Pen Computer Technology

Educates the reader about the technologies involved in a pen computer

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This paper is intended to educate the reader about the technologies involved in a pen computer. After reading this paper, the reader should be better equipped to make intelligent purchasing decisions about pen computers.

**Types of Pen Computers**

In this white paper, “pen computer“ refers to a portable computer that supports a pen as a user interface device, and whose LCD screen measures at least six inches diagonally. This product definition encompasses five generally recognized categories of standard products, listed in Table 1 below.

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Since the different types of pen computers are often confused, the following paragraphs are intended to help explain the key distinguishing characteristics of each product category.

**Pen Computers Contrasted**

**Webpad:** A Webpad’s primary characteristic is that its only user interface is a Web browser. While applications may be written in languages supported by browser plug-ins such as Macromedia’s Flash, Webpads don’t support standalone application programs. A Webpad’s sole purpose is to act as a Web access device, a “thin client for the Internet.” Most Webpads use wireless LAN as their connection to the Internet, since being tethered to a telephone line severely limits the portability of a Webpad. The operating system on a Webpad is essentially a “don’t care” item, since the user never interacts with it; for this reason, some Webpads use “embedded” (hidden) operating systems such as Linux or QNX. Webpads are targeted at both consumer and enterprise markets, but the majority of the very small number of Webpads that are actually sold go to the latter.

**CE Tablet:** A CE tablet can be viewed as a Webpad that uses Windows® CE as its operating system and has additional...
flash memory to support standalone application programs. CE tablets are focused exclusively at enterprise applications. CE tablets often include some hardware optimization for enterprise applications such as additional I/O ports, enhanced ruggedness, or integrated wireless. A CE tablet can function as an enterprise-oriented Webpad or even a portable thin client for accessing server applications (e.g., in healthcare applications). Note that neither Webpads nor CE tablets are true PCs; they are special-purpose devices that don’t follow standard PC architecture. Fujitsu's PenCentra tablet is one of the most popular CE tablets on the market, with a substantial market share.

**Pen Tablet:** The distinguishing characteristic of a pen tablet is that it's a tablet form-factor device (without an integrated physical keyboard) running Windows 9x, NT-4, 2000 or XP with a hard drive. A pen tablet is a true PC. It's capable of running essentially any software that runs on a notebook or desktop computer. However, when used in corporate project-based applications, pen tablets typically run specialized applications that become the primary user interface. Pen tablets today are marketed exclusively to enterprise, since there currently is no consumer market for pen tablets. (See Fujitsu's white paper entitled "The State of the Pen Tablet Computer Market" for more information on the market for pen tablet computers.) The Fujitsu Stylistic® series of pen computers, which has been in existence since 1994, is the leading product family in the pen tablet market.

**Pen-Enabled Notebook:** This category is easily distinguished by the fact that the typical product is a notebook (with an integrated physical keyboard) rather than a tablet, yet it also supports a pen. As such, it is somewhat of a hybrid product. Because it's a notebook, it tends to appeal to both consumer and enterprise markets. However, also because it's a notebook, its form factor is less optimized for working while standing or walking around. The operating systems supported on pen-enabled notebooks tend to cover less of a range than for pen tablets; for example, NT-4 is not typically supported on pen-enabled notebooks. The Fujitsu LifeBook® B Series is a good example of a pen-enabled notebook.

A pen-enabled notebook can also be built in a way that allows it to be used as either a traditional notebook or a pen tablet (slate). A product with this characteristic is generally called a "convertible." The advantage of this construction is that it meets the need for both an all-in-one device for keyboard entry on a desk, and for a device that can be used with a pen while standing or walking around. The mechanism that enables this characteristic is usually some form of unique hinge that allows the screen to be rotated and then closed over the keyboard while facing up, or to be folded back through 360 degrees so that it's underneath the product.

**Tablet PC:** A Tablet PC is a pen computer in any form-factor that runs "Windows XP Tablet PC Edition," the new pen-enabled version of Windows that's due to be released in the second half of 2002. In order for an OEM to license this new OS, the OEM's hardware must meet the requirements of Microsoft's Tablet PC platform specification. There are only seven unique requirements, as follows:

- High-performance active digitizer with "hover"
- Resume from suspend in two seconds or less
- Battery life in suspend of at least 72 hours
- Automatic hibernation (save-to-disk) when the battery is exhausted
- Rotation between landscape and portrait modes without rebooting
- Docking and undocking without notifying the OS ("Grab-and-Go")
- Legacy-free hardware (no serial, parallel, PS/2, game or FDD ports)
- A Tablet PC without an attached keyboard must provide a dedicated hardware mechanism to produce a "Ctrl-Alt-Delete".

