and websites.

The fourth goal of the study is to illustrate the assessment of the technology readiness of the

workforce with regard to adopting wireless technology and to provide steps for increasing employees' likelihood of accepting new wireless and mobile technologies. We also provide suggestions to help government agencies increase employees' technology acceptance.

Key Findings

- The widespread use and personal nature of wireless/mobile technology make it appropriate for government-to-employee (G2E) and government-to-citizen (G2C) applications. However, due to limited security/privacy features and a plethora of incompatible standards, it is currently more suitable for G2E applications rather than G2C applications. Government-to-business (G2B) (vendors/system integrators/contractors) applications also have significant potential.
- Strategies for successful wireless adoption depend on four important factors: extent of mobility in the target segment, information access needs, security/privacy requirement of the application, and technology readiness of the target segment.
- Most of the current applications of wireless/mobile technology in government are basically taking advantage of the "low-hanging fruit"—e-mail, situational awareness, procurement updates, field-force automation, etc. A few citizen-centric applications are motivated by the need to reach out to geographically remote communities or by the lack of wired access.
- Measuring employees' technology readiness is a key component of the wireless technology implementation process. Employees' technology readiness is a good predictor of their attitudes toward wireless technology adoption in their work processes and their ultimate acceptance of wireless/mobile applications.
- Employees' acceptance of wireless technology can be influenced through technology training and other programs. These can have a positive impact on employees' perceptions of the usefulness of wireless applications, the ease of use of wireless applications, and the availability of necessary resources.

Recommendations

- *Measure Technology Readiness, and Educate and Train Employees.* Based on a technology readiness measurement, an important first step is planning for formal education and training focusing on wireless/mobile technology basics, specifics, and role in government.
- *Harvest the "Low-Hanging Fruit."* Once the low-hanging fruit are identified based on the prescriptive matrix, government organizations should go for quick and full deployment to take advantage of the productivity improvements.
- *Plan for the "Stars."* Stars are high-impact projects that have complex requirements in terms of security/privacy needs and information interactivity and reliability needs. These projects should form part of strategic plans, and budgets should be allocated for experimentation and pilots.
- *Launch Pilot Programs.* Government organizations should think creatively in identifying opportunities for wireless/mobile implementation. Wireless may be a good substitute for wired technology in geographically remote areas where citizen access is important. Wireless may indeed play a role in bridging the "digital divide," given its wide usage. Creation of a central testing environment, such as the Defense Information Systems Agency (DISA) or the National Institute for Standards and Technology (NIST) laboratories, may help significantly in launching pilots.
- *Encourage Employees' Wireless/Mobile Use.* Increasing the employees' comfort with the technology and their perceptions of ease of use is the best way to prepare employees for technology acceptance.

In the context of the fast-paced developments in wireless technology and widespread consumer adoption of the technology, it is imperative that public-sector organizations focus on integrating the wireless channel as part of their multi-channel effort to reach citizens and businesses, as well as use mobile technology within their processes. However, public-sector organizations should not rush into premature applications of the technology without understanding the technology, usage, and their workforces' readiness. Our study helps in understanding the dynamics of wireless adoption in the context of government-sector organizations.

Introduction*

"Hopefully, high-speed access will come over the air as opposed to fiber optics."

—President George W. Bush

"The greatest challenge we face is to get a handle on how new technologies have created new opportunities, and to reconfigure government accordingly."

—Senator Joseph Lieberman

In the last five years, we have seen a phenomenal increase in initiatives and efforts toward reinventing government with the help of information technology (IT). This trend has been fueled by the dot.com era and the changing expectations of citizens and government employees, and by the desire of government leaders to capitalize on the emerging technologies to make government processes more efficient and effective. Part of the current excitement of this trend is the emergence of the wireless channel. The wireless channel is being viewed as the extension of the Internet-based e-channel, a paradigm shift from the static terminal of the personal computer (PC) to the flexible "anytime, anywhere" context of the mobile environment.

Although the enthusiasm has been dampened a bit by the dot.com bust, the concept of enabling enterprise, commerce, and service applications for citizens, businesses, and employees anytime, anywhere is being viewed as the next big technology-enabled breakthrough looming over the horizon.

Many mobile devices, such as notebook computers and personal digital assistants (PDAs), are already being used as extended enterprise tools. This mobile suite is now being supplemented by digital telephones with Internet and wireless data access capabilities. The extended enterprise applications are closely followed by wireless commerce applications directly to the customer and consumer via these wireless devices.

The growth of wireless technology and its potential for enterprise applications have already galvanized private-sector organizations to focus on system designs and business models that can render the applications a reality. There is a similar growing interest in the government sector as evidenced by agency-level projects that seek to leverage the wireless technology for e-government applications: Department of the Interior's emergency response systems, Army Corp of Engineers' support of the mobile workforce, and the wireless portal services of the Defense Information Systems Agency and the

* The authors would like to thank Ranapratap Chegu and Mark Abramson for their critical review of earlier drafts and for their many suggestions and contributions of content to improve the exposition of this report.

United States Postal Service (USPS), to name a few. Whereas these efforts can be viewed as taking advantage of the low-hanging fruit, it is important to identify and understand the nature of the wireless/mobile technology and its appropriateness for different enterprise applications, the key drivers of successful adoption and application, and, most important, the technology readiness of the government workforce and citizens. These are precisely the objectives of this research report as we outline the context and research issues in the following sections.

Era of E-Government

The coming decade is clearly the era of e-government. Societies in each city, state, and country are increasingly interconnected, and citizens and customers who have experienced the improvements and efficiency that the Internet facilitates are demanding more from their governments—at the federal, state, and local levels. In fact, a recent study by the University of Maryland's Center for e-Service and Rockbridge Associates (Federal Computer Week, 2002) reveals that government websites in the United States attract more visitors than commercial websites, underlining the emerging importance of e-government. This trend is not confined to the United States. All over the world, governments are increasingly leveraging connectivity to provide citizen services electronically; the list includes Australia, the United Kingdom, Germany, Taiwan, Singapore, and Malaysia.

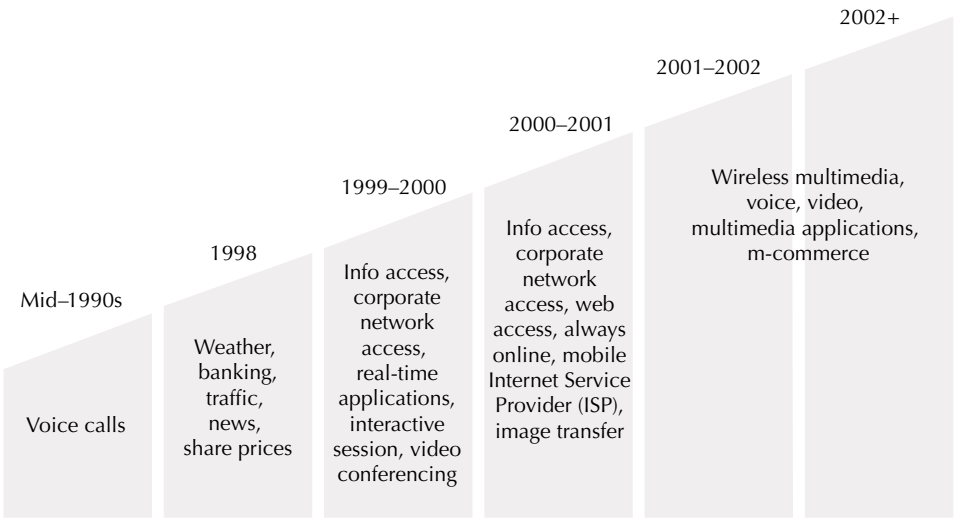
In the United States, e-government is thriving at all levels of government. It has been reported that more than 60 percent of all Internet users in the United States interact with government websites (OMB, E-Government Strategy, 2002). State and local governments, given their closer proximity to citizens, have taken the lead in many cases to provide direct service through the Internet channel. At the federal level, with a view to making government more focused on citizens and results, President Bush has made "expanding e-government" a priority in his Management Agenda. The E-Government Strategy report of the Office of Management and Budget (OMB) (February 27, 2002) points out that the primary focus of the "expanding e-government" initiative is on citizen service—to make it easy for citizens to obtain services and interact with the federal government, to improve the government's responsiveness to citizens, and to improve government efficiency and effectiveness. The report further points to suboptimal technology leverage and resistance to change as two key reasons, among others, for the federal government's inability to increase productivity. In the 1990s, government agencies used IT to automate existing processes rather than to create efficient solutions through process redesigns. Moreover, agency culture, fear of reorganization, and fear of technology created resistance to integrating work and sharing use of systems across agencies. Our study is specifically relevant in this context because it focuses on understanding technology and assessing its fit to applications and processes, and understanding the technology readiness of employees to help identify appropriate implementation of technology and successful adoption.

Wireless/Mobile Technology Trends

In this study we use "wireless" and "mobile" interchangeably, while being fully cognizant that mobility does not always equate to the wireless space, and wireless does not always equate to mobility. However, there is significant overlap in applications of these technologies, so it makes sense to treat them together for the purpose of this study. However we define the basic technology, it is inarguable that the technology is diffusing at one of the fastest paces witnessed among personal technology products all over the world (see Figure 1).

Studies by various market research firms lend credibility to this trend. Gartner predicts that by 2004, 60 percent of office productivity workers will carry or own at least three mobile devices, and 80 percent of all new applications for consumer use will permit access from wireless devices (Casonato, 2002). International Data Corporation (IDC) has estimated that pervasive computing devices, which include PDAs, wireless phones, pagers, and global positioning systems (GPSs), will exceed 6 billion (Caldow, 2001). By 2003, wireless phones will be as common as television sets. This applies not only to the United States but also across third-world countries, where consumers are directly adopting wireless phones, completely bypassing wired connections. In countries like Japan and Finland, wireless devices have become a social phenomenon—users

Figure 1: Wireless and Mobile Technology Trends



State of Technology	First Generation Systems (1G)	Second Generation Systems (2G–2.5G)	Third Generation Systems (3G)
Features	Analog voice service, no data	Digital voice and data, 9.6–14.5 Kbps data, enhanced calling features, not always on data connection	Superior voice quality, up to 2 Mbps always on data, broadband data services

Source: PricewaterhouseCoopers Consulting

play games, send and receive instant messages, access data, and use them as substitutes for PCs.

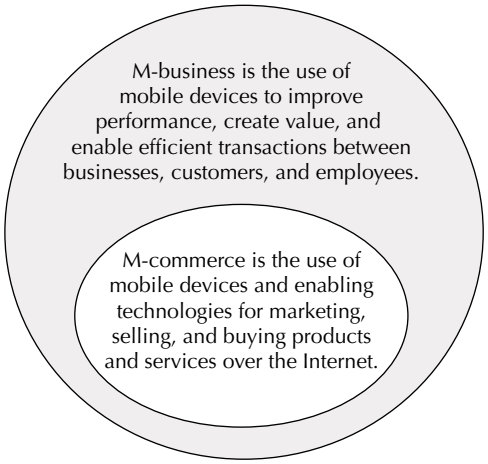
The growth in device sales is also spurring commerce. The market potential for wireless commerce is quite significant. Market researchers predict that by the end of 2005, there will be almost 500 million users of wireless devices, generating more than $200 billion in revenues (Ovum Online, 2000). By 2004, more end users will access the Internet via handheld mobile terminals than wired connections (ARC Group, 2002). And by 2006, the global m-commerce market will be worth $230 billion (Strategy Analytics, 2002).

