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Sasha Dekleva
DePaul University

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Sasa M. Dekleva
DePaul University
sdekleva@condor.depaul.edu

Abstract

This tutorial presents a broad overview of the history, current state and the likely future evolution of wireless voice and data technologies, mobile devices, and mobile business applications. The first section, which is not too technical, defines and explains the most important standards and protocols. The second section focuses on m-business and explains where it has a particularly strong potential. It also addresses the weaknesses of mobile devices, mistakes in the design of wireless applications, and concerns over security, privacy, and a lack of awareness. The final section provides some suggestions for successful implementation of m-business initiatives and presents several cases. This overview paper touches on only selected topics of the tutorial.

Introduction

After several disappointing attempts, major U.S. wireless communication service providers believe that mobile business (m-business) will finally get off the ground in 2002, as they roll out faster third generation (3G) wireless networks. They are hastily upgrading the radio equipment so that their 3G networks will be turned on in the major metropolitan areas by the end of this year. Verizon unveiled its Express Network in Salt Lake City, the San Francisco Bay Area and the Northeast corridor connecting Boston, New York and Washington. Sprint PCS Group Inc. plans to turn on its entire nationwide high-speed network this summer. Cingular Wireless, AT&T Wireless Services Inc. and others are also implementing new networks (Kaplan 2002).

The way most people are connected to their data networks is indeed changing significantly, . In 2001, 50 to 65 percent of European and U.S. population could access the Internet occasionally, but only 10 percent of users experienced the "always-on" connection. Gartner predicts that by 2007, 80 percent of EU and U.S. users will not only be permanently connected, but will carry this connection with them anywhere they go (Jones 2002a). However, tiny cell phone screens are difficult to navigate with only about a dozen keys on the pad. Less than 2 percent of Americans who own Web-enabled phones use them for m-business. Part of the problem is that although the phones may be capable of accessing the Web, the wireless service providers cannot afford to support each of the many phones and personal digital assistants (PDAs) that are designed with different physical and functional characteristics.

Jupiter Media Metrix nevertheless predicts that by 2005, $22.2 billion worth of goods and services will be purchased globally using mobile devices. Business and consumers in Asia are expected to spend $2.6 billion through m-business this year, and Europeans an additional $500 million. In contrast, the projection for m-business in North America this year is only $100 million (Kaplan 2002). A big question now is whether faster wireless networks and always-on devices will change the spending habits in the U.S. and elsewhere.

As wireless speed and coverage improve, business users will be the first to connect to their corporate networks and the Internet. They are able to use wireless networking cards to connect their laptops and PDAs to the fast, inexpensive and popular wireless local area networks (LANs). They also will be more willing to pay the higher prices that carriers will charge for 3G services. The consumers, likely following a year or two later, may never embrace m-business as enthusiastically as patrons in Asia and Europe. An average worker in Japan, for example, spends two hours commuting to work and back by train each day. These commuters use their mobile devices to keep in touch, while the Americans commute to work by car. In addition, the penetration of personal computers and fixed line connections to the Internet in Japan is very low, while Americans are used to a richer experience of using the Internet with personal computers (PCs) and will hesitate to replace them with inferior mobile devices.

Although mobile computing in North America may never supplant desktop computing, analysts still believe that m-business activities eventually will become important and that the introduction of 3G just may be the inflection point.

Wireless or Mobile?

The terms wireless and mobile are often used interchangeably, but mobility need not involve wireless transmission. An application running on a laptop computer used by a sales representative at various customers' locations is perfectly mobile but not totally wireless.

The three basic categories of mobile applications are(Schroder 2002):

- Mobile applications in the broadest sense involve portable devices such as laptops, PDAs, and smart phones, which can operate either always connected to the network, never connected to the network, or connected only periodically.
- Wireless applications involve mobile devices connected to the network over wireless communication links such as infrared, Bluetooth, wireless LAN or a cellular network.
- Wireless Internet applications involve devices that are always online, connected to a server over one of the many wireless transmission protocols, often using a Wireless Application Protocol (WAP) through a Wireless Application Gateway (WAG).

