

INTEROPERABILITY OF WIRELESS COMMUNICATION TECHNOLOGIES  
AND MOBILE INTERNET APPLICATION DEVELOPMENT TOOLS

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### Abstract

With the explosive growth of various mobile wireless communication technologies, selecting proper technologies and developing wireless mobile Internet applications that are interoperable on various mobile wireless devices is challenging to the IT professionals. This study is to test the interoperability of wireless communication technologies and mobile Internet/Web applications development tools through comparative hardware and software analyses and tests. The findings report (a) which wireless communication technologies and devices are Internet/Web enabled, (b) to what degree the varied wireless communication technologies and devices are interoperable, and (c) what tools exist for developing mobile wireless Internet/Web applications that are interoperable on various mobile wireless communication devices.

### Introduction

The world has witnessed an explosive growth of using mobile wireless communication devices such as cellular phones, pagers, palm devices, and pocket and notebook PCs (e.g., Bruinius, 1999; Miller, 2000; Nelson & Pilone, 2001; Rae-Dupree, 2002, Yang, 2000). Many of these devices enable users not only to make phone calls but also to send and receive email, browse and interact with the Internet at anytime from anywhere for registering classes, paying bills, shopping, managing bank accounts, trading securities, checking inventories, to mention just a few (e.g., Kennedy, 2001; Nadesan, 2001; Paul, 2002; Schwartz, 2002a, 2002b; Suominen, 2000).

However, because these devices use different technology standards, selecting proper wireless communication technologies and developing mobile Internet/Web applications that are interoperable on various mobile wireless devices is challenging to the IT decision-makers and mobile wireless applications developers (e.g., Berlind, 2002; Brewin, Verton, & Disabatino, 2002; Swanson, 2002a, 2002b). For

example, cellular phones, pagers, palm devices, and pocket and notebook PCs have varied screen sizes and display lines. They use different mobile wireless communication technologies such as GSM, CDMA, Wi-Fi (802.11a/b/g), and Bluetooth. In addition, they use different markup languages such as HTML for PDAs and Pocket PCs and WML (wireless markup language) for cellular phones. As Wexler (2003) indicated, with varied wireless communication standards, architectures, and suppliers continually emerging, it is no wonder a recent Synergy Research Group report cited “buyer confusion” as one of the top reasons enterprise wireless LAN equipment sales were down almost 3% in the third quarter of 2002 and have fallen nearly 13% annually.

#### Problem and Purpose of the Study

The problem addressed in this study was to identify the interoperability of mobile wireless communication technologies and devices as well as the tools for developing interoperable mobile wireless Internet/Web applications. The purpose of the study is twofold. First, the findings of the study would inform mobile Internet/Web developers and educators of which wireless communication technologies are interoperable and which development tools are appropriate for developing interoperable mobile Internet/Web applications. Second, the findings would also provide schools and companies with the information they need for planning wireless Internet/Web-based campus or business.

#### Review of Related Literature

Wireless communication technologies include various standards such as Bluetooth, Wi-Fi (Wireless Fidelity or 802.11a/b/g), GSM (Global Systems for Mobile Communications), CDMA (Code Division Multiple Access), GPRS (General Packet Radio Service), and EDGE (Enhanced Data Rates for GSM Evolution). Each of these wireless communication technologies serves a specific need (e.g., Kay, 2002; Schlesinger, 2002; Sibillin, 2002; Yager, 2000).

Bluetooth operates on the unlicensed or free airwaves of 2.45 GHz and provides a short-range wireless radio communication up to 10 meters with the data transmission speeds up to 1Mbps. Therefore,

it enables wireless personal area networks (WPAN), which can connect a cell phone or a PDA to a notebook PC, to a desktop PC, or to a printer (Bluetooth, 2003). Several major IT manufactures such as 3Com, Ericsson, Dell, IBM, Intel, Motorola, Nokia, and Toshiba produce Bluetooth-enabled cell phones, PDAs, or notebook PCs and Bluetooth PC cards, USB adapters, and printing kits.