The current generation (second generation or 2G) of wireless/mobile technology includes cellular phones, pagers, wireless-enabled laptop computers, PDAs, wireless local area networks (WLANs), and GPSs, with the wireless service providers' technology enabling transmittal of voice and text/data (at 9.6 to 14.5 Kbps) working fairly well. With the advent of third generation (3G) wireless networks and broadband in the near future, wireless devices can be content rich, enabling transmittal of content-rich graphics, video, and other information at speeds up to 2 Mbps. Currently, technology such as Bluetooth can provide short-range wireless connectivity that can link several types of devices enabling seamless interactions among various devices. 3G technology can further extend the similar functionality and coverage. There is consensus, however, that 3G services require resolution of several factors such as spectrum allocation, technical development, and significant network build-up before their potential can be realized. Although this may take several years, telecommunications companies are rolling out 2.5G services such as general packet radio service (GPRS) that can provide significant improvements over 2G services.

With the rapid penetration and adoption of personal technology worldwide and with the impending expansion of network functionality and capacity to provide rich content in a mobile environment, wireless/mobile technology has significant potential for providing commercial applications, especially in the business-to-consumer (B2C) domain, which we call "m-commerce" (see Figure 2). At the moment, wireless and mobile technologies are being adopted significantly in the business-to-employee (B2E) realm because their benefits (such as productivity gains) are easily quantifiable and therefore their adoption is justifiable. We call this domain "m-business."

Although this trend is significant in private-sector applications, it is also quite visible in the public sector. At the state and local government levels in the United States, there is greater emphasis on using wireless/mobile technology for public safety and emergency response applications, such as supporting field personnel, sharing information, locating personnel, and maintaining network communication. At the federal level, wireless applications are prominent among the 24 initiatives that OMB's E-Government Task Force has identified as priority e-government implementations. For example, the Department of the Treasury will manage the Wireless Public Safety Interoperable Communications (SAFECOM) project aimed toward achieving interoperable wireless infrastructures among all levels of government. It is clear that against this backdrop, the time is right to examine the role that wireless and mobile technologies could play in e-government.

Figure 2: Difference between M-Commerce and M-Business



Research Issues

Our study has four important goals with regard to understanding how to leverage wireless technologies for e-government applications:

- Understanding the unique characteristics of the wireless/mobile environment and the use of wireless/mobile technology
- Mapping the characteristics and usage for enterprise applications based on studies of successful adoption of the technology in private-sector settings
- Understanding the role of wireless/mobile technology in e-government based on the findings of the first two goals
- Assessing the technology readiness of the government workforce for wireless/mobile applications and increasing the likelihood of technology acceptance

Understanding the unique characteristics of wireless technology and its usage is a prerequisite to a successful wireless strategy at the enterprise level. In this context, our research focuses on understanding how the characteristics drive the usage of the technology under different situations—both from a customer/citizen viewpoint and from an enterprise usage situation viewpoint. Our prior research in this area (Chang et al., 2002; Kannan et al., 2001) has uncovered interesting insights into how consumers use this technology and how it affects their behavior. We extend this work in the domain of enterprise users and in the context of enterprise application.

The second goal of this study is to map the characteristics of the wireless environment and application orientation in the enterprise context. This is accomplished using studies of initiatives and implementations in private-sector organizations. The focus is on identifying the underlying common factors that are related to mapping wireless characteristics with application orientations. Identification of such factors will help in a normative way to understand what types of applications can be successful in leveraging

wireless technology and under what specific usage situations. We develop a prescriptive matrix that managers can use to evaluate the application of wireless technology to specific applications.

Based on the findings of the first two parts of the research and the prescriptive matrix, the third part of the study examines emerging e-government applications and potential applications in which wireless technology can be successfully leveraged. The focus is on both intra-governmental applications as well as upstream channel applications such as procurement and downstream channel applications such as service provision through portals and websites. We also examine the pros and cons of adopting wireless technology within an e-government setting.

The fourth goal of the study is to illustrate the assessment of technology readiness of the workforce with regard to adopting wireless technology and to provide steps for increasing employees' likelihood of accepting new wireless and mobile technologies. Wireless devices are *personal* devices, carried by employees, customers, and citizens on their person. The usage of wireless devices and the ultimate success of the projects will depend on the technology readiness of the employees of an organization with respect to wireless technology.

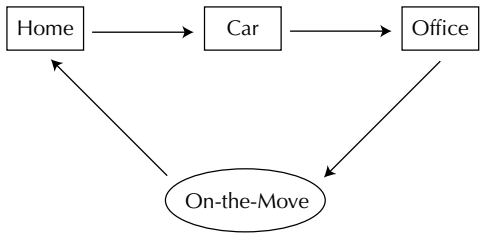
The study includes a survey that collected responses from a group of federal employees on multiple-item scales (some developed by Rockbridge Associates to measure consumer technology readiness) to understand how the technology readiness of employees relates to their attitudes toward adoption of wireless applications and perceptions of their usefulness. Students from several government agencies who attend classes at the National Defense University, Information Resources Management College (IRMC), were surveyed for the study. The survey offers insights into understanding perceptions of employees toward wireless technology and formulating appropriate implementation strategies. We also provide suggestions that a government agency can use to increase its employees' technology acceptance.

In the context of fast-paced developments in wireless technology and widespread consumer adoption of the technology, it is imperative that public-sector organizations focus on integrating the wireless channel as part of their multi-channel effort to reach businesses and citizens as well as use mobile technology within their business processes. Adoption of the wireless environment by citizens and private-sector organizations creates an expectation among citizens and businesses toward such integrated channels of communication and commerce. However, public-sector organizations should not rush into premature applications of the technology without understanding the technology, its usage, and their workforces' readiness. Our study focuses on helping government-sector organizations understand the dynamics of wireless adoption.

Understanding Wireless/Mobile Technology

In this section, we focus on key characteristics of the wireless/mobile devices and technology and the characteristics of the environment within which the applications are embedded. It is necessary to remember that devices vary in processing capability from cell phones and pagers, to PDAs and laptops. We will focus mostly on cell phones, pagers, and PDAs, and when necessary address issues regarding laptops separately. The characteristics we discuss are relevant to both G2C (B2C) and G2E (B2E) applications.

Figure 3: Ubiquitous Interactivity



Adapted from Chang et al., 2001

Device Characteristics

The key characteristic of the wireless environment is "ubiquitous interactivity" (see Figure 3), as opposed to "interactivity" of the Internet environment, because the wireless device is one that is always handy and available to an individual. These characteristics distinguish wireless devices from PCs and laptops, which are not generally handy or easy to use at a moment's notice, although they may be available at all times. Second, a wireless device is distinctly *personal,* and its usage can be tracked to an individual rather than to a household, as is the case with PCs and other devices. Third, wireless technology is "location aware"; that is, it is easy to track where the user is physically as long as the wireless device is on. These characteristics have important implications.

The first implication is the issue of accessibility. A wireless device enables a citizen to access government services at any time and from any place. It also allows employees and organizations (government agencies) to access each other at any time and from any place. The second implication is that a citizen can be targeted specifically and reached by a government agency instantaneously because a wireless device can be associated with a particular consumer rather than a household or Internet protocol (IP) address. This may allow a government agency to be proactive in providing services and reaching citizens at their points of need. (In the B2E context, this implies that a government agency can contact a specific employee—who is telecommuting, for example—at a moment's notice.) This enables the organization to interact quickly with citizens and employees.

Location awareness also implies that an organization can pinpoint where the citizen or consumer is using the wireless device. This has implications for the types of applications being considered for wireless deployment. It is advantageous in an emergency situation when the caller needs to be located and rescued. However, it might imply an unnecessary invasion of privacy.

Usage Characteristics

Given the near-term limitations in information processing capabilities and information transmission capabilities, the usage of wireless/mobile devices in their current form and technology is an important factor to consider in any development of applications. Given the constraints of its size for handy usage, the user interface of a wireless device is quite limited and cannot display information-rich content in a useful way. (This is not the case for laptops, but then laptops are not very handy.) This constraint limits the clients' capabilities for processing and storing information and data. Most important, the bandwidth over the air for wireless transmission is also a constraint in the near term. These constraints limit the use of wireless technology to predominantly text-based, less information-intensive exchanges and interactions.

This limited usage implies that a consumer's (or citizen's) search for information in the wireless environment may be limited, and customers may be constrained in their search behavior (Kannan et al., 2001). This may also imply that there are higher switching costs in moving away from an organization with which a consumer is transacting business in the wireless environment. This may suggest that there could be first-mover advantages for an organization using the wireless channel to retain customers through implementation of customer relationship management (CRM). This is aided by four factors: (1) the ability to provide truly personalized content and service by tracking personal identity, (2) the ability to track consumers across media and over time, (3) the ability to provide content and service at the point of need, and (4) the capability to provide highly engaging content. In the case of service provision from a government-agency viewpoint, this constraint has implications on how such services may be provided. Also, in the B2E domain, the interaction and transfer of content may be quite limited in nature. The technology can be used for sending alerts and for short interactions but not for transferring large amounts of enterprise data.

Another usage-related issue is consumers' *compulsion to use* wireless technology. The convenient nature of the wireless device has made it easy for consumers to use the technology for interactive purposes such as "chats." Experiments have shown that consumers who use wireless devices for making commercial transactions (such as trading stocks) tend to use the same devices even when alternative channels (Internet, telephone, etc.) are available for making those transactions (Chang et al., 2002). This tendency may indicate that as costs decrease and bandwidth increases, the wireless channel can significantly substitute other channels for service delivery to the extent that customers adopt the technology. As the technology advances, the most significant potential lies in the delivery of services over wireless devices, including interactive games; gambling; banking; stock trading; and booking and ticketing for travel, hotels, and events. This tendency will also create expectations regarding services obtained from government agencies.

The compulsion-to-use aspect of the wireless technology also implies, in the case of B2E applications, that identification of user technology readiness can pay rich dividends. If employees are already significant users of the technology, their compulsion to use the technology can facilitate the adoption of wireless applications. This also points to the advantage of launching pilot programs within organizations to study the use of wireless for enterprise applications—it prepares employees and organizations for easier transitions when the technology starts delivering on its potential.

Environmental Characteristics

Three important issues need to be addressed in the context of the characteristics of the wireless/mobile environment: security, privacy, and application platforms. These three characteristics, in addition to the other characteristics, play an important role in determining the success of wireless/mobile applications.

Security

Security in a wireless/mobile environment must be addressed at several levels. The most commonly addressed level in a cursory analysis is the over-the-air security of content being transmitted. However, security can exist at different levels: at the network infrastructure level, at the software application level, and at the device level. The security of the overall application is a function of security at each of these levels.