In the rest of this paper, we l focus mostly on the latter two categories.

Mobile Technology

Devices

The devices most commonly used for m-business are small handheld devices with wireless data communications capability. They are designed to be highly portable. People keep them handy most of their waking hours. Mobile devices are of three principal types:

- mobile phones,
- handheld computers (such as PDAs), and
- laptop/notebook computers.

The handheld and laptop computers can connect to the wireless data networks if they are equipped with a radio-frequency communication interface.

The range of mobile devices is broad and growing. It spreads from industrial robust portable computing devices to tiny wearable computers. Although the wearable computers can also be found in industrial applications, they may soon become fashionable consumer items. A new category of tablet devices falls between PDAs and notebook computers in terms of their screen size, software platform and portability. Mobile computing and communication devices can also be built into larger mobile equipment, such as trucks, airplanes, trains, farming equipment, and automobiles.

As mentioned, the next several years will bring increased complexity and divergence in physical device characteristics and their roles and types (e.g., business/consumer, phone/PDA, interactive TV/toy). For example, a new family of Sony digital video cameras is Web enabled and can be used to exchange e-mail. Fragmented market will be driven by fun, fashion, function, and technology. The boundaries between different types of devices, such as phones and PDAs, will become blurred as some devices become multifunctional. However, a number of users will favor multiple specialized and optimized devices interconnected by Bluetooth (described below) over a single converged universal device.

The design of mobile devices will converge logically, however, by integrating common features in various devices. They will be able to play music in stereo, display multimedia formats, provide 3G mobile phone capabilities, determine location, and support personal information manager (PIM) applications. This logical convergence, however, will not be enough to enable portability of wireless applications among various types of devices (Jones 2002).

Wireless Communication Protocols

Two characteristics of the wireless communication evolution are the migration from analog to digital formats and the increasing speed or bandwidth. The first generation (1G) available through 1970s and 1980s offered mobile phones and analog voice signaling. The second generation (2G) technology, introduced in the 1990s, featured digital voice encoding. Examples include Code-Division Multiple Access (CDMA), Time-Division Multiple Access (TDMA), and Global System for Mobile communication (GSM). The 2G technologies are improving steadily, offering increased bandwidth, packet switching, and the support of multimedia formats. The current, transitional state of mobile wireless communications is often called two-and-a-half G (2.5G).

The third generation wireless (3G) is expected to support:

- enhanced multimedia including voice, data, video and remote control
- many popular modes including cellular phone, email, paging, fax, videoconferencing and Web
- bandwidth upwards of 2 Mbps
- roaming capability throughout Europe, Japan and North America

While 3G is perceived relevant mainly to mobile wireless, it is also relevant to fixed wireless. In reality, the bandwidth in mobile wireless mode is only up to 384 Kbps and in fixed wireless up to 2 Mbps. In fact, vendors disagree on the definition of 3G and on its first global implementation. Koreans claim that their three mobile carriers offered 3G services, otherwise known as CDMA2000 1x, based on Qualcomm's wireless technology since October 2000 and that about 4.2 million subscribers with compatible handsets are now able to download data at up to 144 Kbps. In Korea, major carriers are also rushing to upgrade their systems to offer CDMA2000 1x EV-DO (evolution data only). This technology can deliver data at up to 2.4 Mbps. EV-DO, optimized to offer videophones and wireless multimedia services and was set to debut just ahead of the 2002 Korea-Japan World Cup finals, that started in late May (Sung-jin 2002). Others suggest that Japan's biggest mobile phone operator, NTT DoCoMo, introduced the world's first 3G cellular phone service on October 1, 2001 (Watts 2001) based on the so-called wideband CDMA (WCDMA), which is incompatible with CDMA2000.

