PDA and Smartphone Operating Systems: Technology Overview

Summary
The handheld device operating system market includes Palm OS, Symbian OS, Windows Mobile and several Linux systems. They vary in price, application, form factor, market, security and wireless capabilities.

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Technology Basics

Introduction to Personal Digital Assistants and Smartphones

A PDA is a small handheld device that provides digital organization functions. PDAs were originally designed to replace paper for organizing calendar and contact functions. As such, early devices contained address books, calendars and notepads. Today, PDAs supplement this functionality with wireless connectivity and e-mail. A typical PDA consists of a small liquid crystal display, an operating system, a processor and memory. Most standard PDAs include a variety of application software, such as games, music players, and spreadsheet and word processing products. The devices can not only synchronize with desktop PCs, but can also connect directly with server applications to access Web content and Web applications. To appeal to business users, independent software vendors offer sophisticated business applications like business intelligence, collaboration, customer relationship management, data collection, field service, sales force automation, supply chain management and others. Developers need to note that with the exception of Microsoft’s offering, all of the operating system platforms listed rely heavily on third-party tools for development.

PDAs, which are data-centric devices, are available in two form factors: tablet and clamshell. There is another category of mobile devices: smartphones. These are actually cellular phones with some PDA functionality.

Generally speaking, the market-leading embedded operating systems — including Palm OS and Microsoft Windows Mobile — as well as a number of Linux-based operating systems can run on both PDAs and smartphones. Symbian OS and Microsoft’s Windows Mobile-based Smartphone platform are geared to mobile phone devices.

Device Classifications

Tablet PDAs

Tablet PDAs are palm-sized devices with a stylus and a touch screen. They typically have a display between 50 mm and 100 mm (2 inches to 4 inches) diagonally and weigh between 100 grams and 220 grams (3.5 to 8 ounces). They feature either a QWERTY keyboard or stylus-operated software keyboard for data input. Examples of tablet PDAs include Palm Zire and Tungsten models, Sony Clé and Microsoft Pocket PC-based devices. Also included in the Tablet PDA category are some industrial handhelds, such as the Intermec 700 Series, Symbol PPT 8800 and Panasonic Toughbook CF-P1.

Clamshell PDAs

Clamshell PDAs usually include a small keyboard, a stylus and a touch screen. Form factor and display size vary substantially. Data input is not significantly easier than with tablet PDAs, as the small keyboard requires nimble fingers. Examples of clamshell PDAs include the Sony Clé PEG NX80 and Sony Clé UX50, Sharp Zaurus C-760 and T-Mobile Sidekick. Clamshell PDAs have a closed face.

Wireless Subcategory of PDAs

A subclassification includes tablet and clamshell PDAs that are natively wireless-enabled. Wireless PDAs offer integrated wireless LAN or WAN communication capabilities, but Bluetooth alone does not satisfy our definition. Examples of wireless-enabled tablet PDAs include the Research in Motion (RIM) Blackberry 7200 Series, Toshiba Pocket PC e800, Hewlett-Packard (HP) iPAQ h5550 and 02 Xda. Wireless PDAs are distinguished from smartphones by their form factor and primary purpose. Wireless PDAs are mainly data-centric, while smartphones are voice-centric devices. PDAs that use add-on
modules to achieve wireless capabilities are still classified as they were at the time they left the factory, so a stand-alone PDA that has been enhanced with a wireless General Packet Radio Services (GPRS) module is still considered a stand-alone PDA.

**Smartphones**

Where a PDA is a data-centric device, a smartphone is a voice-centric device. Its primary functionality is voice communication; data is only a secondary feature. This is reflected, in most cases, in its handset-like form factor. While one typically needs both hands to operate a PDA, smartphones are generally designed for one-handed operation, offer smaller displays, have greater battery life and are usually smaller in size and weight. Both PDAs and smartphones rely on full-featured operating systems with ample third-party software support. Smartphones have rich telephony features with some data capabilities.

The most common applications included in a smartphone are calendar, address book, text messaging, wireless Internet connectivity, PC synchronization and “to-do” list. It is often possible to expand storage through cards, such as Secure Digital or others. Features, such as integrated digital cameras, multimedia messaging and Motion Picture Experts Group (MPEG) Audio Layer 3 (MP3) players, are also increasingly common. Examples of smartphones on the market today include the Orange SPV E200 (manufactured by HTC), the Nokia 3660, the Sony Ericsson P900, the palmOne Treo 600 and the Motorola MPx200.

