PDA Operating Systems

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Abstract

This paper describes the operating systems – OS – for personal digital assistants – PDAs. Three systems, namely Windows CE, Palm OS, and Symbian OS are discussed. At first the general features of PDA operating systems are introduced. Then the differences of the three systems are discussed from the functionality, usability, and scalability of each system. After that some future predictions are given and analyzed.

1 INTRODUCTION

This paper presents three of the most prominent operating systems (OSs) for personal digital assistants (PDAs). The OSs discussed here are:

1. Windows CE, which is developed by Microsoft, Inc. and it is intended to be a general purpose operating system for wireless and personal systems.

2. Palm OS, which was originally developed for the handheld devices produced by Palm Computing, Inc. It is now adopted by several important manufacturers of the industry.

3. Symbian OS, which is an open operating system developed by a consortium of the major developers for portable and mobile devices.

The purpose of this paper is to make a distinction between the systems and their goals and especially to analyze the functionality and the future of each PDA OS.

2 BACKGROUND

Small devices come in many shapes and sizes, each addressing different target markets and having different requirements. The market segment of the scope of this paper is that of the wireless information device (WID). This spans the spectrum between traditional PDAs (with handheld computer functionality and occasional communication) and mobile phones (with voice communication and enough data capability to support an address book and basic messaging).

It is important to look at the WID market on its own. It has some specific needs that make it unlike most other markets such as PCs or fixed domestic appliances. Scaling down a PC operating system or bolting communication on to a small and basic OS results in too many fundamental compromises. Symbian believes that the WID market has five key characteristics at its core that make it unique, and require a specifically designed operating system:

- devices are both small and mobile;

- the target is a mass market of consumer, enterprise and professional users;

- devices are occasionally connected: they can be used both when connected to the wireless phone network or locally to other devices, and also when not connected to any network;

- manufacturers need to differentiate their products in order to innovate and compete in a fast-evolving market;

- and last but not least, the platform has to be open for third-party application development.

To address each of these characteristics is the only way to create good products where technology doesn't limit functionality and creating good products is the way to grow the WID market. (www.devx.com/wireless/articles/PDA/PDAIntro.asp(20.11.2001))

3 OVERVIEW OF THE PDA OPERATING SYSTEMS

For the PDA OS there are several viewpoints that need to be addressed. Those include:

- fast bootstrap processes

- immediate response to switching from one application to another

- efficient back-up/synchronization operations

The requirements are best met by using real-time operating systems (RTOS), which provide the means for fast and efficient responses needed for running the PDAs.

In general, real-time operating systems are said to require:

- Multitasking

- Process threads that can be prioritized

- A sufficient number of interrupt levels

Real-time operating systems are often required in small embedded operating systems that are packaged as part of microdevices. Some kernels can be considered to meet the requirements of a real-time operating system. However, since other components, such

as device drivers, are also usually needed for a particular solution, a real-time operating system is usually larger than just the kernel. (www.whatis.com (19.11.2001))

It is important to distinguish between a real-time system and a real-time operating system (RTOS). The real-time system consists of all elements—the hardware, operating system, and applications—that are needed to meet the system requirements. The RTOS is just one element of the complete real-time system and must provide sufficient functionality to enable the overall real-time system to meet its requirements.

3.1 Windows CE

Although the Windows CE Operating System is the leader among handheld personal computers (H/PCs), it holds only about 10% of the PDA market. Those numbers won't stay that low.

The latest version of Windows CE, now known as Windows CE for the PocketPC (P/PC), is coming back with a vengeance. Microsoft has partnerships with some key companies in the industry (Casio, HP, and Compaq) – all manufactures of PocketPC devices.
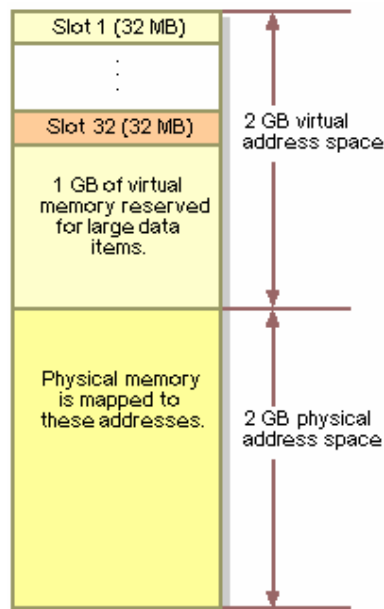

Figure 1.   How memory is allocated in the Windows CE address space. (www.microsoft.com/windows/embedded (20.11.2001))

Microsoft Windows CE is an open, scalable, 32-bit operating system that is designed to meet the needs of a broad range of intelligent devices, from enterprise tools such as industrial controllers, communications hubs, and point-of-sale terminals to consumer products such as cameras, telephones, and home entertainment devices. A typical Windows CE-based embedded system is targeted for a specific use, often runs disconnected from other computers, and requires an operating system that has a small footprint and a built-in deterministic response to interrupts.

