

Handheld Operating Systems

A Comparison of Pocket PC 2002, Palm OS 5, and
the Embedix Plus Linux Operating System

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Introduction to Handheld Operating Systems

Since the development of handheld computers in the 1990's, the demand for software to operate and run on these devices has increased. Three major competitors have emerged in the handheld PC world with three different operating systems for these handheld PC's. One of the first of these three companies was the Palm Corporation with their PalmOS. Microsoft also released what was originally referred to as Windows CE. Microsoft's recently released operating systems for the handheld PC are now under the name of PocketPC. More recently, a few companies producing handheld PC's have now started offering a handheld version of the Linux operating system on their machines. In this paper, I intend to analyze these three operating systems on the following criteria: standard applications, file system, cost, availability, and ease of use to try to determine the best operating system.

How are Handheld Operating Systems Different from Desktop Operating Systems?

Since handheld operating systems are designed to run on machines that have lower speed processors and less memory, they were designed to use less memory and require fewer resources. For example, Windows 2000 Professional Requires a 133MHz Processor with at least 64 Mb RAM and a 2Gb hard drive with 664 Mb free disk space (www.microsoft.com), whereas PocketPC 2002 is currently offered on the Compaq iPAQ h1910 model handheld PC with 200MHz Processor, 64MB RAM, and 16MB Flash ROM (www.hp.com). From this comparison, we can easily see that standard desktop operating systems could not be run on handheld devices.

Handheld operating systems are also designed to work with different types of hardware than standard desktop operating systems. This is because the power requirements for standard CPU's and memory far exceed the power that handheld devices

can provide. Handheld devices aren't able to dissipate the large amounts of heat generated by standard CPU's either. To deal with this, companies such as Intel and Motorola have designed smaller CPU's with lower power requirements and lower heat generation. Many handheld devices rely on flash memory cards for their internal memory as large hard drives could not fit into handheld devices.

Pocket PC 2002

History of Windows Handheld operating systems

Microsoft released its first version of an operating system for the handheld PC with windows CE in September of 1996. Windows CE was built completely from scratch as opposed to stripping down a desktop version of Windows such as NT or upgrading from another system. Windows CE was built on the Win32 platform and implements multithreading and a pre-emptive multitasking system. Since Windows CE was released in 1996, Microsoft has changed the name of its handheld operating systems to the Pocket PC name. Pocket PC 2000 was the first along these lines and was issued in 1999. The most recent release is Pocket PC 2002 and will be analyzed more in later sections of this paper.

Standard Applications

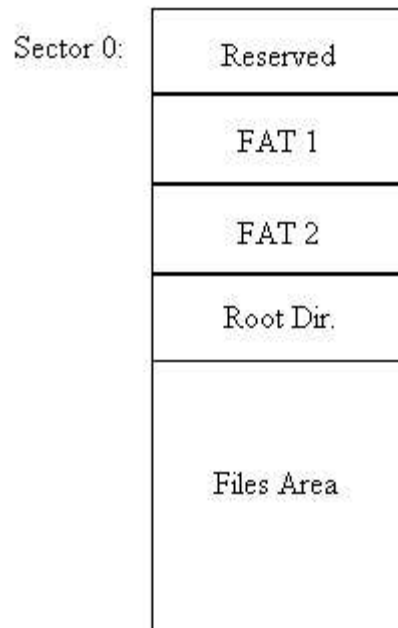
Pocket PC 2002 as well as almost all other Microsoft released handheld operating systems come with versions of Microsoft Messenger, Microsoft Outlook, Windows Media Player, and pocket versions of Microsoft Word and Excel. The pocket version of Microsoft Outlook comes with all the calendar and address book options included in the desktop version. According to Microsoft, Messenger was included to help people keep in

touch with each other via the Internet. Pocket PC 2002 also includes a pocket version of Internet Explorer for surfing the Internet.

File System

Pocket PC 2002 operates using the FAT16 file system. FAT16 is similar to all other FAT systems implemented by Microsoft with the exception that it has a smaller file allocation table than FAT32. The file allocation table is simply a linked list of pointers to memory locations. The FAT is used in an attempt to help increase file access time by allowing the operating system to skip over parts of the table that are not needed instead of having to scan through the whole table to find certain sections of memory. This shortens the access time of a memory location from $O(n)$ time to a more constant time. The standard FAT disk structure is shown below:

Figure 1.1: Standard FAT Disk Structure



Notice that there are two implementations of the FAT in the structure. The second FAT was implemented as a backup in case the first FAT was corrupted or changed.