**PDA Operating System Characteristics**

Operating systems for highly portable computing devices should have the following characteristics:

- They must be small — typically a few megabytes — so as not to consume valuable storage space.
- They should consume very little power to support long battery life. Battery life can be one of the main constraints of PDAs. Batteries for stand-alone PDAs last between four and 12 hours of continuous usage. However, batteries in wireless-connected PDAs and smartphones last only between two and 10 hours of talk time.
- They should support a high degree of task switching, allowing users to switch smoothly from one program to another.
- They should support all types of voice and data communications, including established and emerging wireless standards.
- They must be able to synchronize. The operating system typically supports PC synchronization, but third-party synchronization products may offer generalized support for all platforms and for server synchronization.

**Table 1: Major PDA and Smartphone Operating Systems**

<table>
<thead>
<tr>
<th>Palm OS 5.2</th>
<th>Microsoft Windows Mobile 2003 (Pocket PC and Smartphone)</th>
<th>Symbian 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>32-bit multiprocess multithreaded OS</td>
<td>32-bit real-time preemptive multitasking OS</td>
</tr>
</tbody>
</table>
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</thead>
<tbody>
<tr>
<td>Memory Requirements</td>
<td>Kernel: 2MB Devices currently shipping have 2MB to 16MB of main memory, and systems with more memory have been announced</td>
<td>Between 16MB and 32MB depending on stock-keeping unit (SKU) version per product</td>
<td>Kernel and built-in applications: 6MB</td>
</tr>
<tr>
<td>Hardware Platforms</td>
<td>Advanced reduced instruction set computer (RISC) machines (ARM)-compliant processors from Intel, Motorola and Texas Instruments; Motorola 68000 processors</td>
<td>ARM</td>
<td>ARM, Intel StrongARM, Texas Instruments and Motorola processors</td>
</tr>
</tbody>
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<th>Palm OS 5.2</th>
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<th>Symbian 7.0</th>
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<tbody>
<tr>
<td>Communicatio ns Support (Note that communications support for an operating system is highly dependent on third-party manufacturer’s choice of communications protocols and particular implementation choices.)</td>
<td>Bluetooth, 802.11b, Wireless Application Protocol (WAP), HTML 4.01, Secure Sockets Layer (SSL) 3.0, TCP/IP, OBEX or Object Exchange, Point-to-Point Protocol (PPP), Simple Mail Transfer Protocol/Post Office Protocol 3 (SMTP/POP3), serial dial-up, Infrared Data Association (IrDA)</td>
<td>TCP/IPv4, IPv6 IPsec (or Internet Protocol security), TCP/IP plug-in framework, WAP stack, Bluetooth v.1.1, IrDA Universal Serial Bus (USB) (slave), serial, SSL/Transport Layer Security (TLS)/Wireless Transport Layer Security (WTLS) (secure Web connections)</td>
</tr>
<tr>
<td></td>
<td>802.11b wireless, Bluetooth, Remote Access Services Server (RAS)/PPP, Extensible Authentication Protocol (EAP), IrDA, Lightweight Directory Access Protocol (LDAP) client, Network Driver Interface Specification (NDIS) 5.1, OBEX, Point-to-Point Tunneling Protocol (PPTP) server, real-time collaboration (RTC) client application programming interface (API) (original equipment manufacturer [OEM] option), serial communication, SNMP, TCP/IP (includes specifically support for IPv4 and v6), Telephony Application Programming Interface (TAPI), Hypertext Transfer Protocol Daemon (HTTPD), Winsock 1.1, 2.2, SSL 3.0</td>
<td></td>
</tr>
<tr>
<td>Development</td>
<td>Palm OS 5.2</td>
<td>Microsoft Windows Mobile 2003 (Pocket PC and Smartphone)</td>
</tr>
<tr>
<td>-------------</td>
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</tr>
<tr>
<td>Development</td>
<td>Palm Application Compatibility Environment (PACE) — interprets the 68K family instructions of applications and makes them run on the ARM. Supports Visual C++ and Visual Basic, the Conduit Development Kit (CDK) for Mac OS and the Windows CDK (which includes updated project files/wizards for Visual Studio .NET).</td>
<td>Visual Studio .NET, eMbedded Visual C++ 4.0 (Service Pack 2) and Visual J .NET</td>
</tr>
<tr>
<td>Java Runtime</td>
<td>JavaScript 1.5 (browser), numerous Java Virtual Machines, including IBM K Virtual Machine</td>
<td>Supported by third-party virtual machine</td>
</tr>
<tr>
<td>Desktop Synchronization</td>
<td>HotSync</td>
<td>ActiveSync</td>
</tr>
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<th>PACE</th>
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<th>Symbian 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm OS 5.2</td>
<td>Acer s10, AlphaSmart Dana, Handspring Treo, Kyocera 7135 smartphone, Palm Tungsten and Zire families, Samsung MIT SGH-i500 smartphone, Sony Clé family</td>
<td>Windows-powered Pocket PCs: Dell Axim X5, HP iPAQ Pocket PC, T-Mobile Pocket PC Phone, Toshiba e800</td>
<td>Siemens SX1, Sony Ericsson P900 Smartphone, Nokia 3660, Samsung SGH-D700, BenQ P30</td>
</tr>
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</table>