Real-time performance is essential for the time-critical responses required in high-performance embedded applications such as telecommunications switching equipment, industrial automation and control systems, medical monitoring equipment, and space navigation and guidance systems. Such applications must deliver their responses within specified time parameters in real-time.

Although previous versions of Windows CE offered some RTOS capabilities, a number of significant changes made to the kernel of Windows CE 3.0 have greatly enhanced real-time performance. Some of the changes made for Windows CE 3.0:

- Increased number of thread priority levels from 8 to 256.

- More control over times and scheduling. Applications can control the amount of time provided to each thread and manipulate the scheduler to their advantage. Timer accuracy is now one millisecond for Sleep- and Wait-related APIs.

- Improved method for handling priority inversion.

- Full support for nested interrupts.

- Reduced ISR and interrupt service thread (IST) latencies.

- More granular memory management control.

The kernel is the inner core of the Windows CE operating system and is responsible for scheduling and synchronizing threads, processing exceptions and interrupts, loading applications, and managing virtual memory. In Windows CE 3.0, the kernel has undergone several changes to increase performance and reduce latencies, including:

- Moving all kernel data structures into physical memory (Figure 1), thus largely avoiding translation look-aside buffer (TLB) misses while executing non-preemptible code in the kernel.

- All non-preemptible, but interruptible, portions of the kernel, known as Kcalls, were broken into smaller non-preemptible sections. This introduces some complexity, due to the increased number of sections, but now lets preemption be turned off for shorter periods of time.

3.2 The Palm Operating System

In 1996, a product called the PalmPilot was released by US Robotics. The Palm Pilot ran on an operating system made especially for that device, called the Palm OS.

The Palm Operating System (Palm OS) is the current leader in the PDA market, accounting for 70% of the market share. The Palm Pilot (now known as just Palm), became one of the fastest growing computer platforms in history, reaching the million-sold mark faster than the IBM PC or Apple's Macintosh.

Today, the Palm line has grown to include a variety of models. In addition, a number of other companies such as IBM, Qualcomm, and Symbol Technologies released their own Palm OS PDA models, with Sony's version hitting the market later this year.

Palm OS is the computer operating system that provides a software platform for the PalmPilot series of handheld personal digital assistants made by Palm Computing, now part of 3Com. Palm OS was designed from the beginning to fit into a palm-size device of a specific size and with a specific display size.

Palm OS uses multitasking, but only one task is for applications. The user uses one application at a time, one application program must finish before the next can be selected. This constraint allows the operating system to devote full attention to the application that is open. The space needed by the system for any application that is running is kept in dynamic, reusable random access memory.

The application and its related database are kept in what is called permanent storage, but here the permanent storage is RAM (rather than a hard disk) that cannot be reused as the dynamic RAM can. Palm OS divides an application into runnable code and different types of data elements, such as user interface elements and icons. The data elements can be easily changed without necessarily having to rewrite code.

Palm Computing chose not to include a keyboard in the PalmPilot in order to produce a truly palm-size device. Learning from Apple's Newton, an earlier attempt at a pen-and-notepad interface, the company also chose not to provide full handwriting recognition code. Instead, PalmPilot users learn to use a more quickly recognized but restrictive set of pen strokes. These decisions helped keep Palm OS small in size. Palm OS comes with these applications built-in: Dates, Address Book, To Do List, Memo Pad, Calculator, and Password Protection. New applications can be written and added using several facilities that accelerate development. (www.palmos.com(20.11.2001))

The Palm OS platform consists of five primary components:

- Palm OS software

- Reference hardware design

- HotSync conduit data synchronization technology for one-button synchronization

- Platform component tools including an API that enables developers to write applications