Unfortunately, there was no way for the system to determine which FAT to use making the second FAT more or less wasted space. Pocket PC 2002 allows the user to determine whether or not to use the second FAT when formatting memory cards. Because of the file structure, however, the space still remains wasted in effect.

In order for the OS to be able to use the data on the drive, it has to know where the data is and how to make use of it. The boot sector “tells” the operating system how to make use of the data on the disk. The FAT16 boot record setup is shown below

(Dobiash, Jack):

Figure 1.2: FAT16 boot record setup

Offset	Description	Size
0x00	Jump Code + NOP	3 Bytes
0x03	OEM Name	8 Bytes
0x0Bh	Bytes Per Sector	1 Word
0x0D	Sectors Per Cluster	1 Byte
0x0E	Reserved Sectors	1 Word
0x10	Number of Copies of FAT	1 Byte
0x11	Maximum Root Directory Entries	1 Word
0x13	Number of Sectors in Partition Smaller than 32MB	1 Word
0x15	Media Descriptor (F8h for Hard Disks)	1 Byte
0x16	Sectors Per FAT	1 Word
0x18	Sectors Per Track	1 Word
0x1A	Number of Heads	1 Word
0x1C	Number of Hidden Sectors in Partition	1 Double Word
0x20	Number of Sectors in Partition	1 Double Word
0x24	Logical Drive Number of Partition	1 Word
0x26	Extended Signature (29h)	1 Byte
0x27	Serial Number of Partition	1 Double Word
0x2B	Volume Name of Partition	11 Bytes
0x36	FAT Name (FAT16)	8 Bytes
0x3E	Executable Code	448 Bytes
0x1FE	Executable Marker (55h Aah)	2 Bytes

*One word is defined as 2 bytes

*A double word is defined as 4 bytes

The FAT file system allows for a maximum of 65525 clusters on the hard disk. The maximum hard drive size is dependant therefore on the number of clusters. Since the size

of a cluster must be a power of 2, and less than 65,536 bytes, 2^{16} bytes, the maximum cluster size can be determined to be 32,768 bytes. Multiplying the maximum cluster size by the maximum number of clusters is equal to 2,146,123,200 bytes or approximately 2GB. Since most handheld devices have considerably less drive space than this, the 2GB limit is well within reason. Pocket PC 2002 allows the user to determine whether or not to have a redundant FAT table when formatting memory cards. The standard FAT system has the following setup at the beginning of each disk.

Ease of Use

For users familiar with the Windows operating systems, Pocket PC 2002 is fairly easy to use. Pocket PC 2002's interface is similar to that of Windows 2000 with a hint of Windows XP. The pocket versions of Word and Excel are extremely similar to their desktop counterpart. Much of the interface with the system is dependent on the hardware the software is used on. Many of the systems that support Pocket PC 2002 have multiple ways of providing input to the system. Pocket PC 2002 comes ready with support for a touchpad, external keyboard, handwriting recognition, "graffiti" style writing, and voice recognition. With a number of different input devices, Pocket PC 2002 can be easy to use for a number of different people and age groups.

Pocket PC 2002 also supports wireless Internet connectivity and includes a pocket version of Internet Explorer. Pocket Internet Explorer supports HTML and WAP, Secure Socket Layer protected transfers, and XML format web pages to provide virtually the same access to the Internet as provided by desktop computers.

Pocket PC 2002 comes with Microsoft ActiveSync® technology to keep data on the handheld synchronized with data on the desktop computer. The software comes with

four different user specified synchronization modes: automatic, continuous, scheduled, or manual. With these four modes, the user can easily customize their handheld computers to update as often as their needs require.

Palm OS 5

History of Palm Operating Systems

Palm's first operating was the Palm OS 1.0 operating system released in the mid 1990's. Palm OS 1.0 was first available on the Palm Pilot 1000 and Palm Pilot 5000 systems. Pilot 1000 was released with 128KB of RAM with Pilot 5000 having 512KB of RAM. Many of the early versions of Palm OS were loaded into ROM and could not be upgraded. In 1998 Palm released Palm OS 3.0. This was a major breakthrough for Palm as is made use of the newest four-shade grayscale displays, "state-of-the-art" 16MHz processor, and took advantage of the new infrared "beaming" technology to transfer data. Palm OS 3.0 was also the first Palm OS included in flash-memory so that it could be upgraded should the user choose to do so. OS 3.0 represented a large milestone for Palm as it became widely accepted and gained in popularity. Because of this, many more applications were written for the Palm OS.