Let us first examine the issue of over-the-air security, which becomes a popular issue whenever a "drive-by" hack attack is reported in the press. It is undeniable that despite encryption of content that is transmitted, the over-the-air security can be breached with sophisticated hacking. Although encryption technologies are useful, there are many of them, and the problem for a single-service provider is how to accommodate all of them. The lack of standards has left the issue of end-to-end encryption for all traffic still a distant objective. But it is also true that over 85 percent of the security breaches occur at the device level—breaches involving lost or stolen devices, passwords, and lax authentication procedures and access control. In this context, wireless/mobile applications should be treated as any other IT enterprise application. The security issues are the same: having an effective security policy, authentication and access control, firewalls, and virus protection. The only additional issue will be over-the-air security. In the context of enterprise applications, depending on the coverage and application, security concerns can be minimized. Also, individual organizations can use proprietary solutions for end-to-end security without much problem, thereby eliminating many of the problems that arise from lack of standards in the B2C context. But this does create the problem of lock-in with one vendor for the organization adopting the technology.

The implication of concerns regarding over-the-air security for B2C (or G2C) applications can be twofold. One is the issue of an actual security breach, which can result in increased risk of economic loss and potential litigation from consumers. The second and more serious issue is negative security perceptions that consumers/citizens may have regarding the wireless/mobile environment that may affect their adoption of the technology for critical applications. Extant research (e.g., Frels and Kannan, 2002) has shown that security concerns can increase customers' perceptions of risks in conducting transactions in the e-channel and affect their behavior. For example, in a recent interview, a senior vice president of a wireless security services firm remarked, "I personally would not buy stocks and check bank accounts using my cell phone or mobile laptop today." (Stone 2001). Therefore, it is conceivable that over-the-air security will remain an important obstacle in the short term.

When wireless/mobile applications are used in the WLAN environment, the security issues are similar to any other IT enterprise application. The 802.11b WLANs, the common WLAN standard (see Appendix II), suffer from several problems: Wireless signals meant for enterprise use can still be intercepted from public areas; interoperable implementation can lead to less secure networks; and rogue access points can be set up with an enterprise network. However, improvements to security standards, proprietary solutions offered by vendors, and the use of "sniffers" to discourage rogue elements can provide a relatively "safe" environment for WLAN enterprise applications. Using security protocols such as the Wired Equivalent Privacy (WEP) specified in the IEEE Wireless Fidelity (Wi-Fi) standard, 802.11b can provide a level of security and privacy comparable to what is usually expected of a wired LAN. Other applications such as remote wireless access into corporate networks (without the use of a laptop) are prone to security breaches. Implementations of Bluetooth (for local, short-coverage wireless network applications) are designed to operate with as many devices as possible and thus do not have strong authentication schemes to prevent rogue elements from entering the network.

The Computer Security Resource Center within NIST provides many publications that list the benefits and security risks of many of the wireless devices, such as Bluetooth, handheld devices, and WLANs. These publications also provide practical guidelines and recommendations for mitigating the risks associated with these technologies (see http://csrc.nist.gov/publications/draft.html). There are many vendors and service providers who provide security solutions at various levels, and they should be used if vendor lock-in is not a concern. If the application is piecemeal or a pilot, which is the common type of implementation today, then end-to-end solutions provided by vendors can be used.

Privacy

The location-aware property of the wireless/mobile devices can lead to privacy concerns, especially for consumers/citizens who do not wish be to be tracked geographically. In the B2C market, organizations are excited about the prospect of communicating and interacting with consumers and persuading them at the point-of-need or point-of-

Mobile and Wireless: Aren't They the Same?

While these two words are often used interchangeably, there is a definite and logical difference between the two:

Wireless: "without wires." As a rule, almost all mobile devices are wireless, but wireless devices may not always be mobile. For example, a desktop PC can wirelessly be connected to a cable modem or a LAN to access the Internet but does not have mobility.

Mobile: "capable of moving or being moved." In terms of IT and communications, "mobile" refers to devices that are portable and can be carried by an individual to (almost) any place and still satisfy the communications needs. Some of the most prevalent mobile communication devices include:

- *Mobile phone:* Wireless hand-held phones with built-in antennas, often called cell, mobile, or PCS phones.
- *Laptop computer:* Also known as a notebook personal computer. This is the most common type of mobile computing device, having all the features available in regular desktop computers, with the additional advantage of mobility.
- *Personal Digital Assistant (PDA):* A hand-held computer that allows you to store, access, and organize information. Basic PDAs allow you to store and retrieve addresses and phone numbers, maintain a calendar, and create to-do lists and notes. More sophisticated PDAs can run word processing, spreadsheet, money manager, game, and electronic book reading programs, and also provide e-mail and Internet access.
- *Pocket personal computer:* Brainchild of Microsoft Corp., it is similar in functionality to the Palm PDA but based on the Microsoft Windows operating system. It has in-built versions of Microsoft Word and Excel software.
- *Tablet personal computer:* A hybrid of a PDA and a notebook PC. Some of its distinguishing features include the latest Microsoft XP operating system and the option of having an integrated or docking keyboard. Users can write directly on the screen using a digital pen; notes can be saved as they are or converted to text to be used by other applications. These are relatively lightweight, with longer battery life as compared to notebook computers.
- *One-way pager:* Fits easily in a shirt pocket; some are as small as a wristwatch. A miniature, short-range wireless receiver captures a message, usually accompanied by a beep. The simplest one-way pagers display the return-call telephone number of the person who sent the message.
- *Two-way pager:* Allows you to send data as well as receive it. It works much like a mobile phone, except text rather than voice is exchanged. In some cases, a two-way pager can serve as an alternative to a cellular phone.
- *Global Positioning System (GPS):* A "constellation" of 24 well-spaced satellites that orbit the Earth, making it possible for people with ground receivers to pinpoint their geographic location. The location accuracy is anywhere from 100 to 10 meters for most equipment.

purchase. For example, if a consumer were tracked walking in a shopping mall, then personalized messages can be transmitted to his/her wireless device with regard to a product or service. Such tracking can be extremely invasive, however. Similarly, cell phones, PDAs, and pagers can be tracked as they are used. Location awareness is now being used to track citizens during emergencies. However, if "emergency" were to be defined as "state emergency," then the technology can be used for tracking private activities. The potential for such applications can lead to serious privacy concerns and can severely impact the usage of the technology. In the case of enterprise applications, one can make a case that employees can be monitored at work (whether or not through wireless devices), but if personal boundaries are violated in such monitoring activity, it could lead to serious litigation problems.

Application Platforms

Another characteristic of the current wireless/mobile environment is the multitude of application platforms for end-user and client applications. These range from Wireless Application Protocol (WAP) 1.2 and Global Systems for Mobile Communications (GSM), to DoCoMo's (Japan) I-Mode, Windows CE, Palm OS, and Nokia's open middleware. WAP is an open platform, whereas I-Mode is a proprietary platform. The challenge with the presence of a plethora of platforms is to understand who the winner will be and what platforms will enjoy a large user base. Given the current state of flux in client-side platforms, rolling out applications in the B2C domain is risky. In the case of enterprise applications, the impact of this will be to render the wireless strategies of organizations quite fluid and oriented toward the short term.

Table 1 provides a summary of the various characteristics of the wireless/mobile technology and how they impact B2C (G2C) applications and B2E (G2E) applications.

Table 1: Wireless/Mobile Characteristics and Implications

Characteristics		Implications for:	
		B2C/G2C	**B2E/G2E**
Device	Ubiquity—handy, available at all time, user friendly	Citizen/consumer accessible at all times, demand for 24/7 service	Employee accessible, work accessible
	Personal	Marketed to consumer at individual level	Individual employees accessed
	Location-aware	Consumer/citizen tracked by location	Employees can be tracked by location
Usage	Search/information download—limited storage and processing capacity	Limits application to text-based, short messages, e-mail, and voice mail; search limited	Alerts employees, interacts with databases, updates information
	Compulsion to use	Implications for multi-channel design to service consumers/citizens	Easy to roll out B2E applications and easier adoption
Environment	Security—limited over-the-air security	Security risks exist, suitability varies by application	Need for proprietary solutions for end-to-end reliable security, switching costs increase
	Privacy	Consumers/citizens can be tracked, privacy standards are needed	Employee privacy must be ensured
	Application platform—too many standards	Difficult to roll out applications impacting a large market, uniformity in service could be a problem	Piecemeal applications based on standard/interoperable platforms is the way to go

Understanding Enterprise Applications

Many factors must be considered in making a decision to adopt wireless/mobile technology for B2C/G2C and B2E/G2E applications. Extant studies (e.g., Casonato, 2002) have shown that in the B2E/G2E realm, the primary reason for adopting a wireless technology was to increase employee productivity, followed by cost containment. Some organizations also consider such initiatives as experiments to launch a new information channel. In the B2C/G2C realm, service improvements and competitive advantage seem to be the main reasons for adopting wireless initiatives. Enterprises must take a proactive approach to leading the deployment of wireless/mobile technology. With the advent of sophisticated devices and the rapid adoption at the personal level, both employees and citizens/customers will be demanding that more services and access be available in handheld devices at "anytime, anywhere" environments. An enterprise will have to control the adoption of the technology on its own terms rather than fully acceding to customer/employee demands or fully banning the use of such devices. The six critical factors that enterprises should consider in adopting the technology are discussed below.

Employee/Customer Mobility

It is understandable that with the increase in mobility of the workforce, customer/citizen demand for mobile access technology will be higher. In the B2E/G2E realm, many enterprise functions require the workforce to be mobile. One example is sales and service teams, which can be frequently on the road. In addition, in some industries, workforces tend to be very mobile—for example, the construction industry, news media, transportation and logistics organizations, other organizations in the supply chain link, insurance industry, health-service industry, and retail and other service industries. In such cases, where information access or alerts are needed, wireless applications tend be the low-hanging fruit. In the B2C/G2C realm, a certain segment of consumers (who could be mobile employees of other companies or those living in large metropolitan areas) could be compulsive users of mobile technology and may demand service in that channel. Thus, it is not surprising that many financial services industries are adopting wireless/mobile technology as a complementary channel to reach and service consumers. Additionally, organizations that focus on meeting customer demand at the point-of-need or point-of-purchase can seriously consider the use of wireless technology to communicate and interact with customers based on their locations. Thus, a simple rule of thumb would declare that the larger the fraction of employees/customers that are mobile, the greater the case for wireless/mobile technology, although the following factors could play considerable roles in moderating this need.