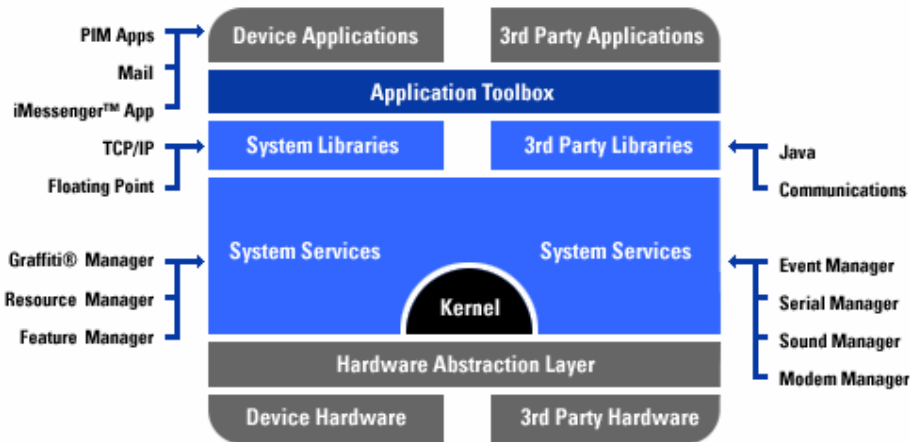- Software interface capabilities to support hardware add-ons

Figure 2. The Palm OS platform structure. (www.palmos.com (20.11.2001))

Palm OS 4.1 new features:

- Improved security to mask or hide private records
- New auto-locking feature
- New security password hinting process
- Time zone support
- Enhanced on-screen keyboard supporting tapping or Graffiti strokes
- New telephony services for communications to mobile phones
- New preferences panel for more detailed control over your connections to devices like modems, cables and mobile phones
- Address Book that dials
- Instant messaging to most phones via SMS Messenger application (www.palmos.com (20.11.2001))

3.3 Symbian OS

The third major player is Symbian OS, an operating system developed by London-based software developer Symbian. Symbian OS has following types of handheld device designs:

- *Pearl* for smart mobile phones

- *Quartz* for small communicator type of devices, like PDAs

- *Crystal* for H/PCs and other communicators with a small keyboard

- Additionally, the full VGA design will be introduced.

Symbian OS does have some major advantages. It is an extremely power-efficient operating system – other operating systems require double to triple the size of a battery. Also, Symbian OS has a small memory footprint and a compact code, which allows for customization. This potential for customization is a huge advantage over Windows CE.

Symbian OS is an operating system designed for small, portable computer-telephones with wireless access to phone and other information services. Symbian OS is based on an earlier operating system from Psion.

Symbian refers to the class of hardware Symbian OS serves as "wireless information devices." Symbian OS is a 32-bit, multitasking operating system that supports a pen-based graphical user interface. It is written in the C++ programming language using an object-oriented design. The code is very compact so that it can fit on a small ROM chip.

In addition to basic services, the operating system comes with an "application suite," that includes a word processor, e-mail handler, spreadsheet program, a scheduling application, general purpose database, sketch program, world clock, voice recorder, spell checker, calculator, communication programs, and a Web browser.

Symbian OS can be scaled from relatively large configurations for a fully-functional H/PC to small configurations for embedded systems programming applications.

Although Symbian OS can be ported to other microprocessors, Symbian's preferred platform is the Advanced RISC Machines (ARM) architecture. Symbian considers ARM the best platform in terms of millions of instructions per second (MIPS) per watt and per dollar cost.

Some of the key features of Symbian OS Version 6.1 (see also Figure 3.)

- comprehensive integration of contacts information, messaging, browsing and wireless telephony

- messaging – Internet email using POP3, IMAP4, SMTP, MHTML; standard attachments including Microsoft Word documents; fax; text messaging using SMS

- mobile telephony protocols – 2G voice and circuit-switched data, 2.5G packet-switched data, and SMS