Palm's most recent operating systems, OS 4.0 and OS 5.0 are vast improvements from the days of OS 1.0. Palm OS 4.0 supports screens with up to 65,000 colors yet still does not support multithreading limiting the number of concurrent applications to one. Palm OS 5.0 solved this problem by implementing the ability to support multithreading. Palm OS 5.0 is also an upgrade from the 16-bit OS 4.0 to a 32-bit system and has support for faster processors. According to ZDNet in a comparison of OS 4.0 and OS 5.0, this allows OS 5.0 to run up to 10 times faster than a handheld with Palm OS 4.0.

Standard Applications

Palm OS 5.0 is a first in the Palm OS series in a number of different ways. OS 5.0 includes a number of standard applications that other Palm OS's have not. OS 5.0 includes a Word reader and Sheet reader programs capable of reading Microsoft Word Documents and Microsoft Excel spreadsheets. OS 5.0 also includes a standard web browser, support for 128-bit encryption, and a media player capable of playing a number of different media formats.

File System

Palm OS's differ from many other operating systems in that they do not have a concrete file system. Palm OS's use a virtual file system or VFS. The VFS was designed to be able to support expansion cards since handheld computers have little room of memory. The VFS was built on the FAT file system used in the Windows CE and Pocket PC operating systems. Palm OS 4.0 and higher natively supports the FAT file system as well as VFAT file systems. The VFS differs from other FAT based file systems in that it can also be modified to support other file systems through the use of palm developer software. The FAT file system is covered more in depth under the Pocket PC 2002: File System section of this paper.

Ease of Use

For users familiar with old versions of the Palm OS, OS 5.0 will be fairly easy to use. Palm OS has a similar interface to most other GUI's. The main difference between the Palm OS and a Windows system is the fact that Palm OS was created so that the user would not have to browse a file/directory structure in order to find their files. The Palm OS simply lists all of the files on the handheld device in one file manager window.

Different types of files are listed in different colors to allow the user to determine the file type.

Palm OS 5.0 includes support for an external keyboard as well as handwriting recognition and the “graffiti” style input of letters. Learning graffiti takes some learning and can be somewhat unnatural for a writing style. Palm OS, as well as Pocket PC and Linux supports infrared technology to “beam” files from handheld to handheld or to the desktop, assuming you have the correct hardware and software installed on the desktop. Palm OS 5.0 also includes support for 802.11b format wireless connections in addition to WAN and Bluetooth that was included in Palm OS 4.0. The incorporation of a standard web-browser into Palm OS 5.0 also makes use easier as a third-party web-browser no longer has to be added.

For users accustomed to the Windows operating system environment, Palm OS can be “skinned” to allow the user to have more of a Windows look and feel. There is still a noticeable difference between a skinned Palm OS and Windows, however. Unlike Pocket PC 2002, Palm OS 5 does not have active synchronization software built in to the operating system to update new data from the handheld to the desktop. Using Palm OS, the user simply has to push a button to download data to their desktop when needed, however.

One main disadvantage of the Palm OS’s up to OS 5.0 is that early Palm operating systems could not multitask. This allowed the operating system itself to be considerably smaller than other handheld operating systems, but allowed only one application to run at a time. Palm OS 5.0 takes care of this by implementing multi-threading and multitasking abilities into the operating system.

Linux

History of Linux on Handheld Devices

One of the most recent additions to the handheld operating system market is a version of Linux that can be installed on the handheld computer. Sharp is one of the first companies to offer Linux on their handhelds. Prior to this, a few users of handheld devices experimented with adding Linux to their handhelds. Linux's main advantage over many other operating systems on the market is the fact that it is an open-source language and allows the user to customize it as they see fit. The handheld version of Linux is somewhat of a stripped-down version of Linux for desktop computers. Changing an operating system from either Palm OS or Pocket PC to Linux requires additional setup not associated with Pocket PC or Palm OS. The main reason for the extra overhead when setting up Linux is because of the extra partitioning needed for swap files and other system functions.