The Market Leaders

According to Gartner Dataquest, in the second quarter of 2003, Palm OS was shipped on 1.2 million PDAs, which equals 55.2 percent of the total PDA OS market. Palm is followed by Pocket PC (based on Microsoft Windows CE), with 0.9 million shipments. Microsoft accounted for 37.4 percent of the market.

The smartphone OS market sees a more prominent role for Symbian OS, together with Windows Mobile Smartphone and Palm OS. A number of operating systems based on Linux are also trying to gain ground both in the PDA and in the smartphone markets.

Palm OS

PalmSource, the software spin-off from Palm, released Palm OS 5 in 2002 with a significant shift in its architecture. Previous versions of Palm OS ran on Motorola DragonBall 68000 processors. The operating system itself was created around the multithreaded AMX real-time operating system from Canadian Kadak. However, the license with Kadak limited the company’s ability to expose multitasking to software developers because it only permitted a single-threaded subset of AMX.

The Palm OS 5 operating system has a new multiprocessing kernel without licensing restrictions. It is designed to operate on ARM-compliant processors, which run anywhere from two to 30 times faster than 68000 processors. Aside from hardware speed, the shift in architecture also allows Palm-driven devices to run 32-bit applications. With ARM support, PalmSource gives licensees the options to create a variety of devices at different price points.

To accommodate backward compatibility, Palm created PACE, which translates 68,000 instructions to 32-bit ARM and adjusts bit-ordering inconsistencies. This allows for Palm OS 4 applications to run transparently under Palm OS 5. Early reviews on the emulation process are mixed. Degradation in performance for some applications has been noticed, while other applications reported faster performance.

Palm OS 5 is a multithreading operating system. It provides native support for wireless technology (802.11b, Bluetooth, code division multiple access [CDMA], Global System for Mobile Communications...
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[GSM], and 2.5 and third-generation [2.5G/3G]) mobile networks and offers 128-bit SSL encryption services (SSL 3.0/TLS 1.0). Through a partnership with RSA Security, Palm OS 5 includes Rivest Code 4 (RC4), Secure Hash Algorithm 1 (SHA-1) and signature verification using RSA-verify. Other cryptographic architectures, like Advanced Encryption Standard (AES), can be plugged into the Palm OS environment.

Version 5 supports improved screen resolution (320 x 320 pixels, extended by some licensees to higher resolution) and new audio APIs for playing and recording 16-bit multivoice audio files. Palm OS 5 was released in June 2002, and by December 2002, products like the Palm Tungsten T and Sony NX70V started shipping with the operating system. Still, most products on the market at this time run under Palm OS 4.

Key Palm OS 5 Features

- ARM-compliant processors from Intel, Motorola and Texas Instruments are supported.
- A library of more than 17,000 commercial applications is supported.
- Investment in 68000-based support is protected through Palm’s PACE compatibility/translation environment.
- A user’s data and applications are automatically backed up whenever a device is synchronized.
- Built-in software suite includes calendar, address book, alarm clock, memo pad, calculator and e-mail. Most licensees bundle it with third-party software to read and edit Microsoft Office files.
- 802.11b and Bluetooth wireless network standards are supported. For smartphones, CDMA and GSM networks are supported.
- The new browser supports such Internet standards as HTML 4.01, Compact HTML and Dynamic HTML.
- PPP support uses the Challenge-Handshake Authentication Protocol (CHAP), MS CHAP (Microsoft CHAP) and Password Authentication Protocol (PAP).
- SSL, 128-bit data encryption, PPTP and IPsec connections are supported.

Palm OS 6

PalmSource announced in September that Palm OS 6 will be released to its licensees on 29 December 2003. Licensees such as palmOne, Sony and Samsung will likely need a few months to customize the software for their PDAs and smartphones. Devices based on Palm OS 6 will likely be launched about three to four months after licensees receive the final code.