- communication protocols – TCP/IP, WAP, Bluetooth, IrDA, serial

security – full-strength encryption and certificate management, secure communications protocols (including HTTPS, WTLS and SSL), certificate-based application installation (www.symbiandevnet.com(20.11.2001))
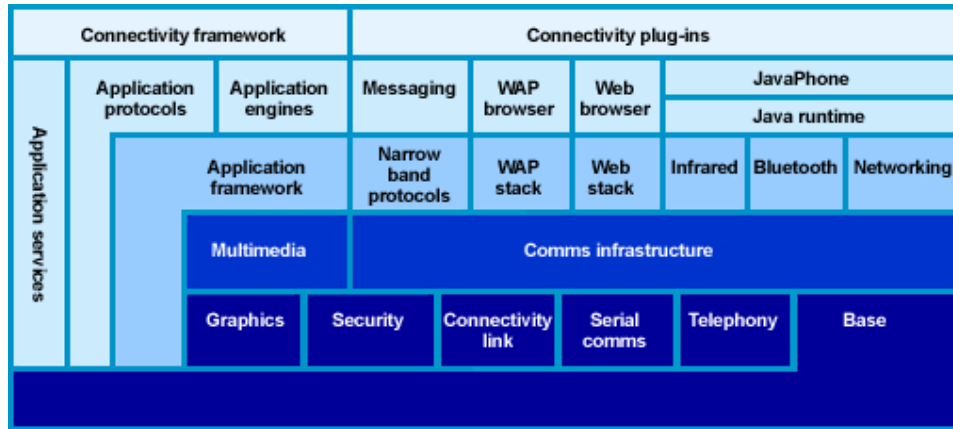
Figure 3.   The major components of Symbian OS Version 6.1. (http://www.symbiandevnet.com/technology/symbos-v6x-det.html (20.11.2001))

4 THE DEVELOPMENT TOOLS OF THE PDA OPERATING SYSTEMS

The development tools for each of the systems are introduced next. Even though all systems are running on PDAs, there are some differences in the development processes on the platforms. These issues are discussed next.

4.1 Windows CE

Windows CE offers the application developer the familiar environment of the Microsoft Win32 application programming interface (API), ActiveX controls, message queuing (MSMQ) and Component Object Model (COM) interfaces, Active Template Library (ATL), and the Microsoft Foundation Classes (MFC) Library. ActiveSync provides easy connectivity between the desktop and the embedded device, whether by serial connection, infrared port, or network cable. Windows CE provides built-in support for multimedia (including DirectX), communications (TCP/IP, SNMP, TAPI, and more), and security. A variety of integrated applications, including Pocket Internet Explorer, Pocket Outlook, and Pocket Word expose objects that allow the developer to extend and customize the existing system, as well as extend the functionality of the created applications. (www.microsoft.com/windows/embedded (20.11.2001))

4.2 Palm OS

The Palm OS Software Development Kit (SDK) provides application programming interfaces (APIs) for developing Palm OS applications. There are functions for user interfaces, system management, and communication.

The Conduit Development Kit (CDK) supports the implementation of conduits, which enable the exchange and synchronization of data between a desktop application and an application running on a device. The CDK is available for Windows, Mac, and Solaris.

Each Palm application must have assigned an unique identification, called CreatorID,which can be obtained from Palm.

Beyound these development kits, programming is supported by several development environments and tools. (Hansmann, U., Pervasive Computing Handbook)

4.3 Symbian OS

Symbian provides development kits for C++, for OPL, and for Java. Programmers write programs at a PC and use an emulator to test them. At a very basic level the operating system shouldn¹t be too resource hungry - it should support low-power processors with limited amounts of memory. Unlike other operating systems, Symbian OS implements most of the multi-tasking through event-driven messaging rather than with multi-threading. Multi-threading is complex, prone to errors and expensive (there can be several kilobytes of overhead per thread). Symbian OS is much more efficient - to create another object in a primarily event-driven operating system doesn¹t need any context switching and can have an overhead as low as a few tens of bytes.

Symbian OS is the common core of application programming interfaces (APIs) and technology that is shared by all Symbian OS phones. Symbian OS includes a multi-tasking kernel, middleware for communications, data management and graphics, the lower levels of the GUI framework, and application engines. (www.symbiandevnet.com)

Similar to Palm OS, the Symbian OS applications must have an unique UID for file identification and association. The UID must be requested from Symbian. (Hansmann, U., Pervasive Computing Handbook)

5 NEXT GENERATION PDA OPERATING SYSTEMS

All three of the discussed OSs are under continuous development. The paths for future systems do reflect to the company and/or consortium policy in the market. Microsoft is continuing its .NET-strategy, Palm has announced a merger through purchasing an interesting OS developer – Be, Inc. – , and Symbian is relying on openness and general standards.

5.1 Windows CE.NET

Windows CE.NET, formerly code named "Talisker", is the current code name for the next version of the Windows CE operating system. It is the robust real-time operating system for rapidly building the next generation of smart mobile devices. Windows CE .NET Beta 2 contains everything you need to create custom Windows CE–based devices. Features include Beta 2 of the next version of the Windows CE operating system, Platform Builder, a set of embedded development tools, an integrated development environment (IDE), a SDK export tool, and support for the Microsoft run-time libraries, sample code and Embedded Visual C++ development system. With this

end-to-end toolset, you can rapidly build smart designs on the latest hardware running rich applications.