Information Needs

This critical factor usually determines the value of wireless/mobile applications in a given context. Information needs cover four main areas:

- How intensive is the information needed in a mobile environment
- How urgent is the information requirement in the mobile setting

- How reliable should the access be in the context of the application
- The degree of interactivity desired

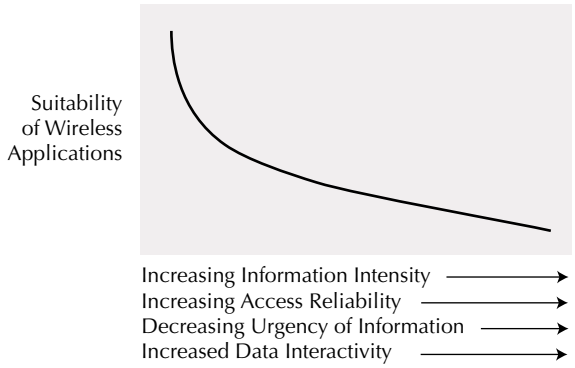
We have observed that content-rich information (animation and video) is inherently unsuitable for the 2G and 2.5G applications. The wireless environment is more suitable for text-based information. Even with text-based information, applications such as database access and updating in real time and such synchronization activities can render the information requirement intensive.

The second issue is how urgent the information requirement is. If it is not needed immediately for an application (such as in emergency situations) and can be downloaded and used later, then wired laptop-based applications could be used in place of wireless technology.

The third important issue is the reliability with which the information and access is acquired. Wireless networks are quite unreliable in their current state: Coverage is spotty, latency could be high, and there could be frequent disconnects. In the case of data applications, static could lead to unreliable information being transmitted. Or because data applications use algorithms to prevent transmittal of faulty data, static could lead to repeated, automatic re-transmission of data and thereby create delays in mobile applications. Given the limited processing and storage capacities, using information-intensive applications in such an unreliable context could be challenging. The same argument could be extended for the degree of interactivity desired. If the interactivity is voice based or involves sporadic interactivity of other types, then the reliability issue may not be significant. However, continued interactivity required for data synchronization and replication activities could pose a significant problem. Figure 4 provides a summary overview of the suitability of wireless/mobile applications as a function of the component of information needs.

In the context of B2E/G2E applications, the mobile workforce can easily use applications such as contact information for clients, address databases, calendar functions, basic personal information management (PIM), e-mail, voice-mail functions, and messaging. These activities are Level 1 activities

Figure 4: Suitability of Wireless Applications as a Function of Information Needs



(see Table 2), which we classify as *access and alert* activities (Lemon et al., 2002). These are also the most common activities for which wireless/mobile technology is currently being used. Messaging/e-mail is seen as the key application in terms of revenue in the next five years. The Level 2 activities involve access and updates and require more reliability in connection. Level 3 activities involve access and transaction, and they require continued interactivity. Office applications such as WLANs could fall in the Level 2 and Level 3 category of applications.

Table 2: Levels of Information Intensity and Types of Applications

Degree of Information Intensity	Examples of Applications
Level 1 *Access and Alert Activities*	E-mail (desktop, server-based), voice mail, PIM, messaging, and calendar
Level 2 *Access and Update Activities*	Real-time data access (checking prices, inventory, credit status), file and content distribution, basic data synchronization applications (data collection, forms, inventory)
Level 3 *Access and Transact Activities*	Advanced data synchronization applications (sales force automation, supply chain management, customer relationship management, marketing communications)

Security Requirements

The security needs for the application may further constrain the use of wireless and mobile technology for the Level 1 through Level 3 activities. In general, the security requirements for messaging/e-mail applications may not be very high, but this depends on the context within which the application is set. In the government context, it has been reported that military applications have a much higher security requirement for Level 1 applications (Intergovernmental Advisory Board [IAB], 2001). In the context of B2C/G2C applications, security risk assessments have to be carefully made given the generally poor security features of the wireless environment.

Extent of Cost/Revenue Impact

The extent of cost reduction (and/or revenue increase) from Level 1 activities is usually marginal. Generally, as applications move from Level 1 to Level 3, the cost reduction opportunities from process *changes* (rather than process *automation*) and revenue increases from productivity improvements are much more significant. In fact, many enterprises have embarked on Level 3 activities with a view toward improving their bottom line in a significant way (Anonymous, 2001). This obviously implies that the organizations can quantify the cost reductions and revenue increases through the use of wireless/mobile technology. However, there are also instances of adoption of wireless technology at Level 1 applications with a view toward experimenting with the technology and gaining valuable experience before rolling out enterprisewide deployment. This is the reasoning behind many pilot projects being carried out in enterprises—the experience allows one to evaluate the suitability of technology and its adoption to less risky processes. The learning will be useful for later deployment on larger projects.

Competitive/Strategic Advantage

There are times when an organization must deploy wireless/mobile applications because competitive pressures demand it. This is the case in the financial services industry in the B2C domain. Many full-service and discount brokers offer wireless-based transaction capabilities for their clients as a means of providing them the advantages of e-service and thereby retaining them as customers. Given the competitive pressures in the industry, the deployment of wireless technology is motivated primarily not by productivity gains or cost containment (which may certainly be by-products) but by the need to move fast and stay ahead of the competition. Many of the wireless deployments in the transportation and logistics industry have occurred for this same reason. This suggests that strategic needs and pressure for significant returns may override security concerns that may be inherent in wireless/mobile usage.

Technology Readiness

Technology readiness of users (consumers/citizens and employees) plays an important role in the decision to deploy wireless/mobile technology. We focus on this issue specifically in the upcoming sections of this report, although we have highlighted this factor here for the sake of completeness.

A Prescriptive Matrix

Based on our analysis, we provide a prescriptive matrix that considers all the relevant factors in deciding whether a specific wireless application should be deployed (see Table 3). In the next section, we illustrate the usage of the matrix in considering e-government applications.

Table 3: A Prescriptive Matrix for Wireless Adoption

		Degree of Sophistication of Technology*	
		High	Low
Technology Readiness of Target Segment	High	**Stars** *High-impact projects* Mission-critical applications of high strategic advantage should be undertaken; high-level commitment needed for success	**Low-Hanging Fruit** *Go for immediate wireless deployment* High probability of successful adoption
	Low	**Future Potentials** *Wait and see* Applications more complex; go forward with pilots; educate/train employees; wait for mature technology	**Near Harvests** *Educate/train target segment* Wireless deployment with extensive training; significant chance of success

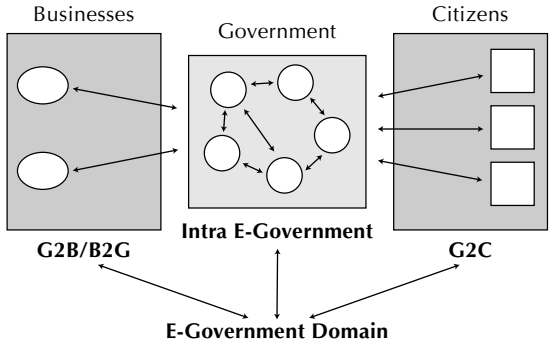
* Factors influencing degree of sophistication of technology: Information intensity, reliability of access, interactivity intensity, and security/privacy requirements. Each factor ranges from high to low.

Applying Wireless/Mobile Technology to Government

The potential for wireless/mobile applications within government is immense. It is estimated that at least 30 percent of the government workforce has traditionally been mobile (Caldow, 2001). With the advent of e-government and high-tech device use that allows telecommuting, it could easily be much higher in the coming decade. Thus, the extent of mobility in the target employee segment can be significantly high, setting the stage for widespread wireless/mobile deployment. Given that governments, by their very nature, have a segment of the workforce involved in law enforcement and compliance enforcement, transportation and logistics, and health and social services, there are many instances of low-hanging fruit—this involves the police force, traffic enforcement, firefighters, health-care workers, social workers, inspectors of all kinds, transportation officials, emergency management workers, and maintenance workers. This indicates that the potential for deploying wireless technology for *intra-governmental* applications is significant.

However, the potential does not stop there. As seen in Figure 5, e-government activities encompass not only intra-governmental processes but also the interface between businesses (G2B/B2G interface) and the interface with citizens (G2C interface). Wireless applications in these interfaces, although less common at present, also have a bright future. We first discuss the most common applications seen in e-government (the low-hanging fruit quadrant of our prescriptive matrix, Table 3) and then examine the wireless/mobile potential in other quadrants.

Figure 5: The Scope of E-Government



Adapted from Rust and Kannan, 2002

The Low-Hanging Fruit

A plethora of intra-governmental applications at the state, local, and city and municipal levels fall within this category. Most of them are characterized by the following features: high mobility of the workforce, which highlights the productivity-enhancing potential of wireless and mobile technology; low security or privacy concerns (at least currently) or operations in protected band spectrum; required urgency of access; and quick employee buy-in because of the evident gains in productivity and simplification of job functions. These applications include (see Table 4) police applications in Sacramento, California, and in Pasco, Washington; use of BlackBerry handheld devices in Seattle's transportation hub and Boston's Logan Airport to increase security against terrorism; integrated network links between Colorado Springs

Table 4: Examples of Low-Hanging Fruit Wireless Applications

	Government Agency	Application Description
1.	Sacramento, CA, Police	800 MHz radio network allows data networking and helicopter video downlink possibilities.
2.	Pasco, WA, Police	Incident reports are directly transmitted to police headquarters by wireless from incident locations.
3.	Houston, TX, and New Jersey Parking Enforcement	Handheld devices print tickets and send information directly to database using wireless.
4.	Seattle International Airport and Seaport Boston's Logan Airport	Research in Motion (RIM) BlackBerry pagers tap into National Crime Information Center (NCIC) databases, and allow e-mail and networking with other officers for crime prevention.
5.	City of Edmonton, Alberta	Building inspectors use mobile devices to enter inspection reports directly into database.
6.	Colorado Springs, CO, and El Paso County	800 MHz radio network deployed to connect 51 agencies through a shared infrastructure, including police, fire, EMS, and public utility agencies.
7.	Fire Management, Southern California	GIS systems are used to map and track moving fires for fire management.
8.	Military and Government Hospitals	Use computerized physician order entry (CPOE) for mobile tracking of patients and patient care.
9.	Biomedical Research in Mali, West Africa, by U.S. NIAID	Uses NIAID's microwave radio communication to access Internet instead of phone lines to overcome wired infrastructure problems (expensive, unreliable, and experiencing frequent outages).
10.	Department of Justice and Department of the Treasury—Wireless Public Safety Interoperability	Resolving wireless interoperability to provide seamless, coordinated, integrated public safety communications for the safe and efficient protection of life and property.
11.	Centers for Disease Control and Prevention, Atlanta, GA	Plans using GPS-equipped devices to collect data in bioterrorism-related incidents.
12.	U.S. Marine Corps	Field warehouse sites are using handheld wireless computers and special warehousing software to track inventory.

(Source: Government Technology (www.govtech.net) and IAB, 2001)

and El Paso County to share communications infrastructure for police, fire, and public utility agencies; and so on. One of the main characteristics of these projects is that the productivity improvements are immediately quantifiable and easily measured. In fact, not only have there been reports about productivity gains, process simplifications, and increases in program effectiveness through the use of mobile technology in the police force, but literature also suggests improvement in job satisfaction and employee morale (Agrawal et al., 2002). Another observation concerning these projects is that they are spread over all levels of government—local, state, and federal—indicating that such opportunities exist at all levels. Also, it is interesting to note that in some instances, wireless access acts as a substitute for wired access, especially in cases of emergency and situations of unreliable wired connections. All these opportunities are intra-governmental applications.