The attention given to 3G obscured the importance of transition from dial-up circuit-switched data networks to always-on packet-switched networks. This transition occurs with the move to 2.5G technology, particularly GPRS on existing GSM networks and CDMA2000 1x on existing CDMA One networks. The other important near-term development in wireless communications will likely be the addition of localization capabilities, based either on determining the location of the mobile device via its Global Positioning System (GPS) or by the characteristics of signal propagation between the device and several antennas in the cell.

Mobile network access can also be provided by short-range wireless technologies such as Wi-Fi and Bluetooth. Wi-Fi network, also known as wireless LAN, is usually installed by an organization on its own premises, such as an office building, a manufacturing plant, or a university campus. Wi-Fi networks are also provided in selected public areas like airports, hotels, Starbucks coffee shops, and even some parks and street sections. These networks are based on one of the versions of the IEEE standard 802.11, operate in an unlicensed frequency spectrum and include encryption. The range is limited to about 100 meters. Currently the most popular version—802.11b—provides up to 11 Mbps transmission in the 2.4 GHz band, while the 802.11a version operates in the 5GHz band with bandwidth of up to 54 Mbps.

Bluetooth is a set of radio frequency communication protocols that describe how mobile phones, computers, PDAs, and various appliances can easily connect with each other and with home and business phones and computers. A low-cost transceiver chip, which must be included in each device, emits and receives in a frequency band of 2.4 GHz at a rate of up to 2 Mbps and provides one data channel and up to three voice channels. Connections can be point-to-point or multipoint. Maximum range is only 10 meters, but can be extended to more than 100 meters by increasing the transmission power. Built-in encryption and verification is provided.

Proponents of 3G technology promise that it will "keep people connected at all times and in all places." Researchers, engineers, and marketers are trying to determine how much technology consumers will actually be willing to pay for. Four digital voice standards compete in North America. However, the next-generation systems will pare these down to two main ones — CDMA2000 and WCDMA. In the longer term, fourth-generation mobile networks, with the ability to carry High Definition Television (HDTV) signals at speeds up to 20 Mbps, could appear as early as 2010 (Acuff 2001

Software Platforms

In 2001, we observed a proliferation of client-side technologies for mobile devices. Some of the client platforms (in the broadest sense) available or announced in 2001 included DoCoMo's i-mode, Java 2 Micro Edition (J2ME), PersonalJava, Symbian's EPOC, Microsoft's Windows CE, PalmSource's Palm OS, Microsoft's .NET Compact Framework, Nokia's "open" middleware, Qualcomm's Binary Runtime Environment for Wireless (BREW), Global System for Mobile Communications (GSM) M-Services and Wireless Application Protocol (WAP) 1.2 (Jones 2002b). Last year's announcements defined the market where competitive battles will be fought for two years or so among vendors such as DoCoMo, Microsoft, and Qualcomm. No winners are expected in the short term.

DoCoMo is the wireless division of Japan's gargantuan Nippon Telegraph and Telephone (NTT) Corporation. Its i-mode is extraordinarily successful in Japan and shines as the brightest star on the wireless applications sky. Unlike most of the other services, it is not compatible with the Wireless Application Protocol (WAP). Continually connected customers are charged according to the amount of data transmitted or received. Encouraged by the success of i-mode, NTT DoCoMo rolled out up to 25 times faster 3G service in October 2001 in Tokyo and later in Nagoya and Osaka. This service, known as FOMA, was not as successful as i-mode, and attracted only 42,900 instead of the forecasted 150,000 subscribers by February 2002 (Kageyama 2002).

J2ME (Java 2 Platform, Micro Edition) is a technology that allows programmers to use the Java programming language and related tools to develop programs for mobile wireless information devices. It consists of several building blocks that can be implemented to match the memory and other resources of various mobile devices. Sun introduced J2ME for Palm OS in December 2000.

Symbian's EPOC, Microsoft's Windows CE, and PalmSource's Palm OS are competing operating systems for mobile devices. EPOC is based on an earlier operating system from Psion, which formed a company called Symbian with Ericsson, Nokia, and Motorola. EPOC is a 32-bit multitasking OS that supports a pen-based GUI. The compact code comes with a comprehensive suite of applications, which can be scaled down when used for embedded systems applications.