Major new features/capabilities include:

- Developers will be able to write ARM-native applications, although legacy applications will be able to run as long as they follow PalmSource rules for “well-behaved” software
- New API will support switching between portrait and landscape display modes
- Support for multithreading and background processes, allowing more than one application to run simultaneously
- Protected memory and process protection
- New API will support roaming among Wi-Fi, GPRS and CDMA networks
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- Much improved graphics and multimedia handling
- Improved access to Microsoft Exchange and Lotus e-mail servers and Web services
- Much improved security
- Eliminates 4K memo and 16-category limits
- Pluggable input/output (I/O) interfaces — allows licensees to choose what input methods are supported
- View Microsoft Office and Adobe Acrobat files in native formats

In theory, since OS 5 devices are running on ARM processors, upgrades of some older devices to OS 6 are possible. The new OS 6 is expected to retain the ability to fit within an 8MB ROM footprint. However, it will be up to each licensee to develop the software necessary to support established device upgrades.

Symbian

The Symbian OS is targeted at the smartphone market. It is based on a 32-bit multitasking kernel and provides middleware for communications, data management and graphics, a graphical user interface framework and application engine. Symbian OS runs natively on the ARM RISC processor and is designed with the real-time capability to support both voice and data applications over wireless networks. It supports serial, infrared and Bluetooth connections, as well as a telephony API that enables clients to initiate, receive, control and terminate data, fax and voice calls using the same methods for any hardware. Like Palm OS and Windows Mobile, Symbian OS has its own synchronization code (Symbian Connect) that lets a PDA or smartphone exchange data between its personal information management (PIM) applications and PC applications.

Symbian 7.0, released in February 2003, includes support for multimode and 3G mobile phones. It supports IPv6 and IPsec technologies, giving mobile phones the capability to communicate securely on a peer-to-peer basis. Symbian 7.0 also adds Java J2ME MIDP 2.0, which extends the capabilities of phone devices to run Java applications and services geared exclusively to mobile phones. The vast majority of developers for Symbian will use Java and C/C++, although a niche programming language initiative (OPL) is also supported and available for open source development. An alpha version of OPL for Nokia’s Series 60 on Symbian OS 6.1 is already available. The UIQ interface first appeared on a Symbian 7 phone with the Sony Ericsson P800 in September 2002. The UIQ interface is also found on other Symbian 7 phones, such as the Motorola A920, BenQ P30 and Sony Ericsson’s P900.

Key Symbian Features

- Includes applications such as contacts, scheduling, messaging, browsing, office, utility and system control. It provides OBEX to exchange objects, such as appointments and business cards, as well as integrated APIs for data management, text, clipboard and graphics.
- Includes Web browser and WAP stack for mobile browsing.
- Supports multiple user interfaces, including any input mechanism, from a full QWERTY keyboard, to a pen-based touch screen, to a numeric mobile phone keypad.
- Multimedia messaging using Multimedia Messaging Service, picture messaging with Enhanced Messaging Service and text messaging using Short Message Service (SMS); Internet e-mail using POP3, Internet Message Access Protocol 4 (IMAP4), SMTP and Multipurpose HTML; standard attachments; and fax capabilities. Provides APIs for graphics acceleration and streaming.
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- Supports communication protocols, such as TCP/IP version 4, IP version 6 and WAP, and personal-area networking stacks, including IrDA, Bluetooth and USB.

- Telephony standards include GSM circuit-switched voice and data (circuit-switched data [CSD]), packet-based data (GPRS and Enhanced Data rates for Global Evolution [EDGE]); CDMA: circuit-switched voice and data and packet-based data (IS-95 and cdma2000 1x); subscriber identity module (SIM) Application Toolkit (SAT) and SMS. Other standards can be implemented by licensees due to the extensibility of the APIs.

- Provides over-the-air synchronization support using SyncML DataSync. PC-based synchronization is enabled by a PC connectivity toolkit, supported over serial, infrared, Bluetooth and USB links. Framework provides synchronization of PIM data, transfer of files and document conversion to and from non-Symbian OS formats.

- Full-strength encryption and certificate management, secure communications protocols (including Hypertext Transfer Protocol over SSL [HTTPS], WTLS and SSL), WAP Identity Module framework and certificate-based application installation.

- Four primary programming and content development options: C++, Java (J2ME MIDP 1.0/2.0 and PersonalJava 3.0 with JavaPhone 1.0 options), WAP and Web; tools for building C++ and Java applications and ROMs and for in-target debugging.

- User interfaces from UIQ Technology and Nokia Mobile Software (Nokia Series 40, 60, 80, 90 and a CDMA platform).