Government-to-Citizen Applications

These applications generally tend to fall within the "low-hanging fruit" quadrant as well as the "near harvests" quadrant. As seen in Table 5, there are not as many examples of G2C services through wireless. At the local government level, IBM's Total Web-Government project involves small cities and municipalities belonging to the National League of Cities and National Association of Counties to set up information portals that could be accessed by wireless devices. Such services aimed at the general public are especially useful where a wired network infrastructure does not exist (as in remote and sparsely populated communities) because they enable citizens to access the portals to check on community events and send e-mail to legislators. The other applications involve accessing information portals using wireless devices: bus riders checking on bus schedules, citizens checking on the status of bills, and students at universities accessing portals and the Internet through wireless devices. The universities, especially, have gained significant experience in rolling out services for students that can be accessed in the mobile mode. The advantages they possess include promoting a homogeneous population and relatively tech-savvy, enclosed, small environments that allow deployment of reliable wireless technology and easier troubleshooting.

There are many issues that need to be resolved in the G2C domain before the applications catch on. First is the issue of urgency of access: Are government services ever needed in such an urgent access mode? Except for emergency situations, this is generally not the case. Citizens could well use wired access through the Internet or telephone to access the services. However, as we have seen in some applications, if the wired infrastructure is nonexistent or expensive, then the wireless infrastructure becomes a viable alternative. In such cases, government needs to look at this service channel seriously. Second is the issue of security and privacy. For extensive rollout of services using wireless technology, an adequate level of security and privacy must be ensured. Finally, there is the issue of user acceptance of technology: Is a significant portion of the user group sufficiently tech savvy to appreciate the value of the service? This is a question of cost versus benefit that needs to be critically analyzed before a wireless deployment is contemplated.

Mobile Collaboration Applications

These government applications tend to fall within the "stars" quadrant based on their security requirements and the need for collaborative interactivity. Some examples include WLAN applications in U.S. Navy destroyers and the U.S. Air Force, wide area

Table 5: Examples of Government-to-Citizen Applications

	Government Agency	Application Description
1.	National League of Cities (NLC) and National Association of Counties (NACo)	Broadband satellite connectivity to rural and remote areas to access local government websites and information portals for checking on community events and for sending e-mail to municipal officials.
2.	King County Metro Transit, WA	Bus riders use wireless devices to access information portals to check real-time schedule information on bus arrivals and departures.
3.	State of Virginia	"Lobbyist in a Box," an interactive application, allows citizens, lobbyists, and legislators to access information on the status of bills moving through the legislative process.
4.	City of Buffalo, MN	Provides broadband data services accessible through wireless devices for citizens and businesses as a subscription-based service.
5.	University of Texas at El Paso Various State Universities	Local wireless access to the Internet and students services are becoming more common in such captive environments.

Source: Government Technology (www.govtech.net) and IAB, 2001

network (WAN) applications in the city of Blacksburg in Virginia and the town of Enfield in Connecticut, and the two-way messaging systems of the Department of Energy in the Nevada Operations Office. The common feature in these applications is that they are all in the intra-governmental domain, all requiring effective security features, and all requiring a good deal of interactivity in applications.

Most of these applications are also mission critical. For example, in the U.S. Navy application, sailors aboard the U.S.S. Howard use wireless devices to access the ship's wired LAN from wherever they are on the ship. The technology helps in the critical maintenance operations aboard the ship. The WAN application of Blacksburg uses wireless to connect the city's government agencies to help provide integrated services to the community.

These applications are "stars" in the sense of their potential revenue/cost impact, which can be of an order of magnitude larger than those in the low-hanging fruit quadrant. Sometimes, competitive pressures can lead to the deployment of "star" applications, even within the government, without much regard to potential cost/revenue impact. A case study at one branch of the U.S. military has been reported (Anonymous, 2001) where competition for potential recruits is quite fierce between branches of the armed forces. This branch, which traditionally used form-based tracking of potential recruits, switched to using wireless-based applications to facilitate the process and reduce lead times in recruiting, and to help field recruiters react quickly to the market.

Future Potentials

Many potential applications in the e-government realm can become a reality with maturing technology, increased security, and increased bandwidth. These include applications such as e-learning through wireless technology, wireless WAN applications, CRM applications based on service portals accessed by citizens in a secure and private mode using their wireless devices, and so on. Although the potential is seemingly limitless, it is necessary to understand that wireless is but another alternative channel that can be used for services. Therefore, wireless/mobile technology should not be adopted for the sake of the technology itself. Rather, the adoption should be driven by the needs that we have identified in the prescriptive matrix. There are many who suggest deploying wireless pilot programs for accessing information from government portals. The key question is whether such access is needed (now or in the future) for the target segment that accesses the information. This will play a key role in determining the "future potentials."

Other Issues Relevant to E-Government

In addition to the factors presented in the prescriptive matrix (Table 3), a few more issues are relevant in the case of e-government. These factors moderate the impact of the other factors in Table 3 in determining whether to deploy wireless/mobile technology and, if so, how to deploy it.

Substitute for Wired Networks

In some examples we have discussed, wireless technology was deployed as a substitute for wired technology. Although it is generally not recommended, there are special instances in which wireless is actually a better option than wired technology. These are cases in which the areas of operation are remote and the wired infrastructure is very expensive. In many developing countries, the wired networks are unreliable, expensive, and experience frequent outages (as in the case of the National Institute for Allergy and Infectious Diseases' [NIAID's] deployment in Mali, West Africa). In some developing countries, technology has skipped a generation and thus, while the wired telecommunication infrastructure is spotty and sporadic, one may find extensive wireless coverage. In such cases, wireless technology is an obvious choice for e-government applications.

Multi-Channel Strategies

E-government is accomplished through providing multiple "touch points" to citizens and businesses. The wireless channel is but one of them. It is important to understand that the application of the prescriptive matrix is done with a multi-channel strategy to provide services to citizens and businesses. The impact and role of wireless technology on e-government ought to be examined within the context of a multi-channel strategy.

Impact on Digital Divide

Given the penetration of wireless technology among citizens, its social acceptability, its user-friendliness, and its cost as compared with the PC-based Internet, the use of wireless technology may be a significant way to reduce the impact of the digital divide and provide e-government services that more citizens can access other than through the PC-based Internet. This is one of the key reasons that may drive the deployment of pilot programs in many government agencies that currently provide portal-based e-service to its citizens. We believe that local and state governments can take a proactive role in bridging the digital divide through the use of wireless technology because they are in closer contact with the citizens than the federal government is.

Impact of Competition

It is obvious that government should not be looking at wireless technologies from the point of view of return on investment (ROI) and cost containment alone. This is an era in which governments compete. Local governments, state governments, and even national governments compete in today's global economy for business investments, a skilled workforce, good jobs, and so on. Governments need to view wireless/mobile technology as a means of gaining competitive and strategic advantage in a crowded field. Thus, some wireless applications may not make much sense from an ROI viewpoint but may make good sense from a strategic viewpoint.

Wireless and Mobile Statistics

- Analysts estimate 17% compound growth over the next five years in wireless communications (both services and equipment) spending. (Cahners In-Stat Group)
- There will be over 650 million cellular/PCS subscribers worldwide by 2003, more than tripling from nearly 210 million subscribers at year-end 1997. (*iSky* magazine)
- The growth in the number of users (worldwide) for the various wireless services will be as follows (ARC Group):

	Number of users in millions					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**
Messaging (SMS, e-mail, fax)	100	230	399	611	916	1,268
E-commerce and retail	12	36	107	195	318	469
Financial services	50	123	225	357	529	798
Intranet (corporate)	5	20	49	81	129	206
Internet browsing, WAP	4	20	85	183	344	614
Entertainment	61	143	246	372	554	775
Navigation/location	47	146	239	345	488	785

- Spending for e-government (including federal, state, and local) will grow from $1.5 billion in 2000 to more than $6.2 billion by 2005. In 2005, the G2G and G2B segments will top $4 billion. The G2C segment is forecast to reach $455 million in 2000, and it will grow to $2.2 billion in 2005. (Gartner Group)
- President George W. Bush's FY 2003 budget request includes $3.5 billion in support of first responders. The single biggest portion of that amount, $1.4 billion, is designated for enhancing communications. (PRIMEDIA Business Magazines + Media)

Getting Users Technology Ready

As we have seen in the context of the prescriptive matrix, user technology readiness plays an important role in determining whether to go for immediate deployment of wireless/mobile technology and in determining the strategy for deployment. In this section, we formally define technology readiness as a construct that can be measured and the role it plays in the acceptance of wireless technology by employees. We also focus on the factors that affect technology acceptance of employees and how organizations can influence employees' technology acceptance through concrete measures, with a particular focus on wireless technology acceptance.

Technology Readiness Defined

The construct of technology readiness has been defined as "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work" (Parasuraman, 2000, p. 308). The construct pertains to "an overall state of mind resulting from a gestalt of mental enablers and inhibitors that collectively determine a person's predisposition to use new technologies" (Parasuraman, 2000, p. 308). It is important to emphasize that technology readiness is an overall state of mind and not a measure of technology competency. Thus, "it is a combination of technology-related beliefs that collectively determine a person's predisposition to interact with technology-based products and services" (Parasuraman and Colby, 2001, p. 27).

Many researchers (Mick and Fournier, 1998, for example) have found that people's views and attitudes toward technology are a mixture of positives, which push them to adopt and use technology, and negatives, which pull them away from technology. A person's technology readiness, therefore, is determined by the combination of these pushes and pulls. Thus, technology readiness consists of four dimensions: two positive dimensions called "contributors" and two negative dimensions called "inhibitors."

The first contributor is "optimism"—a positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives. The second contributor is "innovativeness"—a tendency to be a technology pioneer and thought leader. The first inhibitor is "discomfort"—a perceived lack of control over technology and a feeling of being overwhelmed by it. The second inhibitor is "insecurity"—a distrust of technology and skepticism about its ability to work properly (Parasuraman, 2000).

Technology readiness is a composite of these four dimensions. Employees' technology readiness can be measured using a multiple-item scale, which, in turn, can be used to construct an index called the Technology Readiness Index (TRI). In Appendix I, we provide a study that illustrates how employees' TRI can be measured. (The full list of items and the survey administration kit are available from Rockbridge Associates, which holds the copyright for TRI.)

A key reason why employees' technology readiness is one of the important dimensions of our prescriptive matrix (Table 3) is due to the linkage between TRI scores and technology-related behaviors. Research by Parasuraman (Parasuraman, 2000) and Rockbridge

Associates (Parasuraman and Colby, 2001) has shown that the TRI is able to (1) distinguish between users and non-users of high technology services; (2) identify, between two groups, the stronger one in terms of acceptance of more complex and more futuristic technologies; and (3) identify specific groups of users for whom discomfort and insecurity is likely to be significant. TRI scores correlate well with consumers' ownership of technology-based products and services (people who own technology-based products and services have a significantly higher TRI score) and with people's use of technology-based services (as compared with those who have no plans to use the services, those who do plan to use the services in the next 12 months or have used the services in the past 12 months have significantly higher TRI scores).