Wi-Fi, referring to IEEE 802.11b/a/g specifications, is a wireless local area network (WLAN) technology for wireless communication up to 100 meters by using unlicensed spectrum at high transmission speed. For instance, 802.11b provides 11 Mbps transmission in the 2.4 GHz band, which is about seven times faster than a T1 (1.5 Mbps) line. Wi-Fi wireless networks are proper for PDAs and notebook PCs used by mobile professionals and college students to have wireless Internet access in their office or classroom, at home, or at airport. According to a study by the Yankee Group (Cisco, 2002), more than half of U.S. businesses will deploy Wi-Fi networks by the end of 2003. IBM, AT&T, and Intel announced to form a joint venture, Cometa Networks, to build a nationwide Wi-Fi wireless network (Andrews, 2003).

GSM, a 2<sup>nd</sup> generation leading digital cellular network system, uses narrowband TDMA (Time Division Multiple Access), which allows eight simultaneous wireless phone calls on the same radio frequency with a data transmission speed of 9.6Kbps. Recently, its major carriers, T-Mobile, Sony Ericsson, Nokia, AT&T, and Cingular, upgraded GSM/TDMA to GSM/GPRS (Genral packet radio Service), a 2.5 generation technology that provides a transmission rate of 144Kbps on the licensed airwaves of 1900 MHz and 2100 MHz (e.g., GSM World, 2003; Nobel, 2002a; Schlesinger, 2002).

CDMA is another 2<sup>nd</sup> generation leading digital cellular network system mainly used for cell phones in the North America. CDMA is now upgraded by Qualcomm, Kyocera, Verizon, Sprint, and Virgin Mobile to CDMA 2000 1X (also named CDMA 1xRTT), a 2.5 generation technology with a transmission speed of 144Kbps on licensed airwaves of 450 MHz, 800 MHz, 1700 MHz, 1900 MHz and 2100 MHz. The 3<sup>rd</sup> generation W-CDMA (or CDMA 2000 2X) will provide data transmission

speeds up to 2Mbps (e.g., CDMA Development Group, 2003; Nobel, 2000a, 2002b; Schlesinger, 2002).

Regarding the technologies on the mobile wireless Internet/Web application layer, different technologies and languages exist for different types of mobile wireless devices. For example, to make Internet/Web applications work on cell phones, WAP (Wireless Application Protocol) technology needs to be built into the phones, and WML (Wireless Markup Language), a subset of XML, should be used for developing cell phone-based Internet/Web applications (e.g., Brooks, 2002; Nobel, 2002a; Rae-Dupree, 2002).

By contrast, PDA-based Internet/Web applications are designed to fit PDA screen size and developed with HTML or XHTML. PDAs operating on Palm OS or Microsoft Pocket PC operating system usually use Wi-Fi or Bluetooth to access the mobile Internet/Web applications. The Pocket PC phones or smart phones can have the mobile wireless Internet/Web access by connecting either the nationwide GSM/GPRS or CDMA 2000 1X network or the broadband WLAN (Wi-Fi) network (e.g., Green, 2002; Kort & Dulaney, 2001; Nobel, 2002b; Paul, 2002; Schwartz, 2002; Shaw, 2002).

Mobile wireless notebook computers can connect the Internet by using inserted wireless Wi-Fi PC cards and can also make phone calls by using Web-conferencing software such as Microsoft NetMeeting. Notebook computers with built-in Wi-Fi and Bluetooth wireless networks are now available on the market. For instance, in addition to install a built-in Bluetooth wireless network in the new PowerBook computers, Apple Computer's new PowerBook computers are built with both Bluetooth and Wi-Fi/802.11g that has a data transmission speed of 54Mbps, five times faster than the Wi-Fi/802.11b network (Lewis, 2003).

With such a wide variety of mobile wireless communication technologies and devices, a need exists to identify the interoperability among the varied wireless communication technologies and devices and the tools for developing Internet/Web applications that can interoperate on various mobile wireless

devices.

### Research Questions

In order to solve the problem addressed in this study, the following three research questions were addressed:

1. Which wireless communication technologies and devices are mobile Internet/Web enabled?
2. To what degree the varied wireless communication technologies and devices are interoperable?
3. What tools exist for developing Web applications that can interoperate on various mobile wireless devices?