Windows Mobile 2003

Microsoft is the most challenging competitor to PalmSource for PDA operating systems. Windows Mobile 2003 is based on the Windows CE 4.2 operating system, which was upgraded to include built-in support for Wi-Fi and Bluetooth. New imaging and media functionality is added through Pictures, an application that allows users to display, edit and store digital photos, and Media Player 9, which offers improved audio and video capabilities along with support for broadband content streaming.

Windows Mobile 2003 comprises three software profiles:

- Windows Mobile 2003 software for Pocket PCs, supporting stand-alone and wireless LAN integrated PDAs. The Pocket PC software includes a one-quarter Video Graphics Array (QVGA) screen resolution (240 × 320 pixels) with 65,000 colors. It offers multiple options for text input, including handwriting software that Microsoft has licensed from Vadim (Calligrapher). ActiveSync 3.7 provides synchronizing with the desktop for Pocket PC devices. It provides two levels of security that allow users to set a simple four-digit personal identification number (PIN) or a full Windows 2000-level strong alphanumeric password. Pocket PC is based on a real-time preemptive multitasking embedded operating system.

- Windows Mobile software for Pocket PC Phone Edition, which supports PDAs with integrated telephony features. It offers such telephony applications as caller ID, conference calling, speed dial and SMS and is based on the same kernel and specifications as Windows Mobile 2003 software for Pocket PCs.

- Windows Mobile software for Smartphones, for use with mobile phones combining wireless voice and data communications. Microsoft Smartphone is targeted for use with mobile phones designed for one-handed navigation and a smaller display. Microsoft makes Smartphone software available for both GSM/GPRS and CDMA/single carrier radio transmission technology (1xRTT) networks.
Key Windows Mobile 2003 Software Features

- Supported on any ARM v.4-compatible processor
- Support for the following networking technologies: IPv4, IPv6, EAP, LDAP v.3.0, RAS server, NDIS 5.1, TCP/IP, and Winsock 1.1 and 2.2
- Includes Pocket versions of Internet Explorer, Windows Player and Microsoft Office applications
- Native support for Bluetooth
- Support for OBEX protocol over both Bluetooth and IrDA

.NET Compact Framework, a programming infrastructure for writing Web-services software for mobile devices, is available for developers. The .NET Compact Framework is a subset of the desktop .NET Framework. It is available for devices running the Microsoft Windows Mobile operating system, such as Pocket PC devices. The aim of .NET Compact Framework is to enable developers to reuse programming skills and established code throughout device, desktop and server environments. Windows Mobile 2003 also offers robust support for consistent programming models and data access, including Microsoft Foundation Class, Active Template Library, Visual Basic, ActiveX Data Objects (ADO), Pocket Outlook Object Model API, queued reliable transactions (Microsoft Message Queuing [MSMQ]), Crypto API and Game API.

Linux-Based Mobile Operating Systems

There are currently a number of commercial and noncommercial implementations of embedded Linux for PDAs and other handheld devices. Using Linux on PDAs and smartphones has advantages: it is able to support sophisticated applications and offers licensees the advantage of eliminating or reducing OS licenses fees. There are many adaptations of Linux for embedded devices. Such diversity, however, could be the main obstacle to the success of Linux in the commercial mobile device market. No Linux PDA or smartphone vendor sets standards on key elements, such as user interface, PIM, power management and synchronization. The result is limited compatibility among different products. Sharp is the dominant vendor of Linux-based PDAs.

Metroworks Embedix

Embedix, initially offered by Lineo, was one of the first embedded Linux operating systems. It is specifically designed to handle the unique speed, memory and storage requirements of embedded devices. It runs on such devices as PDAs, smart handheld devices, residential gateways and digital TVs. Embedix supports a broad range of processor platforms, including x86, PowerPC, ARM and MIPS. In December 2002, Motorola’s embedded subsidiary, Metrowerks, acquired Embedix.

Midori Linux

Created by Transmeta, Midori Linux is an open-source operating system for small devices. Transmeta released Midori Linux to the open-source community in 2001 under the GNU General Public License (GPL). Midori includes a build system, a Linux kernel with memory- and storage-conserving features, and system-level support for running normal Linux software. It also supplements the Linux kernel with such embedded-oriented features as both Flash ROM- and RAM-based file systems and boot/runtime that can run from Flash ROM. It offers power management features that are optimized for Transmeta’s Crusoe processor line.