Since the Tablet PC operating system won't be released until the second half of 2002, Tablet PCs are not shipping yet. Fujitsu along with a number of other vendors showed prototype Tablet PCs at Comdex 2001.

**CPUs**

Most pen tablets today use the same CPU (central processing unit) that's used in notebooks: the Intel Pentium III. The difference is in the speed (MHz). Speed generates heat. Within the same processor family, a faster CPU generates more
heat. Somehow this heat must be removed from the device in order to keep the maximum temperature of the processor within specification limits. A notebook has three heat-dissipating surfaces: the bottom of the unit (which usually includes a thin metal plate), the underneath of the keyboard (made of metal), and the back of the display. Both of the first two surfaces are typically connected to the CPU via a heat pipe (a device that moves heat very efficiently from one location to another). The display, which typically generates about 25% of the heat in a typical notebook, has its own heat dissipation surface. In a pen tablet, there is only one heat-dissipating surface (the back of the unit), and the user typically has his hand or arm against the back when using the unit. A pen tablet therefore inherently has less heat dissipation capability than a notebook, which tends to limit the maximum speed of the processor used in the device unless sophisticated, expensive heat dissipation techniques are used.

Over time, the power consumption of portable computers has steadily decreased. The first notebook, the GRiD Compass, drew about 70 watts of power. Today a typical notebook draws about 15-20 watts, and a typical pen tablet draws about 12-15 watts. CPUs have gotten steadily more efficient, at a faster rate than other subsystems such as the display, the video controller or the hard drive. This means that the percentage of a unit's total heat that's attributable to the CPU has decreased. This has allowed faster CPUs to be used in pen tablets, since the amount of heat that has to be dissipated by the CPU has decreased to the point where it's not a significant problem. The result is that pen tablets are now approaching the same CPU speeds as ultraportable notebooks.

Displays

Pen tablet LCD displays differ from notebook LCD displays in two key areas, size and outdoor viewability. In 2001, more than 50% of notebooks were shipped with an LCD display of 14 inches or larger. The largest display used in any current pen tablet is 12.1 inches. Pen tablets are designed to be arm-held while standing or walking around; using a large display makes the pen tablet heavy, awkward to hold and difficult to read. The most common display size used today in pen tablets is 10.4 inches; the next most common is 8.4 inches.

Because a pen tablet is a much more mobile device than a notebook, outdoor viewability of the display is much more important than in a notebook. Out of the hundreds of notebook models on the market today, only a few have outdoor-readable displays. Most pen tablets have at least an option for an outdoor-readable display. Fujitsu has consistently been a leader in delivering pen tablets with outdoor-readable displays. All current Fujitsu pen tablets allow the buyer to choose between indoor-only or indoor-outdoor displays. For more information on the technologies used to achieve outdoor viewability, see http://pencomputing.com/frames/displays.html.

Resolution of the display used in pen tablets is driven largely by the resolution required by application-specific software. Today most software used in corporate project-based applications is written for SVGA (800x600) resolution. As a result, most pen tablets on the market today are sold with SVGA displays. Pen tablet vendors who are on the leading edge of technology, such as Fujitsu, offer both SVGA and XGA (1024x768) displays. Notebook displays today are mostly XGA, driven by the needs of productivity software such as Microsoft Office. Because of the influence of notebooks, pen tablet displays are beginning to transition to XGA resolution. When products based on the Microsoft Tablet PC specification start shipping in the second half of 2002, this trend will accelerate rapidly, since the Tablet PC specification strongly recommends XGA resolution.

The dot density of a display, expressed in dots-per-inch (dpi), is a useful specification when evaluating the readability of a display. Resolution and density are independent. Resolution is the number of dots in the X and Y dimensions of a display, regardless of the physical size of the display. Density is the number of dots in one inch. Since displays are universally measured in terms of their diagonal dimensions, and essentially all displays used in pen tablets and notebooks have an aspect ratio of 4:3, the actual horizontal dimension of any display can be calculated by dividing the diagonal dimension by 1.25. For example, a 10.4-inch display has a horizontal dimension of 10.4/1.25 = 8.32 inches. If the display is XGA (1024x768) resolution, the dot density is therefore 1024/8.32 = 123 dpi. Doing the same calculation for an 8.4-inch SVGA display yields the interesting result that the latter display has a density of 119 dpi (a difference of only 3%). This means that information on a 10.4-inch XGA display and on an 8.4-inch SVGA display look very similar, even though the displays are
Digitizers

The basic purpose of the digitizer (often called a “touchscreen”) in a pen tablet is to translate the position of the pen on the screen into “X” and “Y” coordinate values, and to accept actions from the pen in the form of left and right mouse clicks. The digitizer, along with the pen, is basically a replacement for a mouse.