The following are some of the key features to developing an embedded platform with Windows CE.NET: (www.microsoft.com/windows/embedded(20.11.2001))

- Windows CE.NET Beta 2 allows you to build scalable wireless platforms to flexibly connect mobile devices into existing infrastructures.

- Broad wireless support for personal area networks (PANs), local area networks (LANs), and wide area networks (WANs), including Bluetooth, 802.11.

- Remotely authenticate, authorize, administer, and update new applications and OS services on your device.

- Windows CE.NET Beta 2 offers reliable core OS services for efficiently enabling the most demanding real-time embedded designs across a breadth of devices.

- Enable low latency, bounded deterministic system performance with hard RTOS kernel support.

- Implement local and network security for the storage and transmission of data.

5.2 Palm OS

Palm has purchased Be, Inc., the developer of Be OS. It's hard to see at first any real synergy between the two. Be developed multimedia-oriented desktop and Net appliance operating systems, while Palm develops operating systems for personal organisers.

Another look reveals that PDAs become more geared toward wireless net access, and through 3G networks, able to cope with ever richer media types. Palm will need expertise in handling those kinds of media. Indeed, a modern PDA is as much a net appliance than the set-top box image most of us think of when we consider boxes an OS like Be's BeIA might run on.

Whether Palm will incorporate BeIA into the Palm OS, use it as the basis for a future PDA operating system, branch out into larger-scale appliances, or just cream off the multimedia expertise, the company has yet to say. Whatever it does, the acquisition of Be gives it a lot of scope to develop some interesting business models. (http://www.palmos.com/news/2001/081601.html)

In the future, handhelds will become ubiquitous tools that everyone will use to manage information, conduct transactions, and communicate with each another. Here are the visions of how the future will be for Palm:

- Wireless connections and services:
  · Clip-on wireless modems supporting most of the world's major cellular standards

· New handhelds with "always-on" e-mail connections
· Support for Bluetooth in every new Palm-branded handheld.

- Secure transactions:
  · Secure transaction processing to enable electronic wallets and identification cards
  · Top-level security for corporate transactions.

- Graphics and multimedia:
  · Support for larger and higher-resolution screens
  · Enhanced video and audio playback
  · Support for faster, more powerful ARM microprocessors, while maintaining compatibility with current Palm software applications.

5.3 Symbian OS

Symbian is not revealing features for their next OS. Instead, the target for open development is addressed through different white papers and documentation provided in their web-site. A conclusion is that they define the guidelines in their own development, and those are:

- Even though mobile phones are small and mobile, they can offer facilities as rich as those on desktop computers in addition to basics such as voice and data communication. The operating system has to support both conventional and mobile computing paradigms, and developers need knowledge of both. To reduce the time-to-market, developers should become proficient in as short a time as possible. Supporting standards that they may already know or can easily learn from a multitude of sources is necessary. Standards also make the platform more open and hence attract more developers.

- Traditional standards such as Unicode for internationalization, a POSIX API, and Java are a must, but for an operating system to take its place in the connected world, open standards such as TCP/IP, POP3, IMAP4, SMTP, SMS, Bluetooth, OBEX, WAP, i-mode, JavaPhone and SyncML should also be supported.   (www.symbiandevnet.com/technology/why-diff-os.html(20.11.2001))

6 CONCLUSIONS

The most likely outcome is that the market will fragment. Each company may lead in one area – such as Symbian for phone-organisers wired to the Internet, Palm for the mass market of personal information devices and Microsoft for more demanding business users.

How those markets shape up is the big unknown. Some people think Europe and America may go separate ways here for the next few years.

Phone-organisers may take off in Europe whilst America – where a lack of common standard hampers digital networks – may stick to phoneless organisers, using data-only or pager-style connections, or which plug in a separate device to communicate.

Keeping in mind the scale and the background of Microsoft and Symbian, it is obvious that the market of mobile devices' operating systems will mainly be divided by them. Others will pick up what is left even though Palm is currently so popular and widespread device. A clear sign of this convergence is that Psion has given up the H/PC line from their production.

The operational differences between the three discussed PDA OSs indicate that Palm OS needs to be redefined to match its competitors. Will that be provided by the Be merger is still unknown. Microsoft will certainly endorse its .NET policy with all of its different OSs, which may also prevent some developers from creating applications on that platform. Other views prevail as well, since Microsoft has gained a large network of developers during the past years. That is something that Symbian is still trying to.approach.

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