MontaVista Linux
MontaVista Software offers several editions of its embedded Linux operating system for a range of applications. The MontaVista Linux Consumer Electronics Edition 3.0 is geared for consumer devices. In March 2003, MontaVista Linux was selected as the operating system for Motorola’s upcoming A760 smartphone. Motorola’s device integrates digital camera, Internet, messaging, multimedia, PDA and telephony capabilities. It is currently available in China. The operating system is designed for use with IBM PowerPC 405LP Arctic II/III and Texas Instruments Open Multimedia Applications Platform (OMAP) digital processor chips.

Trolltech Qtopia

Qtoria is an embedded Linux platform for PDAs, smartphones, hybrid devices and other mobile devices. It provides an embedded development environment and a suite of mobile applications written by Trolltech (for example, document handling, games, multimedia applications and PIM tools). There are more than 600 applications that run under Qtoria. Qtoria drives the popular Zaurus PDA line from Sharp. In February 2003, IBM announced that it is using Trolltech Qtoria software as a component in its embedded Linux reference platform.

Technology Analysis

Distinguishing Factors

Market Slant

Although they each compete in the operating systems market for mobile devices, PalmSource, Microsoft and Symbian are generally geared to specific applications/needs.

The Palm OS is designed for PIM, focusing on durability, mobility and simplicity. The operating system strives to provide a unique user experience, focused on mobility as its design center.

Windows Mobile devices offer PC-like functionality and are optimized for small screens. They provide transparent integration with Microsoft Office applications, Exchange Outlook, and management and security features that are attractive for corporate users.

Symbian OS is designed for data-enabled mobile phones. It supports a broad range of communications standards and network protocols to ensure global interoperability. With support for open standards, the goal is to enable mobile phone users to communicate with anyone at any time.

User Interfaces

PDAs and smartphones come in a variety of forms and therefore need the appropriate user interface for navigational and operational purposes. Mobile device vendors and third-party companies have developed a number of user interfaces to increase product differentiation and ease of use. The following represents some examples of licensable interfaces for mobile devices running on Symbian OS:

- UIQ — A large-screen user interface for small pen-based smartphones with touch screens. The interface platform, developed by UIQ Technology (a wholly owned Symbian subsidiary), provides easy application access, integrated messaging, multimedia and Internet access capabilities. UIQ offers synchronization with desktop applications and also offers SyncML servers through Bluetooth, infrared and serial port connections. The user interface can be found in such products as Sony Ericsson’s P900 and Motorola’s A920 smartphone.

- Series 60 Platform — A user interface, licensed by Nokia, for use with mobile handset devices. This interface is designed for mobile phones with a numeric keypad. It provides mobile Web browsing, content downloading, multimedia messaging and a series of personal information management and
telephony applications. The Series 60 Platform also includes a customizable user interface library. The Nokia 3660 and 6600, the Siemens SX1 and the Samsung SGH-D700, for example, use the Series 60 Platform user interface. The Series 80 Platform is a user interface from Nokia that is designed for smartphones with full keyboards and large color screens. The interface allows users to easily compose and manipulate information while on the road — popular with vertical market and enterprise users. The Nokia 9200 Series Communicator is an example of a device that is based on the Series 80 Platform user interface. The Series 90 is based on Symbian OS v.7.0 and features a 640 x 320-pixel 16-bit-color touch-sensitive display. Built-in applications include messaging and Internet browsing. Users will have the ability to edit most common document formats and view presentations. Phones based on Series 90 will include a camera, media players for audio and video, and FM radio. The Nokia 7700 media device will be based on Series 90.

**Productivity Tools**

The Palm OS includes a suite of productivity tools, including an address book, alarm clock, calculator, calendar, e-mail and memo pad. Although the Palm OS does not include Microsoft software applications, Palm-compatible software, bundled with most Palm-powered devices, can read and edit Microsoft Office files and synchronize data smoothly with PCs and other computers. Palm OS provides an on-screen keyboard, as well as Graffiti text-recognition software that allows information to be entered with a stylus. It allows information to be exchanged with other systems through infrared and Bluetooth beaming. Palm OS offers an extensive selection of third-party software, including databases, spreadsheets, word processors, financial and business tools.

Windows-powered devices include customized user interface software and a variety of integrated applications, including Windows Messenger, Pocket Internet Explorer and Adobe Acrobat. They also include Pocket versions of Microsoft Word and Microsoft Excel. Windows-powered devices can smoothly integrate with Microsoft’s corporate standard software and back office: this is one of its advantages over competitors in the corporate market. Windows CE supports features such as MSN instant messaging and Passport. It provides strong multimedia features through such technologies as Windows Media Player 9, audio/video codecs and MP3 codecs.