Technology Readiness and Wireless Technology Adoption

In Appendix I we show, based on our empirical study, that TRI scores also predict employees' attitudes toward wireless technology and adoption. Specifically, we find that those employees with higher TRI scores (1) feel that wireless technology has an important role to play in e-government, (2) have a more positive attitude toward adopting wireless technology in general, and (3) have a more positive attitude toward adopting wireless technology in their specific work processes. Employees with higher TRI scores also have fewer security concerns about using wireless/mobile technology for personal work as well as enterprise applications. More important, those employees with higher TRI scores were already owning/using a significantly higher number of distinct wireless/mobile devices than those with lower TRI scores, a clear indication of their level of comfort with the technology. The study thus provides a clear motivation for using technology readiness as an important dimension to consider when deciding to adopt wireless/mobile technology.

In the context of adopting wireless technology, measuring employees' technology readiness is necessary for three important reasons:

- First, TRI scores of the employees provide insights into using the prescriptive matrix (Table 3), where the mean TRI values of the employee group can be used to classify employees on the technology readiness scale.
- Second, the individual scores of employees can be used for screening those employees for specific technology assignments, training programs, and education.
- Third, the individual scores on the specific dimensions of optimism, innovativeness, discomfort, and insecurity can be used to group employees into segments based on their scores (Parasuraman and Colby, 2001) so that training and education programs can be tailored for the different segments with a view toward easing the process of wireless technology adoption.

We view TRI not as an end in itself in using it for the prescriptive matrix, but as a starting point for influencing employees' technology acceptance so that wireless technology adoption is smooth and efficient. In attaining this objective, TRI scores provide the current state of technology readiness of employees and indicate means to improve technology acceptance where TRI scores are low.

Factors Influencing Technology Acceptance

Employees' acceptance of new technology and intention to use the new technology for work processes depend on three main factors: (1) the perceived usefulness of the technology, (2) the perceived ease of use, and (3) the perceived availability of resources for technology use (Davis, 1989; Mathieson et al., 2001).

- Perceived usefulness is defined as the extent to which an employee believes that using a particular technology will enhance her or his job performance—the higher the perceived usefulness, the higher the technology acceptance and technology adoption. The implication is that as long as the use of wireless technology is expected to explicitly increase their productivity or make their job easy and increase their job effectiveness, its perceived usefulness is high. However, if the usefulness is not evident, the government organization must make efforts to educate its employees about the technology.

- Perceived ease of use is defined as the degree to which a person believes that using a technology will be free from effort. Perceived ease of use is a catalyst to increasing the likelihood of user acceptance. The advantage of wireless technology on this dimension is that the technology plays an important role in consumer/personal applications. Thus, employees are likely to be familiar with the technology and be at ease with it.
- Perceived availability of resources includes resources such as time available for performing or learning to perform a task, level of support available from other staff (particularly information services [IS] staff), and technology attributes such as system availability, cost of access, documentation, and perceived level of control over the technology. The higher the perception of the availability of these resources, the higher the technology acceptance. This factor is particularly relevant if the wireless/mobile application is complex.

Other significant external factors also play a role in determining technology acceptance by moderating the influence of the above three factors on technology acceptance. The most important of these other factors is employee gender. Researchers (Venkatesh and Morris, 2000) have shown that men consider perceived usefulness to a greater extent than women in making their decisions regarding the use of a new technology, both in the short term and the long term. However, perceived ease of use was more salient to women, as compared with men, after initial training with the technology and over time with increasing use of that technology. Other research (e.g., Agarwal and Prasad, 1999) has established that individual-level differences such as education, similar prior experience, and beliefs about IT also have an impact on the acceptance of technology. These individual-level differences are precisely what we see reflected in the individual-level TRI scores. These differences also affect how employees learn to use the technology over time and have important implications for developing training programs. This is particularly relevant when mean TRI scores of employees are low and the management is embarking on programs to increase the probability of acceptance of the new wireless/mobile applications.

Planning for Technology Acceptance

Government agencies can take the following steps to increase employees' acceptance of wireless/mobile technology.

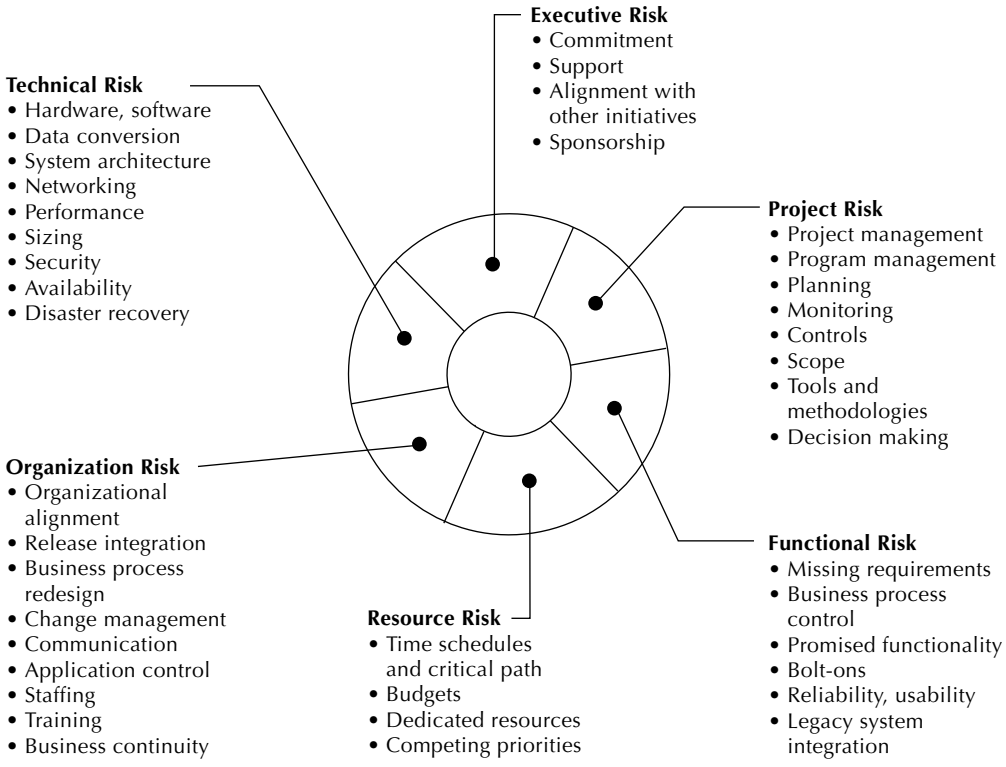
- *Train and Educate Employees.* Training programs, which include formal classroom education and hands-on job training, are essential for employees to understand the role wireless technology can play in their jobs. Given the gender differences, these training/education programs must emphasize the productivity benefits for men and the process/usability issues for women. Testimonials from peer groups and superiors can play an important role in the acceptance of specific applications.
- *Create Peer Support.* One of the advantages of using TRI scores is that an organization can identify employees who are most receptive to wireless/mobile technology and use them as the "lead-user" group in providing support for their peers. Lead-users can be selected for training programs first and then play a critical role in helping/supporting their peers through similar training programs.
- *Implement Pilot Applications.* In many situations, the usefulness of applications may not be evident explicitly before implementing the applications. In such situations, pilot programs are excellent ways to introduce the wireless technology and its benefits to employees. Such programs, in addition to resulting in employee buy-in, may also identify the potential inhibitors to successful applications so that the negatives can be minimized before a full-scale launch.
- *Provide Excellent IS Staff Support.* It is critical that employees perceive and make use of support from IS staff early in the adoption process, especially when technology readiness is low. This helps employees overcome the inhibitors of discomfort and insecurity through liberal help and support from IS staff as they use the technology. An organization cannot provide too much help at the start of the adoption cycle.

- *Encourage Wireless/Mobile Technology for Personal Use*. One advantage of wireless technology is that it also has significant personal applications. To increase employees' comfort level with the technology and increase its perceived ease of use, employees can be encouraged to use wireless technology for their personal and work use. Government agencies can provide subsidies or incentives for buying wireless phones, PDAs, and other handheld devices, as they are quite inexpensive as compared with other types of technology. Employees can be encouraged to check their voice mail and e-mail using wireless devices. This benefits the organization, too, as employees use their personal time to get comfortable with wireless technology, thereby reducing the overall training duration.
- *Recruit, Train, and Assign Using TRI*. TRI can be used as an effective screener to recruit and assign technology-savvy employees to the applications that demand a high level of technology acceptance. The training can also be tailored based on the TRI profiles of employees.
- *Create a Learning Culture in the Organization*. Employees should be encouraged to experiment with new wireless technology and new applications. Incentives should be provided to them for helping in designing applications and for suggesting improvements to the processes and applications. This enhances their involvement in the use of wireless technology, providing a sense of ownership and thereby improving the chances of successful adoption and potential productivity gains.

Application Development—The Next Steps

Since our focus in this report is on understanding the *role* of wireless and mobile technology in e-government and not on the *process of applying* the technology, we have stopped short of the critical next steps: the wireless application development approach and methodology. However, it is imperative that successful implementation of wireless and mobile technology depends on the risk management approach and the selection of appropriate methodology. In Figures 6 and 7, we provide an overview

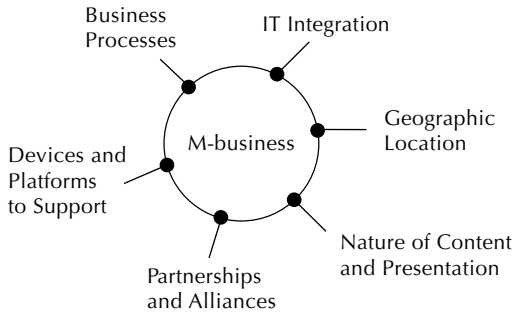
Figure 6: PricewaterhouseCoopers' Risk Management Approach to Application Development



Source: PricewaterhouseCoopers Consulting

of the risk management approach and the critical factors to consider in wireless application development. These next steps should provide a smooth transition from understanding the need and role of wireless technology in e-government to successfully implementing the technology in e-government processes.