Standard Applications

The version of Linux released on the Sharp handheld computes will come with the Embedix Plus version of the Linux/Java operating system, Opera 5 web browser, and a handheld version of the QT development software, a powerful GUI development language created by Trolltech™, Word and Excel Viewer as well as a media player capable of playing MP3, MPEG, and other well known formats. The Embedix Plus operating system was created by Lineo, Inc. and includes the Opera 5 web-browser and standard text editors and accessories. The operating system will include support for all major wireless formats as well as infrared beaming. The text editor and Word viewer

include support for a miniature keyboard, included on the Sharp handheld, handwriting recognition, and “graffiti” style writing.

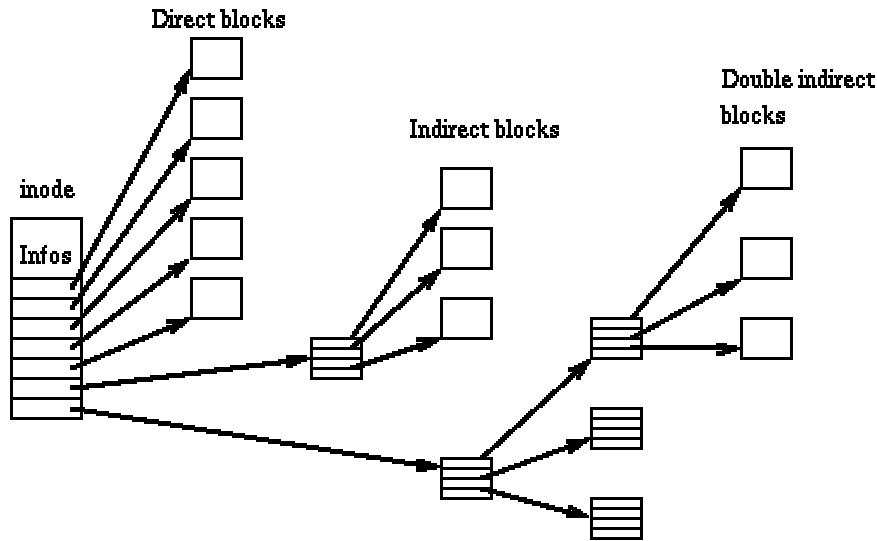
The handheld version of Linux also includes the different command shells for those who don’t want to use the GUI interface. For the advanced user, the QT software can be used to completely rewrite the standard image should the user choose to do so.

File System

The handheld versions of Linux use the EXT2 file system. The EXT2 file system is one of the newest file systems used in Linux operating systems. EXT2 has the advantage over both the Palm OS and Pocket PC 2002 in the fact that it can support file sizes of up to 2GB and partition sizes of 4TB. Because of this vast file size that can be supported, this version of Linux could be used on handheld devices for many years to come.

EXT2 has somewhat of a different structure than the FAT file system. EXT2 supports up to triple indirect addressing when setting up the memory addressed. Because of this, many different memory locations can be addressed, with the largest access time taking 4 memory checks. The EXT2 file system diagram is as shown below (web.mit.edu):

Figure 3.1: Example of EXT2 File System Structure



In the diagram above, the inode contains the file type, user permissions, owners, timestamp, size, and pointers to data blocks. Linux also makes use of a virtual file system implementing the operating system. The virtual file system in Linux contains low-level system commands for opening, reading, writing, etc.

The handheld version of Linux supports memory cards and other devices formatted with both the EXT2 file system as well as FAT16. This gives the Linux operating system another advantage and adds to its ease of use.

Ease of Use

Ease of use in the Linux file system is in large part dependant on the experience of the user. First time computer users should have no problem learning the Linux environment as well as experienced computer users. Those dedicated to the Windows environment will have a slightly easier time with the handheld version of Linux than those used to the Palm OS. The handheld version of Linux contains the familiar shortcut bar at the bottom of the screen to allow the user to switch between applications that are

running. Many of the devices that Linux is included on also have a miniature keyboard to make data input considerably easier than using touch screen keyboards. Linux also provides support for handwriting recognition and “graffiti”.

For the more advanced user, the Linux shell is easily accessible allowing the user to modify file permissions easily and make changes to the Linux environment. One problem with the shell is the fact that not all of the commands needed were installed with Linux. Commands such as the *grep* command need to be installed separately. For users who don't use the command prompt, this won't be a problem though.