Symbian OS provides a range of applications: client/server shared access scheduling manager, shared access database manager, spreadsheet and charting, help facility, text conversion, free-form database and word processing modules. It offers an e-mail client with multimedia messaging, a Web browser and a WAP stack for mobile browsing. The operating system permits several forms of input mechanisms, including a full QWERTY keyboard, a pen-based touch screen and a numeric mobile phone keypad. Symbian OS also offers audio recording and playback.

**Security**

Given the proliferation of PDAs and smartphones within organizations and the growing use of wireless technologies, the issue of security for devices and their operating systems is an important consideration.

Palm OS 5 provides its Cryptography Manager, which comprises a suite of cryptographic services for securing data/resources on Palm-powered devices. It includes 128-bit strong encryption, RC4 encryption, SHA-1 and signature verification using RSA-verify. It incorporates SSL services at the system level (SSL 3.0/TLS 1.0) and authorization and authentication manager features.

Microsoft provides numerous security features, including Security Support Provider Interface (SSPI) authentication services; Kerberos; Schannel (SSL/TLS), which is a protocol for secure authentication and encryption using SSL 2, SSL 3 and TLS/SSL 3.1 public key-based protocols; and Cryptography Services
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(CryptoAPI 2.0) with High Encryption Provider. In addition Microsoft has added IP Security, RFC 2411/Layer 2 Tunneling Protocol (IPsec/L2TP) security to its Pocket PC virtual private network client.

Symbian offers authentication, digital signatures, cryptography, certificate management and secure communications features/standards, including IPsec, SSL/TLS and WTLS. It also integrates RSA technologies, such as RSA BSAFE (wireless core encryption software) and RSA SSL-C (security protocol component software). A few PDA vendors bundle additional security software with their devices. HP, for example, bundles F-Secure’s FileCrypto.

Business Use

Embedded developers have traditionally created their own proprietary code to drive their embedded systems, but in recent years, more developers are turning to capable commercial operating systems for their custom applications. The operating systems described in this report are used primarily in PDAs and smartphones, but they can also be used in embedded communication devices, Internet access appliances, specialized industrial controllers and Web terminals.

Benefits and Risks

Mobile Devices

The benefit of operating systems for personal digital devices can be assimilated with the advantages of mobile computing:

- Mobility
- Always-connected and -synchronized workers
- Faster responses
- Increased productivity
- Flexibility
- Decentralization

The challenges related with the operating systems described in this report, and more generally the risks involved in the adoption of personal digital devices within the corporate environment, can be summarized as follows:

- The need for support for a new device and OS within the enterprise
- Availability and compatibility of ancillary third-party products, hardware platforms supported and sustainability of the OS
- Integration with established systems
- Pricing and licensing
- The security of the device and of the data stored in it
- Possibility of cost of ownership of mobile devices being higher than expected
- The need to establish and enforce policies for mobile devices
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Operating System Strengths and Limitations
The strengths and limitations of the three main PDA and smartphone operating systems can be summarized as follow:

Palm OS

**Strengths**
- Palm OS is the market leader.
- Users appreciate Palm’s PIM applications for their simplicity.
- Palm OS allows for the design of devices with a wide range of price points ($79 to $700).
- There is a large community of application developers (260,000 developers).
- Palm OS 5 runs on ARM-compliant processors that allow higher clock speeds than DragonBall processors.

**Limitations**
- Palm OS 5 relies on emulation tools to run pre-OS 5 applications.
- Palm OS 4 and earlier versions support only Motorola DragonBall processors, which have a clock speed of 16MHz to 66MHz.
- Palm OS’s user interface is aging. Its applications have not been upgraded substantially since their creation.

Microsoft Windows Mobile 2003 (Pocket PC and Smartphone)

**Strengths**
- Windows Mobile has an affinity with Microsoft Outlook, Office and back-end systems. It gives a familiar experience to the end user.
- Windows CE OS is based on the widely used Win32 API, which is consistent with Microsoft’s other 32-bit operating systems — most notably Windows NT, Windows 2000 and Windows XP. There are approximately 6 million worldwide developers that are familiar with Win32 APIs. There are strong developer tools and developer programs to support them.
- Management tools for asset management, software distribution, backup and remote management are available.

**Limitations**
- Windows Mobile PDAs tend to be more expensive than Palm OS-based devices. In the past, Windows CE devices were competitive only at the higher end of the market. Following the launch of Dell’s Axim PDA, however, Windows Mobile devices are becoming more competitive in the lower end of the market too.
- Windows Mobile has a limited presence in low-end devices targeted at consumers.
- There is limited space for device differentiation.