Microsoft stresses that it built Windows CE from scratch based on Windows architecture. It was designed to be embedded in mobile and other small devices and is used in several brands of handheld computers and in cable TV set-top boxes.

Palm OS provides a software platform for Palm, Handspring and other devices including those made by Acer, Kyocera, Sony, Samsung, and others. While Windows CE and EPOC were designed to serve a broader range of devices, Palm OS was designed to fit into palm-size devices with a small display. Palm OS 5 offers enhanced multimedia capabilities, a suite of robust security options, expanded support for wireless connections. It has the largest OS market share.

M-Business

Mobile applications and services will evolve over time and become increasingly complex. Information services (e.g., directories, driving instructions), transaction processing (e.g., banking, brokerage) and interaction (e.g., micro payments, marketing, advertising) will supplement the basic services, such as voice, SMS and multimedia messaging service (MMS). Successful implementation will depend on the evolution of network technologies (e.g., multimedia support, localization), security (authentication, virtual private networks) and integration of technologies and architectures. According to a Gartner Dataquest forecast, total mobile data revenue will exceed $45 billion in 2005, in communication (30 percent), entertainment (20 percent) and information (17 percent) services (Deighton 2002). Mobile wireless technology will be adopted in the business environment based on increased efficiency and related cost savings (e.g., field force automation), improved customer service (e.g., mobile customer relationship management) and supply chain management (e.g., logistics management). The two main issues holding the implementation back will be the cost of service\devices and security concerns.

Mobility applications will clearly have many roles in business but enterprises need to be cautious about embracing them. Enterprises still need to conduct case-by-case evaluations of possible applications, paying attention to financial as well as operational implications. Many uncertainties remain about how devices and networks will evolve and enterprises need to factor such uncertainties into their evaluations (MacMillan 2002).

Consumers will be more selective and will use only the convenient, easy-to-use, cost-effective and appealing services. Personalization will be important, and some population categories will not mind receiving unsolicited advertisements in exchange

for purchasing discounts or additional mobile airtime. Business and consumer services will likely be available from corporate and personal portals, respectively. Services will also facilitate peer-to-peer (both person-to-person and machine-to-machine) communication and interaction.

M-Business Adoption

Wireless mobile technologies are rapidly evolving. This is obvious in the case of mobile devices and digital wireless radio communication protocols, and the war for market share among the vendors of software platforms is intensifying. The first and perhaps the most important conclusion then is that enterprises should implement mobile applications as a tactical rather than strategic choice and when a short-term return on investment or other important benefit can be achieved. They need to consider three main technology domains and evaluate their needs for mobility and the technical maturity, costs and capabilities of wireless technologies. The three domains are:

- Network services (e.g., data bandwidth, coverage, security support, and costs)
- Mobile devices and platforms (e.g., choice of phones or wireless PDAs, memory and storage size, battery capacity, OS and applications functionality, technical support)
- Mobile applications (needs of various user groups, the extent and timing of required mobility)

The challenge for managers is to derive a plan that considers users' needs and the state of wireless technology today and how both will likely evolve in the next several years. The next planning stage should involve the timing of implementation and the size of necessary investments.

M-Business Drivers

A combination of four sets of factors will facilitate the mobile business. They are economics, social trends, technology and business need (Jones 2002a).

Economics

One of the major reasons for growing number of subscribers and revenue is lower-priced digital service. Increased competition caused rapid declines in the average price per minute. Prices of mobile devices are also falling. Mobile phone chip sets will soon cost less than $35 and Bluetooth chip set costs will fall below $5 by the end of this year. This price reduction will make connecting any electronic device to the wireless network possible and make new applications economically feasible.

Social Trend

Mobile phones are a fashionable accessory in many societies and social groups, especially among younger generations. The combination of mobile technology, fashion and entertainment attracts such groups to acquire the newest devices and services frequently. Early adoption of NTT DoCoMo's 3G service, however, does not support this observation.