The digitizer technology used in almost all pen computers today is a passive technology called “resistive.” It’s passive because there is no communication between the digitizer and the stylus and “resistive” because it’s made up of two resistive (conductive) coatings. The structure of a resistive digitizer is fairly simple. In front of the LCD there is a sheet of glass that’s covered on its top side with a conductive, transparent coating. (The coating is made of Indium Tin Oxide, usually abbreviated as ITO.) On top of the glass there’s a sheet of plastic that’s covered on its bottom side with the same conductive coating. The top of the plastic sheet forms the writing surface. In between the glass and the plastic sheet are tiny transparent spacer dots. When you press down on the plastic sheet, it contacts the bottom glass and completes an electric circuit via the two conductive coatings. A controller chip measures the resistance from the contact point to each of the four sides of the digitizer and calculates the location of the contact point.

During the design phase, a resistive digitizer can be optimized for finger-touch or for pen-touch. This is accomplished by varying the distance between the spacer dots. If the dots are far apart, a broad surface (such as a finger) can depress the top plastic sheet enough to make contact with the bottom glass. If the dots are close together, a smaller surface (such as a pen) is required to depress the top plastic sheet enough to make contact with the bottom glass. Standard digitizers are designed with medium spacing between the dots, which allows either a finger or a pen to be used. The problem with this compromise is that when you rest your hand on the screen while writing, the crease in your palm may trigger the digitizer instead of the pen tip. This is called the “palm effect.” The digitizers used in Fujitsu pen tablets are designed with close spacing between the dots, which produces excellent “palm rejection” - meaning that the edge of your hand won’t accidentally trigger the digitizer. This makes the pen tablet much easier to use, particularly in a large-screen model. The tradeoff is that it requires more pressure to activate the digitizer with a finger, but that’s acceptable because as the dot density of displays continues to rise, finger-touch is becoming less and less practical in most pen tablet applications.

In a standard resistive digitizer, the amount of light emitted by the LCD that gets through the digitizer (called the transmissivity of the digitizer) is between 75 and 83 percent. In addition, because there are four distinct surfaces (both sides of the plastic sheet and the glass sheet), a significant amount of ambient light (typically 20%) is reflected from the digitizer. The user perceives this reflected light as glare; it also has the effect of reducing the contrast of the LCD image. The digitizers used in Fujitsu pen tablets add one key ingredient that significantly improves all of these problems: a silicon oil-based liquid that replaces the air between the plastic and glass layers. The liquid makes the digitizer seem like a single unit instead of two separate layers. It improves the transmissivity of the digitizer to over 90 percent, and reduces the reflected light to less than 10 percent. Compared with a standard digitizer, the visual improvement is simply amazing.

Because a resistive digitizer pen has no buttons, a resistive digitizer seems to offer the user less control than a mouse (which typically has at least two buttons). However, special provisions are made in Fujitsu pen tablets to compensate for this. First, the digitizer has a “right click mode.” When a designated “hotpad” (a pen-sensitive, off-screen control similar to a function key) is touched, the next pen touch is interpreted as a right-click. This allows the pen to be used to bring up “context menus” and other Windows right-click functions. Second, the digitizer has a “hover mode.” When a second designated hotpad is touched, all further pen touches are interpreted as “mouseover” or “rollover” events until the hotpad is touched again. This lets the pen simulate the effect of rolling a mouse over the screen without clicking, thus allowing access to such Windows features as pop-up tooltips.

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Tablet PCs, on the other hand, will use an active technology utilizing electromagnetic resonance. It is called active because it uses radio frequency (RF) technology to actively communicate the position of a special stylus to the surface of a sensor grid that usually sits underneath the LCD. This special stylus gives active digitizers the capability of proximity sensing or "hovering". This means the sensor grid can determine the position of the stylus when it comes within 5-10mm (0.2"-0.4") of the writing surface. When the sensor grid recognizes the presence of the stylus, it responds by moving the cursor directly under the position of the stylus. As long as the stylus is within range of the sensor grid, the cursor will follow the movement of the stylus. This action is called hovering. To execute a mouse click, the user simply taps the writing surface activating a mechanism in the stylus that sends a signal to the digitizer.