### Research Procedures

Based on the review of related literature, I employed the comparative analysis and test of the mobile wireless communication technologies, devices, and application development tools to address the research questions. Specifically, first, to identify the specifications of mobile wireless communication technologies and devices and to evaluate which technologies and devices are Internet/Web enabled, I collected data by visiting the related Web sites and using email for follow-up questions and responses.

Second, I cross-examined the Internet/Web-enabled mobile wireless communication technologies and devices to check their degree of interoperability. The cross-examination was conducted among the following mobile devices with their respective GSM/GPRS, CMDA 2000 1X, Wi-Fi, and Bluetooth technologies: Sony Ericsson T61LX, Kyocera 2119b, Motorola 120T, Motorola T720I, LG KH5000, Handspring Treo 300, T-Mobile Pocket PC Phone Edition, iPAQ h5450, and Palm i705 and m500.

Finally, I compared six major programming tools: Nokia Mobile Internet Toolkit 3.1, Ericsson Mobile Internet Toolbox, Motorola CodeWarrior Wireless Studio, Palm Wireless Tools, IBM WebSphere Everyplace Suite, and Microsoft Mobile Internet Toolkit to identify which ones can develop Web applications interoperable on various mobile wireless communication devices.

### Results

*Internet/Web-Enabled Mobile Wireless Technologies and Devices*

Research Question 1 asked, “Which wireless communication technologies and devices are mobile Internet/Web enabled?” As the test results indicated, first, the cell phones using the 2<sup>nd</sup> generation GSM and CDMA, for example, Sony Ericsson T61LX, Kyocera 2119b, and Motorola 120T, are only able to browse and interact with text-based mobile Internet/Web applications via the WAP 1.0 browser. The text-based applications include (a) browsing and navigating the cell phone menu screen, (b) sending and receiving text messages, (c) checking user’s phone account balance, and (d) accessing a variety of online music and information services.

Second, the cell phones using the 2.5 generation GSM/GPRS and CDMA 2000 1X such as Motorola T720i and LG KH5000 support MMS (Multimedia Messaging Service) and EMS (Enhanced Messaging Service) technologies, respectively. Thus, these 2.5G cell phones enable users to browse and interact with multimedia-based mobile Web applications including text, color, animated graphics, and video clips via the WAP 2.0 browser.

Third, PDAs, Pocket PCs, and notebook computers that can connect the nationwide GSM/GPRS or CDMA 2000 1X networks, or broadband Wi-Fi (802.11b) networks do provide users with mobile wireless Internet access. For example, Handspring’s Internet-ready Treo 300 communicator connects Sprint PCS (CDMA 2000 1X) network for its phone use and Internet access, whereas T-Mobile’s Internet-ready Pocket PC Phone Edition runs on the T-Mobile’s nationwide GSM/GPRS network in 8,000 cities across the country.

By contrast, HP iPAQ h5450 is a Pocket PC with the built-in Wi-Fi (802.11b) and Bluetooth chips for mobile Internet access. And Palm i705 and m500 with wireless LAN module can subscribe to the Palm.Net® Wireless Service for a secure, always-on Internet connection. In addition, T-Mobile also offer broadband wireless Internet access for PDAs, pocket and notebook computers through its Wi-Fi (802.11b) networks in more than 1,200 convenient public locations nationwide, including airports, airline

clubs, and Starbucks cafes.

### *Interoperability of Mobile Wireless Technologies and Devices*

Research Question 2 asked, “To what degree the varied wireless communication technologies and devices are interoperable?” The results indicated that the interoperability (also named inter-standard roaming) among various wireless communication technologies is not available to American consumers yet. However, integrated CDMA/GSM and 802.11/GSM networks are already at trial stage in Europe and Asia by Nortel Networks, Mobility Networks, Korea Telecom Freetel, and French Bouygues Telecom. On the other side, Intersil, a U.S.-based company, has introduced to the market the built-in multi-mode (802.11/Bluetooth) chip for mobile wireless communication devices.

At the mobile Internet/Web applications level, WAP applications are accessible only on Internet-ready cell phones, whereas on PDAs and Pocket PCs, users can browse and interact with both palm- and desktop-sized HTML-based Web applications. Web clipping applications only work on mobile devices running Palm OS. To access and interact with cell phone screen-sized or palm screen-sized Web applications on notebook PCs, users can download and install a WAP phone emulator or Palm and Pocket PC emulators.