Technology

Current mobile applications use basic technologies such as SMS and i-mode. New technologies including authentication, caller ID, enhanced 911 locator service, electronic payment, fingerprinting and SIM card will enable new applications, e.g., shopping portals that find alternative sources for products or services near the consumer.

Business Need

Of course, real business need must drive the implementation of mobile applications. A common characteristic of all solutions is the need to communicate at any time or from anywhere. Increased competition will increase the need for faster response times

and increased connectivity with employees and customers. Other related reasons are increasing globalization and the growing number of telecommuters and other mobile workers.

Convenience is the most important driver for consumers. As they become comfortable with the technology, they start using their devices for daily transactions. Vendors such as store and restaurant owners and content providers will benefit from the unprecedented ability to narrowly target potential customers. The obstacles, such as security and privacy concerns and low awareness of m-business applications, will be quite difficult to overcome, particularly in the U.S.

Successful Mobile Data Applications

As a rule, mobile data application must be designed to satisfy specific needs or user group. Companies should not perceive mobile technologies as a universal tool. As always (or even more so), user needs must be carefully analyzed. Solutions must be designed by taking into account limitations of devices and networks. For example, expectations for network speed, reliability and coverage have often been unrealistic under the influence from wireless carriers and application vendors. Pilot testing every new application as early as possible is particularly important because of so many unknowns and related risks. Such testing enables application adjustments before the rollout, sets realistic user expectations and confirms that users will at the end accept the application.

Wireless connectivity is best used when it extends an existing application and provides additional functionality, when it is used to increase productivity or decreases downtime and when it increases the responsiveness and competitiveness. According to Gartner Dataquest (King 2002), the current top five industries using mobile applications are(King 2002),:

- field service (utilities, appliance repair, telecommunications),
- transportation (shipping and receiving),
- public service (police, fire and rescue),
- insurance (auditors, agents) and
- finance (brokers, traders, external customers),

while the future top five application winners will be:

- messaging (e-mail, presence- and location-enhanced messaging),
- field sales (inventory look-up, order status and placement),
- field service (location enhancements, rich content delivery),
- insurance (wireline replacement, increased external communications) and
- finance (information delivery, transactions).

The common characteristic of the industries listed above is a large group of employees who are mobile and spend significant amount of time away from their offices. It may be surprising, but a relatively simple use of messaging (SMS or instant messaging) can be an effective mobile application and even more so when it is combined with presence and location detection. Field sales support is receiving a lot of attention from wireless carriers, traditional vendors and some new application vendors. These and other horizontal applications currently generate most of the wireless data services revenue. Utilities, public services and other such industry groups have been most active in rolling out mobile applications and achieving rapid return on investment (ROI). "There are currently about 50 or 60 million mobile workers in the U.S.," eMarketer's Macklin said, "and certainly a growing number of remote workers as well, so it is a challenge" (Fixmer 2002).

Another suggestion by Gartner is to see m-business as a symptom technology of time-sensitive service economy, perceive the company as a service and recast its core business as a service (Trinkner 2002). Even product manufacturers should see themselves as service companies. For example, sales activities may involve configuring, customizing and educating. Order processing often includes invoicing, delivering and tracking. All these are time-sensitive processes and strongly influence customer satisfaction.

The first step in addressing a question whether m-business is right for a company is to evaluate if mobile applications can directly increase revenue or cut costs. Such benefits are sometimes quite obvious and predictable. When this is not so, the analysis should include three groups of questions. The first group evaluates company's ability. Typical questions in this group are:

- Is company's IS infrastructure mature?
- Is it flexible enough?

- Had new technologies been introduced before?

The second group of concerns involves the employees or assets:

- Are employees or assets rarely stationary?
- Do they need to create short-lived data?
- Are they spread geographically?

The third part of the evaluation focuses on the type of company and addresses the following questions:

- Is the company selling services or products resembling services?
- Are services time-sensitive?
- Are the short-lived data critical?
- Can the flow of data on a critical path be expedited?
- Is customer service critical?