Figure 7: Factors to Consider in Wireless Application Development



Source: PricewaterhouseCoopers Consulting

Findings and Recommendations

We introduced this report with four important goals with regard to leveraging wireless technologies for e-government: (1) understanding the unique characteristics of the wireless/mobile environment and technology usage, (2) mapping the characteristics and usage for enterprise applications based on studies of successful adoption of the technology in private-sector settings, (3) understanding the role of wireless/mobile technology in e-government, and (4) assessing the technology readiness of the government workforce for wireless/mobile applications and increasing the likelihood of technology acceptance. The summary of our findings and recommendations based on the four goals is as follows:

Key Findings

- Wireless and mobile devices are user-friendly personal devices with a significant penetration among citizens and consumers. Wireless/mobile technology provides an alternative channel to reach consumers and citizens. Because of its widespread use and personal nature, its potential for B2E/G2E and B2C/G2C applications is significant. However, due to limited security/privacy features and a plethora of incompatible standards, it is more suitable, currently, for B2E/G2E applications rather than B2C/G2C applications. G2B (vendors/system integrators/contractors) applications also have significant potential.
- Strategies for successful wireless adoption depend on four important factors: extent of mobility in the target segment, information access needs, security/privacy requirements of the application, and technology readiness of the target segment.
- Most of the current applications of wireless/mobile technology in government fall within the low-hanging fruit quadrant. A few citizen-centric applications are motivated by the need to reach out to geographically remote communities or by the lack of wired access. With maturing technology and developments, governments should be able to roll out citizen-focused services through the wireless channel.
- Measuring employees' technology readiness is a key component of the wireless technology implementation process. Employees' TRI scores are good predictors of their attitudes toward wireless technology adoption in their work processes and their ultimate acceptance of wireless/mobile applications.
- Employees' acceptance of wireless technology can be influenced through technology training and other programs. These can have a positive impact on employees' perceptions of the usefulness of wireless applications, the ease of use of wireless applications, and the availability of necessary resources.

Recommendations

Although this report has outlined many of the technology's characteristics and potential, it also holds out a warning. As with any technology, adoption of wireless/mobile technology should not be pursued for the sake of having a new technology; rather, the adoption should be motivated by the needs of the organization or the government agency. We have

described many of these needs and how they affect an organization's wireless strategy through the prescriptive matrix. The following are the specific recommendations for government agencies:

- *Measure Technology Readiness, and Educate and Train Employees.* The organization must determine where its employees stand with respect to technology readiness and technology acceptance. An important first step, based on this measurement, is planning for formal education and training focusing on wireless/mobile technology basics, specifics, and role in government. Case studies of government agencies that have implemented wireless programs could contribute toward this end. IT partners could also provide help in training and education.
- *Harvest the "Low-Hanging-Fruit."* Once the low-hanging fruits are identified based on the prescriptive matrix, government organizations should go for quick and full deployment to take advantage of the productivity improvements. Agency budgeting should reflect funding for these deployments, and these projects should be put on the fast track for immediate implementation.
- *Plan for the "Stars."* Stars are high-impact projects that have complex requirements in terms of security/privacy needs and information interactivity and reliability needs. These projects should form part of strategic plans, and budgets should be allocated for experimentation and pilots. As wireless/mobile technology matures, these projects will pay off significantly. However, care should be taken in selecting the technology platform and infrastructure so that the organization does not get locked into proprietary technology, especially in the realm of G2C applications.
- *Launch Pilot Programs.* Government organizations should think creatively in identifying opportunities for wireless and mobile implementations. Wireless may be a good substitute for wired technology in geographically remote areas where citizen access is important. Wireless may play a significant role in bridging the digital divide, given its wide usage. Launching pilot programs focusing on these areas is especially important as employees and citizens learn using the technology for mutual benefit. Creation of a central testing environment, such as the DISA or NIST laboratories, may help significantly in launching pilots.
- *Encourage Employees' Wireless/Mobile Use.* Increasing employees' comfort with the technology and increasing their perceptions of ease of use are the best ways to prepare them for technology acceptance. Government agencies should encourage, through incentives, employees' use of PDAs, wireless devices, and handheld devices both for work and personal use. Wireless LANs could replace wired LANs in some locations as a means of experimenting with technology and moving up the learning curve.

We also saw that, in addition to the factors in the prescriptive matrix, other issues may have an impact on the decision to adopt wireless technologies in the government context. For example, governments work in competitive environments, just like private business organizations. So sometimes wireless adoption can be motivated purely from a strategic viewpoint rather than from ROI considerations. Governments should be proactive in designing systems and applications with this goal in mind.

It is clear that much needs to be done if wireless applications are to deliver on their potential. Some of these efforts rest with the federal government. The supply of spectrum available to wireless carriers for rolling out broadband initiatives is fast dwindling. This calls for broadband-friendly policies and stimuli to encourage building a wireless infrastructure. The second issue is the confusion over prevailing standards. Market forces will determine and solve much of this eventually, but until then, widespread deployment and adoption of wireless technology can be risky. The third issue is that of security. Widespread G2C applications are possible only when a secure and private environment is ensured. This will also happen eventually, and until then, governments should roll out successive pilot programs to gain experience and expertise for large-scale applications.

Appendix I: Technology Readiness Index and Attitudes toward Wireless Technology Adoption

In this appendix, we explain the measurement of the Technology Readiness Index (TRI) with an illustrative measurement of TRI using a survey administered to a group of government employees. We also relate their technology readiness with their attitudes toward wireless adoption, their perceptions on the role that wireless can play in government applications, and their wireless usage.

The TRI scale consists of four dimensions:

- Optimism—a positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives
- Innovativeness—a tendency to be a technology pioneer and thought leader
- Discomfort—a perceived lack of control over technology and a feeling of being overwhelmed by it
- Insecurity—distrust of technology and skepticism about its ability to work properly

Each dimension is measured using multiple-item scales. Examples of the multiple-item scale include:

- For optimism: "Products and services that use the newest technologies are much more convenient to use." "Technology gives you more freedom of mobility."
- For innovativeness: "Other people come to you for advice on new technologies." "You keep up with the latest technological developments in your areas of interest."
- For discomfort: "Technology always seems to fail at the worst possible time." "Sometimes you think that technology systems are not designed for use by ordinary people."
- For insecurity: "You do not consider it safe giving out a credit card number over a computer." "You worry that information you send over the Internet will be seen by other people."

Each item is responded to on a 5-point scale ranging from strongly agree (5) to strongly disagree (1). (The full list of items and the survey administration kit are available from Rockbridge Associates, which holds the copyright for the TRI). The TRI is the composite score derived from averaging the four dimensions, after reverse coding the scores on the discomfort and insecurity components. Thus, a high TRI score represents a high level of technology readiness. TRI as a measurement scale has been shown to have high reliability, good content, and discriminant validity and to be convergent.

Attitudes toward Wireless Adoption

In addition to the TRI items in the survey instrument, we included several items that measured (1) respondents' perceptions of the role of wireless/mobile technology in e-government settings, (2) their attitudes toward adopting wireless technology in government in general, (3) their attitudes toward adopting wireless technology for their specific work, (4) their usage of wireless technology for personal work, and (5) a number of other related issues. The specific items used are listed in Table A.1. All items were measured on a 5-point scale ranging from strongly disagree (1) to strongly

Table A.1: Items Related to Wireless/Mobile Technology

1.	Role of Wireless Technology (ROLE) (Coefficient Alpha = 0.82)	a. Wireless/mobile technology can play a very useful role in government IT practices. b. Wireless/mobile technology has a limited role to play in government processes (reverse coded).
2.	Attitude toward Adoption (General) (ATTADOPT) (Coefficient Alpha = 0.79)	a. Adoption of mobile technology in government processes is a good thing. b. Adopting wireless/mobile technology at work in government organizations can create more problems than good (reverse coded).
3.	Attitude toward Adoption (Work) (ADOPTWK) (Coefficient Alpha = 0.84)	a. You will actively use mobile/wireless technology for collaborative work if provided the option. b. You will strongly support the adoption of wireless/mobile enterprise applications in your work. c. Wireless/mobile technology can play a very useful role in your work processes.
4.	Personal Usage of Wireless (PERUSAGE) (Coefficient Alpha = 0.72)	a. You often use wireless/mobile technology for personal financial activities such as stock trading or banking. b. You often use wireless/mobile technology for personal work.
5.	Personal Optimism (PEROPTM)	Using wireless/mobile technology gives people more control over their daily lives.
6.	Security in Personal Context (PERSECU)	You do not consider it safe giving out a credit card number over a wireless phone or other mobile devices.
7.	Comfort in Personal Usage (PERCOMFT)	You are not very comfortable using wireless/mobile technology for your personal work.
8.	Security Enterprise Context (ENTRSECU)	Using wireless/mobile devices to access enterprise data has significant security risks as compared with using wired devices.
9.	Wireless as a Substitute for Wired (SUBSTITUT)	If wireless/mobile technologies were adopted in my organization, it will substitute wired technologies.
10.	Wireless Limited Role (LMTDROL)	Wireless/mobile technology is appropriate for voice and e-mail but not for other work processes.
11.	Wireless Is Hyped (HYPE)	The benefits of wireless/mobile technology are often grossly overstated.

agree (5), with 3 being neutral. The items were developed based on pilot studies, and the multiple-item measures were factor analyzed using confirmatory techniques to ensure unidimensionality. The reliability of the multiple-item scales is also high (as indicated by the coefficient alpha values ranging from 0.72 to 0.84). The survey instrument included information on whether the respondent owned wireless devices such as cellular phones, pagers, PDAs, wireless PDAs, and wireless access to the Internet. Gender, age, and education information along with government agency affiliation were also elicited.

Respondent Information

In all, 204 government employees, half of whom were taking courses at the National Defense University, participated in the survey. Three surveys had to be discarded because they were only par-

tially filled out. The government agencies represented include the U.S. Army, U.S. Navy, U.S. Air Force, Department of Defense, Defense Intelligence Agency, DISA, Internal Revenue Service (IRS), Department of State, U.S. Coast Guard, Department of the Treasury, U.S. Customs Service, General Services Administration (GSA), Department of the Interior, Environmental Protection Agency (EPA), Federal Aviation Administration (FAA), and a few other agencies. Based on the responses to the demographic questions, approximately 61 percent of the respondents were male and 39 percent were female. About 44 percent were between the ages of 45 and 55, 46 percent between 35 and 45, and 10 percent under 35. In terms of education, 22 percent had postgraduate degrees, 47 percent had graduate degrees, 26 percent had undergraduate degrees, and 5 percent had completed high school.

In terms of the composition of the respondents, our sample is biased toward the more educated and more IT-oriented employees (some of whom were attending IT-oriented classes at the university). The sample was chosen deliberately for two reasons: We were trying to relate TRI with attitudes toward wireless deployment. If such relationships were significant in this population (where the TRI values are likely to be quite high with low variance across the sample), then it is much more likely to be replicated at a general population level, where variances in the TRI are likely to be much higher. Second, IT employees are more likely to be part of the "lead-user" segment of wireless device users, and it was important to establish the relationships at their level.

Survey Results and Implications

As seen in Table A.2, the respondents as a group scored significantly high on the technology optimism dimension (mean = 4.02) and high on the innovativeness dimension (mean = 3.77). It is interesting to note that although the mean value for the discomfort dimension is around the neutral range, the mean value for the insecurity dimension is higher than that (mean = 3.27). Overall, the mean for the TRI is 3.36, with the minimum TRI value at 2.3 and the maximum at 4.2. The mean TRI is much higher for this group as compared with the general consumers owning technology-based products and services (as analyzed by Parasuraman, 2000) where the means ranged from 2.90 to 3.12. It is also comparable to the TRI scores obtained by consumers using technology-based services such as purchasing e-tickets and other items online. This indicates that, as a group, the respondents have high technology readiness, while there are some individuals with low TRI values (2.3), with the range of TRI values being 1.9.