### *Mobile Internet/Web Applications Development Tools*

Research Question 3 asked, “What tools exist for developing Web applications that can interoperate on various mobile wireless devices?” As the research results illustrated, the major IT companies provide the free-download trail or beta versions of mobile Internet/Web development tools and training programs to attract developers. The following tools are available at their corporate Web sites: Nokia Mobile Internet Toolkit 3.1 at [www.forum.nokia.com/main.html](http://www.forum.nokia.com/main.html), Sony Ericsson Mobile Internet Toolbox at [www.sonyericsson.com/mobilityworld/sub/open/](http://www.sonyericsson.com/mobilityworld/sub/open/), Motorola CodeWarrior Wireless Studio at [kb.motorola.metrowerks.com/motorola/development/pcsHome.do](http://kb.motorola.metrowerks.com/motorola/development/pcsHome.do), Palm Wireless Tools at [www.palmos.com/dev/tools/](http://www.palmos.com/dev/tools/), IBM WebSphere Everyplace Suite at [www-](http://www-)

[3.ibm.com/software/pervasive/products/mobile\\_sols/](http://3.ibm.com/software/pervasive/products/mobile_sols/), and Microsoft Mobile Internet Toolkit at [www.msdn.microsoft.com/downloads/](http://www.msdn.microsoft.com/downloads/).

The foregoing mobile wireless Internet/Web development tools enable developers to build device-specific mobile Web applications, except for IBM WebSphere Everyplace Suite and Microsoft Mobile Internet Toolkit. For instance, Palm's wireless tools are only for developing applications for mobile devices operating on Palm OS, and Nokia's are for Nokia devices. By contrast, IBM WebSphere Everyplace Suite contains several technologies and tools and implements multiple open standards. Its Transcoding Publisher can transform arbitrary Web content into a form that can be presented on a device different from the originally intended target, such as changing HTML content intended for desktop PCs to WML content suitable for the Internet-ready cell phones. Similarly, Microsoft Mobile Internet Toolkit enables developers to write mobile Web applications interoperable on various mobile devices including WML-based cell phones and HTML-based PDAs and Pocket PCs. This is because the Mobile Internet Toolkit allows developers to write a mobile Web application with a set of ASP.NET server-side adaptive components that can generate the appropriate markup language for a mobile device when its user makes a request.

### Conclusions and Implications

Based on the results of this comparative study, the following conclusions are made:

1. Both the licensed wireless GSM and CDMA networks and the unlicensed wireless Bluetooth and broadband Wi-Fi networks and their respective devices are mobile Internet/Web enabled.

Furthermore, the newer the wireless communication technologies and devices are, the more integrated they are with the Internet/Web technologies.

2. Although the interoperability of wireless communication technologies and devices is not available in the U.S. market, the integrated CDMA/GSM and 802.11/GSM networks are already at trial stage in Europe and Asia and the U.S.-made multi-mode (802.11/Bluetooth) chips are also ready for

mobile wireless communication devices.

3. At the mobile Internet/Web applications level, Internet-ready cell phones only enable users to access WML-based Web applications, whereas PDAs and Pocket PCs allow users to browse both palm- and desktop-sized HTML-based Web applications. For notebook computers to access cell phone- and palm-sized Web applications, they need to install WAP phone emulator and Palm and Pocket PC emulators.

4. Among the six major mobile Internet/Web development tools, only IBM WebSphere Everyplace Suite and Microsoft Mobile Internet Toolkit enable developers to write mobile Web applications interoperable on various mobile devices such as WML-based cell phones and HTML-based PDAs and Pocket PCs.

Based on the conclusions, for individuals who travel globally, they should consider purchasing mobile wireless communication devices upgradable to or compatible with multi-standards so that they are able to use those mobile devices anywhere around the world. For institutions planning for mobile wireless Internet/Web-based campus or business, their decision-makers should consider building Wi-Fi networks and purchasing mobile devices connectable to Wi-Fi, GSM, or Bluetooth network. Finally, to develop mobile wireless Web applications interoperable on various devices such as cell phones, PDAs, Pocket PCs, and notebook computers, developers should consider using IBM WebSphere Everyplace Suite or Microsoft Mobile Internet Toolkit.

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