In other words, time rather than location may be the most compelling factor in this analysis. Can the investment in wireless technologies and related technical challenges be justified by the benefits of immediacy? Immediacy, and more importantly, the value of immediacy to an individual company, is the key variable (Trinkner 2002).

Supporting Multiple Mobile Channels

Mobile devices have sufficiently different physical characteristics (e.g., small screens and keyboards, low bandwidth) and functionality (e.g., always on and connected, and being carried by the user wherever she goes) to be considered a different communication channel. Not only are the mobile devices and wireless access different from PCs and their connections to the Internet, but also the ways users employ and value them are different. M-business is not about surfing the Web with a phone. If m-business were considered just an extension of the conventional Internet, the applications would likely be dysfunctional. Mobile devices will be one of the alternative ways to access enterprise applications. They will complement other channels, such as classic Web, interactive digital TV, contact centers and voice response systems.

The ubiquity of wireless networks and the increasing variety of mobile devices will promote a whole set of new applications that will have to be integrated with the existing operational systems and classic Internet applications. Mirroring the integration of enterprise applications with the classic Internet, the m-business channel will be facilitated by new set of middleware products, such as application servers and integration brokers. Multiple channels will be enabled by the multiple layer architecture. Core business processes will be supported by the back-end services, which will feed device independent front-end services. These will, in turn, connect to different channels through the so-called channel adopters. Channel adopters are applications, which provide services appropriate for each channel and allow users or external applications to access the front-end services.

Channel adopters supporting mobile and wireless devices will be very complex because of the variety of devices and access protocols. They will have to support an ever-increasing variety of PDAs and phones with various screen and keyboard resources, diverse communication protocols (e.g., voice, SMS, handset-specific WAP or generic micro-browsers), various operating systems, and different presentation formats (e.g., VoiceXML, HDML, WML). It will also become increasingly important to support multiple networks linking cellular, Wi-Fi, and Bluetooth devices. Companies will likely start with the support of a limited number of portable devices, but will be forced to expand the support due to the lack of standards and following the proliferation of vendor offerings.

Conclusions

Reports of successful m-business applications in various industries (including transportation, field service, hospital, and financial) suggest that wireless technology can improve the corporate bottom line or competitive position. NTT DoCoMo's experience with i-mode is a success story about wireless service to consumers. The first conclusion is that technologies enabling m-business are very important and should be evaluated by all organizations. They can be implemented as a competitive weapon or to defend an existing market position.

The technological evolution is in full swing and its ending is quite unclear. While the design of mobile devices is diverging, four main communication protocols are transitioning to two main contenders. Three operating systems are widely accepted and several application platforms look promising. This situation leads to a conclusion that companies should take a short-term perspective in their m-business implementation. Today's solutions will very likely have to be modified or redesigned in the future.

The third observation is that small portable devices like cell phones and PDAs do not provide the same Internet experience as desktop computers with high bandwidth Internet connections. Wireless mobile communication is a distinct channel and not just another alternative to access the existing Internet and Web applications. When applied, m-business solutions will have to be supported by a multi-channel system architecture.

The common perception that high bandwidth will bring masses to the "m" world is not yet proven. Early experience with DoCoMo's FOMA adds more doubt to this issue, at least when the device is as small as a cell phone. The popularity of SMS and its effective use in business applications imply that we often do not need to wait for general availability of 3G or even faster technologies to take advantage of m-business.

Significant specific impediments have to be addressed, none more important then the issue of security. Contrary to common perception, the mobile devices are much more vulnerable than the data in transition. Lost and stolen devices with growing amount of memory and confidential information present the main point of exposure. The other surprising experience is that even the widely available security technologies, such as encryption and password protection, are often not activated.

We seem to have reached a point of growing expectations on the m-business "hype curve." The telecommunications industry is in a slump. It is difficult to predict how this will all play out, but this is also a proper time to investigate the opportunities seriously, get involved in prototyping, and apply our best assumptions about m-business evolution.

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