Tables A.3 and A.4 provide the mean scores of the respondents on their attitudes toward wireless adoption and perceptions of wireless technology. As a group, these government employees with high

Table A.2: Scores on TRI and Its Component Dimensions

Scale	Optimism	Innovativeness	Discomfort	Insecurity	TRI
Mean	4.02	3.77	3.08	3.27	3.36
Standard Deviation	0.46	0.70	0.51	0.69	0.40
Minimum	3.00	1.70	2.00	1.90	2.30
Maximum	4.90	5.00	4.40	4.90	4.20
Range	1.90	3.30	2.40	3.00	1.90
Sample Size	199	199	199	199	199

Table A.3: Scores on Role and Attitude toward Adopting Wireless and Usage

Scale/Variable	ROLE	ATTADOPT	ADOPTWK	PERUSAGE	PEROPTM
Mean	3.75	3.54	3.51	2.49	3.64
Standard Deviation	0.96	1.02	1.04	1.21	1.11
Minimum	1.00	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00	5.00
Range	4.00	4.00	4.00	4.00	4.00
Sample Size	199	199	198	201	200

Table A.4: Scores on Security, Comfort, and Substitute Perceptions

Variable	PERSECU	ENTRSECU	PERCOMFT	SUBSTITUT	LMTDROL	HYPE
Mean	2.60	1.97	3.22	2.23	2.33	3.40
Standard Deviation	1.40	1.01	1.32	0.97	1.13	0.96
Minimum	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00
Range	4.00	4.00	4.00	4.00	4.00	4.00
Sample Size	199	201	201	200	200	200

TRI scores feel very positively about the role of wireless technology in government processes (mean on ROLE = 3.75). They view that the adoption of wireless technology in government processes is a good thing and that it can do more good than harm in government applications (mean on ATTADOPT = 3.54). This attitude is not just confined to generalities; this group also feels positively about adopting wireless technology to their own work processes (mean on ADOPTWK = 3.51).

In terms of their wireless usage for personal work and activities, although they are quite optimistic about wireless technology providing them more control over their daily lives (mean on PEROPTM = 3.64) and somewhat comfortable about using wireless technology for personal work (mean on PERCOMFT = 3.22), they do not use wireless technology often to do their personal work or financial activities (mean on PERUSAGE = 2.49). This implies that although they have mobile devices, such as a mobile phone, those devices might be intended more for social activities (chatting) than for personal work. This might also reflect their attitudes toward security of using wireless/mobile devices.

The respondents as a group tended to disagree with the statement that they do not consider it safe giving out a credit card number on a wireless/mobile device (mean on PERSECU = 2.60). They also tended to disagree with the statement that using wireless/mobile devices to access the enterprise had significant security risks as compared with using wired devices (mean on ENTRSECU = 1.97).

This might indicate that security concerns become more pronounced when personal work is involved than when enterprise work is involved, although the absolute scores reveal that this group has a positive perception of wireless security overall.

The group did not think wireless is a substitute for wired technology (mean on SUBSTITUT = 2.23) and did not feel that wireless use is limited to voice and e-mail (mean on LMTDROL = 2.33). However, they did somewhat agree that the benefits of wireless/mobile technologies are often overstated (mean on HYPE = 3.40).

The wireless industry has galvanized itself after the events of September 11, 2001, as a possible role player in homeland security. The respondents also answered questions on this issue. As a group, they were close to neutral when it was stated that wireless/mobile technology has a greater role to play as compared with other technologies in providing homeland security (mean = 3.12). They also indicated that the events of September 11 did not in any significant way affect their likelihood of adopting wireless technology either for their work processes or for their personal use.

In terms of ownership of mobile/wireless devices, the respondent group could be termed as early adopters of technology: 87 percent owned a mobile phone, 37 percent had a PDA and 20 percent had a PDA with wireless capabilities, 29 percent owned pagers, and 13 percent had wireless access to the Internet. This correlates well with the high TRI scores that the group obtained.

Although we have seen that as a group the respondents have high TRI scores and positive attitudes and perceptions regarding wireless technology and its adoption in work processes, a better test would be to correlate these scores at the individual level. Table A.5 provides the correlations between individual TRI scores and the individual attitude scores and perception scores on the various dimensions. As seen in the table, the correlations are quite positive (ranging from 0.32 to 0.47 for the attitude toward adoption scores). The other correlations are also in the expected directions. Interestingly, the number of wireless devices that respondents own is correlated positively with their TRI scores. This is a clear indication that TRI scores can predict individual attitudes and perceptions toward wireless technology and adoption. This exercise also shows why we have chosen technology readiness as an important dimension of our prescriptive matrix. It plays a major role in determining user acceptability of technology, which is a key factor in the successful adoption of wireless initiatives.

Table A.5: Correlation between TRI and Wireless Attitudes and Perceptions

Scale/Variables	TRI Correlation
ROLE—Wireless Role in Government	0.42
ATTADOPT—Attitude toward Adopting (General)	0.46
ADOPTWK—Attitude toward Adopting at Work	0.47
PERUSAGE—Personal Usage	0.46
PEROPTM—Personal Optimism	0.34
PERSECU—Security Perception Personal	0.44
ENTRSECU—Security Perception Enterprise	0.32
PERCOMFT—Comfort in Personal Usage	0.35
SUBSTITUT—Wireless as Substitute for Wired	-0.03
LMTDROL—Wireless Has Limited Role	-0.16
HYPE—Wireless Benefits Hyped	-0.41
Number of Distinct Wireless/Mobile Devices Owned	0.37

Appendix II: IEEE Wireless Communication Standards

1. The 802.11 Working Group for Wireless Local Area Networks

The IEEE 802.11 specifications are wireless standards that specify an "over-the-air" interface between a wireless client and a base station or access point, as well as among wireless clients. The 802.11 standards can be compared to the IEEE 802.3 standard for Ethernet for wired LANs. The IEEE 802.11 specifications address both the Physical (PHY) and Media Access Control (MAC) layers and are tailored to resolve compatibility issues between manufacturers of wireless LAN equipment.

802.11aOFDM in the 5GHz Band
802.11a is a Physical Layer (PHY) standard (IEEE Std. 802.11a-1999) that specifies operating in the 5GHz UNII band using orthogonal frequency division multiplexing (OFDM). 802.11a supports data rates ranging from 6 to 54Mbps. 802.11a-based products became available in late 2001.

802.11bHigh Rate DSSS in the 2.4GHz Band
The task group for 802.11b was responsible for enhancing the initial 802.11 DSSS PHY to include 5.5Mbps and 11Mbps data rates in addition to the 1Mbps and 2Mbps data rates of the initial standard. 802.11 finalized this standard (IEEE Std. 802.11b-1999) in late 1999. Most wireless LAN installations today comply with 802.11b, which is also the basis for Wi-Fi certification from the Wireless Ethernet Compatibility Alliance (WECA).

802.11c—Bridge Operation Procedures
802.11c provides required information to ensure proper bridge operations. Product developers utilize this standard when developing access points.

802.11d—Global Harmonization
In order to support widespread adoption of 802.11, the 802.11d task group has an ongoing charter to define PHY requirements that satisfy regulatory bodies/laws[?] within additional countries. This is especially important for operation in the 5GHz bands, because the use of these frequencies differs widely from one country to another.

802.11e—MAC Enhancements for QoS
The 802.11e task group is currently refining the 802.11 MAC (Medium Access Layer) to improve QoS for better support of audio and video (such as MPEG-2) applications. The 802.11e group should finalize the standard by the end of 2002, with products probably available by mid-2003.

802.11f—Inter Access Point Protocol
802.11f is currently working on specifying an inter access point protocol that provides the necessary information that access points need to exchange to support the 802.11 distribution system functions (e.g., roaming). The 802.11f group expects to complete the standard by the end of 2002, with products supporting the standard by mid-2003.

802.11g—Higher Rate Extensions in the 2.4GHz Band

The charter of the 802.11g task group is to develop a higher speed extension (up to 54Mbps) to the 802.11b PHY, while operating in the 2.4GHz band. 802.11g will implement all mandatory elements of the IEEE 802.11b PHY standard. The FCC still needs to approve the use of OFDM in the 2.4GHz band, a generally necessary action when messing with the PHY. As a result, it will likely take a relatively long period of time before 802.11g products appear on the market.

802.11h—Spectrum Managed 802.11a

802.11h addresses the requirements of the European regulatory bodies. It provides dynamic channel selection (DCS) and transmits power control (TPC) for devices operating in the 5GHz band (802.11a). Through the use of DCS and TPC, 802.11h will avoid interference in a way similar to HiperLAN/2, the European-based competitor to 802.11a. 802.11h hopes to have its standard finalized sometime before the end of 2003.

802.11i—MAC Enhancements for Enhanced Security

802.11i is actively defining enhancements to the MAC Layer to counter the issues related to wired equivalent privacy (WEP). 802.11i will incorporate 802.1x and stronger encryption techniques, such as AES (Advanced Encryption Standard). The standard will likely not have IEEE ratification before mid-2003.

2. The 802.15 Working Group for Wireless Personal Area Networks

The IEEE 802.15 Working Group, in the IEEE 802 family, provides standards for low-complexity and low-power consumption wireless connectivity. In March 1998, the Wireless Personal Area Network™ (WPAN™) study group was formed. In May 1998, the Bluetooth Special Interest Group (SIG), Inc. was formed, and in May 1999, the IEEE WPAN Study Group became IEEE 802.15, the WPAN Working Group. In July 1999, Bluetooth™ released the Bluetooth Specification v1.0a.

IEEE 802.15 WPAN™ Task Group 1 (TG1)

Bluetooth is an industry specification for short-range RF-based connectivity for portable personal devices. The IEEE has reviewed and provided a standard adaptation of the Bluetooth Specification v1.1 Foundation MAC (L2CAP, LMP, and Baseband) and PHY (Radio).

IEEE 802.15 WPAN™ Task Group 2 (TG2)

TG2 is developing recommended practices to facilitate coexistence of Wireless Personal Area Networks™ (802.15) and Wireless Local Area Networks (802.11). The Task Group is developing a coexistence model to quantify the mutual interference of a WLAN and a WPAN™.

IEEE 802.15 WPAN™ Task Group 3 (TG3)

TG3 is chartered to draft and publish a new standard for high-rate (20Mbit/s or greater) WPANs™.

IEEE 802.15 WPAN™ Task Group 4 (TG4)

TG4 is chartered to investigate a low data rate solution with multi-month to multi-year battery life and very low complexity. It is intended to operate in an unlicensed, international frequency band. Potential applications are sensors, interactive toys, smart badges, remote controls, and home automation.

3. The 802.16 Working Group for Broadband Wireless Access Standards

IEEE 802.16 specifications support the development of fixed broadband wireless access systems to enable rapid worldwide deployment of innovative, cost-effective, and interoperable multi-vendor broadband wireless access products.

Sources: www.80211-planet.com/tutorials, www.ieee802.org/15/pub

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