Symbian OS
PDA and Smartphone Operating Systems: Technology Overview

**Strengths**

- There is manufacturer diversity.
- Symbian has strong operator backing (Nokia, Sony Ericsson, Siemens and others).
- It’s a strong platform for communication devices.
- The company has a stronger presence in the consumer space.
- The availability of third-party user interfaces allows for product differentiation.

**Limitations**

- The company has a limited market presence in the U.S.
- The user interface needs to be sourced in addition to the operating system.
- There is relatively limited availability of enterprise applications.
- There is little consistency among licensees’ implementations.

**Price vs. Performance**

- Stand-alone tablet PDAs typically cost between $99 and $600. Ruggedized units can cost up to $3,500. Pocket PC devices, with more memory, are generally more expensive. However, a new class of value entry-level devices is available. Prices range from $199 to over $600.
- Stand-alone clamshell PDA prices range from $300 to $1,000.
- Wireless-enabled PDA prices start at $350 up to $650.
- Smartphones, including Symbian-based ones, are priced between $200 and $800.

**Selection Guidelines**

The choice of a PDA/smartphone operating system may be a minor issue for consumer devices, but it is still an important factor within the corporate space. Elements of the PDA/smartphone operating system that should be evaluated carefully include:

- The quality of the applications bundled onto the operating system, such as mail, calendar, contact manager and availability from third parties
- Support for features, such as integrated data and voice capability, unified messaging, multimedia, wireless access to data and PIM functionality
- Availability of development tools, also in relation to an organizations’ in-house developer’s skills
- The capabilities of the operating system, such as communications, tasking and memory management, as they may impact the type of applications that can be developed for it
- The integration of the operating systems with the back-end systems
- Agreements with OEM partners for suitable and compelling devices

**Technology Leaders**

Microsoft
In June 2003, Microsoft announced Windows Mobile 2003 as the global brand for mobile device software for Pocket PC and Smartphone. Microsoft aims to leverage the Windows brand to all software for mobile devices.

Windows Mobile 2003 is designed to appeal to IT buyers within the enterprise market because of integration capabilities with Microsoft Office, Outlook and back-end systems, as well as its security and manageability features.

Current licensees and vendors committed to launch PDAs or smartphones based on Windows Mobile 2003 include Acer, ASUSTeK Computer, Dell, Fujitsu Siemens Computers, HP, Intermec Technologies, Legend Group Ltd., MiTAC, Motorola, JVC, Panasonic Computer Solutions, Symbol Technologies, Toshiba, Trimble and ViewSonic.

PalmSource

In January 2002, PalmSource was created as a subsidiary of Palm to separate the company’s device and operating system businesses. PalmSource claims that there are approximately 30 million Palm-powered handhelds and smartphones sold to date, with more than 19,000 available applications written for the platform. The company also reports that it conducts business with about 260,000 developers, licensees and strategic partners worldwide.

The introduction of Palm OS 5 marked a major platform shift for PalmSource. In moving from the Motorola DragonBall to the high-performance ARM processor architecture, Palm OS will deliver a significant performance boost for PDAs and smartphones and enable new applications development for Palm.

Licensees of the Palm OS include Acer, AlphaSmart, Fossil, Garmin, GSL, HandEra, Handspring, HuneTech, Kyocera, Legend, Palm, Samsung Electronics, Sony and Symbol Technologies.

Symbian

Symbian OS is developed and licensed by Symbian, a privately held software-licensing company that is jointly owned by a group of wireless mobile phone leaders. The company, which is headquartered in the United Kingdom, comprises the following shareholders: Nokia, Panasonic, Psion, Samsung Electronics, Siemens and Sony Ericsson. Samsung is the newest member of the Symbian family, with its shareholder status announced in February 2003.

While there are no longer any PDAs based on the Symbian OS, there are a growing number of mobile phone manufacturers that are basing their wares on the operating system.

Symbian OS licensees include some of the world’s leading mobile phone manufacturers: Nokia, Samsung, Siemens and Sony Ericsson.

Insight

The operating systems described in this report are suitable for use in very different classes of devices. Palm OS continues to be successful as the platform for individual users and for lightweight applications. This is because Palm OS allows the creation of low-cost, easy-to-use devices. Windows Mobile devices appeal to the enterprise market because of strong integration, security and manageability features. Symbian continues to be adopted in the smartphone market, rather than in the PDAs market, due to its communications features.