The Word reader and Excel reader included as standard applications strongly resemble Microsoft Word and Excel making their use extremely easy. The media player included is compatible with many of the common media formats including MP3 and MPEG. Other third-party software written for Linux can be downloaded for free off the Internet making upgrading software considerably cheaper for handheld computers running Linux than other handhelds.

For users familiar with QT, the development of new software for use on the handheld is extremely easy as QT is included as standard software with the Linux operating system. The QT developer is readily accessible with its own shortcut menu from the desktop to make access easy.

Comparison of Handheld Operating Systems

Advantages and Disadvantages

In testing and reviewing each of the three operating systems covered in this paper, each operating system had its own unique advantages and disadvantages. Out of the three reviewed, Microsoft's Pocket PC 2002 has one of the most commonly known

interfaces. Palm, however, owned 51% of the handheld operating system market in 2001 with Pocket PC having 33% of the market (www.palmsource.com). This leaves the remaining 16% of the market to the Linux operating system as well as the other minor handheld operating systems. Pocket PC 2002 also has one of the largest bases of compatible products with Linux and Palm shortly behind. In terms of price, devices with the Palm operating systems are generally cheaper to purchase than devices with either Linux or Pocket PC 2002. Linux devices would almost inevitably be the least expensive of the three, if it weren't for the fact that devices with Linux on them are generally more complex with larger screens and an attached keyboard.

Each of the three operating systems also had their disadvantages. Linux is only available on a small number of devices and is somewhat difficult to add to devices that it is not initially included on. Pocket PC 2002 is probably the most complex of the three operating systems and thus requires more memory resources. Palm operating systems are generally slower to get to market giving Microsoft and Linux a head start on their software.

Security

Palm OS 5.0 has upgraded its security from other versions to make use of the newest 128-bit data encryption techniques based on the RSA's Security RC4 encryption algorithm. OS 5.0 also includes support for Secure Socket Layer, SSL, services for secure transfers over the Internet, secure web-browsing, and e-mail. Both Pocket PC 2002 and the Linux/Java operating system use these same methods of encryption. Since the three operating systems have the same security measures in place, neither of them have an advantage.

Conclusion

In comparing and testing the three operating systems, I found that the Linux/Java operating system worked the best out of the three. The interface was extremely easy to navigate and to learn. The Linux/Java operating system also came with the greatest number of useful software titles such as the Word and Excel emulators. The included QT developer was a major bonus from my point of view. The Linux/Java operating system did come with a calendar and address book, but was not quite as extensive as the one included in Pocket Outlook.

For those looking for entertainment value, all three operating systems did come with games. Pocket PC 2002 came with the standard minesweeper, solitaire, and free cell. The Palm OS came with a few different games such as a version of the popular game Arkanoid, snake, Tetris, and a couple others. The Linux operating system came with its usual asteroids, snake, and a couple different matching games. Pocket PC is the best choice of the 3 for users looking for plain everyday games. Palm OS and Linux have the advantage though with the younger crowds and those looking for something different. In my opinion, the Linux/Unix operating system is the winner in this category as well.

The main disadvantage with the Linux/Java operating system is the fact that it is still fairly new to the market, and is only available on a small number of devices. It is, however, becoming more popular. Palm OS still has a considerably greater share of the market and is the cheapest of the three operating systems. Because of this, I have to award this category to Palm OS.

Both the Linux operating system and Pocket PC operating system, I feel, have the greatest potential of the three companies. The share of the market for Palm OS has

decreased steadily throughout the years since the release of Windows CE/Pocket PC and now more recently the Linux/Java operating system. Pocket PC 2002 is increasing in popularity because it is available on a wide variety of devices. Since Pocket PC 2002 is released by Microsoft, it has access to a wide variety of software, and supports a great deal of software. Many people are also familiar with the Windows operating system giving Pocket PC 2002 an edge over Palm OS 5.0 and the Linux/Java operating system.

If I were to recommend an operating system for the first time user, I would recommend the Linux/Java operating system. The Linux/Java operating system is offered on more expensive devices, but the options on these devices make the higher price, in my opinion, insignificant. The QT developer included makes writing new software for the Linux operating system considerably easier than learning new tools for the Palm OS. For these reasons, I would recommend the Linux/Java operating system out of the three with Pocket PC 2002 coming in a close second and Palm OS 5.0 rounding out the pack.

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