Storage Devices

The hard drives used in pen tablets today are generally the same as those used in notebooks (2.5-inch diameter, spinning at 4,200 rpm). Because of the need to minimize thickness and maximize portability, pen tablets use the thinnest hard drives available (9.5 mm), while high-end notebooks may use thicker hard drives (12.5 mm) in order to provide higher capacity. The capacity of a hard drive in a pen tablet is comparable to that in an ultraportable notebook, ranging from 10 GB to 40 GB. One key difference is that the hard drive in a pen tablet is nearly always shock-mounted, which is fairly rare in notebooks. The need for shock mounting becomes obvious once you think about the difference between the truly mobile pen tablet user and the typical desk-bound notebook user. Fujitsu has several patents pending on methods of shock-mounting and vibration-mounting a hard drive in a pen tablet and in notebooks.

Within the last year or two, the technology used in 1-inch diameter hard drives has improved to the point where the capacity of PC Card form-factor hard drives is now at 5 GB. The compact-flash form-factor IBM Microdrive, which also uses a 1-inch diameter drive, is now at 1 GB. There are two main reasons why these devices are not generally used in pen tablets. First is the cost per megabyte. Using street price as a benchmark, the cost per megabyte of a 30 GB, 2.5-inch hard drive today is around 0.5 cents. The cost per megabyte of a 5 GB PC Card hard drive is around 10 cents (20 times more expensive), and the cost per megabyte of the 1 GB IBM Microdrive is around 30 cents (60 times more expensive!). Second, a maximum capacity of 5 GB is simply not enough for many enterprise applications. After all, would you buy a notebook today with only 5 GB of storage? Most 1-inch storage devices are targeted at consumer digital cameras, where their use is much more appropriate than in an enterprise pen tablet.

Optical storage devices (CD-ROM, DVD and CD-RW drives) are standard today in most notebooks, but no pen tablet includes them in the core product. Instead, optical drives on pen tablets are always in the form of external peripherals. The primary reason is that the enterprise pen tablet user doesn’t need to do the activities generally associated with optical drives while standing or walking around. The primary use of CD-ROMs today is installing software, the primary use of DVDs is watching movies, and the primary use of CD-RW is creating backups. It's clear that these are all desk-bound activities that can be accomplished perfectly well by using an external peripheral drive.

There are, however, some cases where CD-ROMs are used as a data distribution method by enterprise. In these situations, the typical solution for access to the data while mobile is the use of a CD-ROM drive emulator program, such as "Virtual Drive" from FarStone Technology (www.farstone.com). This software creates a virtual CD-ROM drive on the user's hard drive. Once the contents of a CD-ROM are loaded onto the hard drive, applications can access the virtual CD-ROM just as though it was in a physical CD-ROM drive. Since the typical CD-ROM holds about 700 MB, and the capacity of the typical pen tablet hard drive is at least 20 GB, capacity is not an issue, even if the user needs several CD-ROMs loaded at the same time. In addition to the obvious benefit of eliminating the size and weight of a real CD-ROM drive, a virtual CD-ROM drive has two additional benefits: performance equivalent to 200X with zero spin-up time, and much lower power consumption (which produces longer battery life).

In CE tablet products, flash memory is still the storage medium of choice. The reasons are ruggedness, power consumption and storage size requirements. Flash memory has no moving parts, which makes it inherently more rugged than a rotating disk drive can ever be. A typical shock specification for flash memory is 2,000G (operating and non-operating), compared with 175G (operating) and 1,500G (non-operating) for a 1-inch hard drive. This means that even with excellent shock mounting, a 1-inch hard drive cannot even begin to approach the ruggedness of flash memory. The power consumption of flash memory during a write operation is typically 0.1W, compared with 0.8W for a 1-inch hard drive. Using flash memory
therefore provides longer battery life. Flash memory does cost more per megabyte than rotating media - flash memory costs around 60 cents per megabyte, compared with 40 cents per megabyte for a 384 MB, 1-inch hard drive (again, street prices are used as a benchmark). However, 64 MB of flash memory storage is plenty for most CE tablet applications, so the total cost of storage is lower with flash memory, since the lowest-capacity 1-inch drive is 384 MB.

Batteries

The batteries in today's pen tablets use the same technology as is used in notebooks — lithium ion. As is the case with notebooks, most pen tablet designers strive to provide at least four hours of battery life, on the theory that the typical user takes a break for lunch, at which time the batteries can be swapped. However, a pen tablet is carried when in use, while a notebook generally stays on the desk. This puts a greater premium on reducing the size and weight of the battery in a pen tablet to the absolute minimum. Accordingly, a strategy of "standard packs" and "extended packs" is sometimes implemented in pen tablet batteries, to give the user the choice between carrying more weight for longer battery life, or carrying less weight and swapping the batteries more often.

Another factor that is of particular importance in pen tablets is the battery charge time. In some applications, such as healthcare, the pen tablet may spend a significant amount of time in a docking station or charging cradle. If the pen tablet's charging system is designed to charge the batteries as quickly as possible (e.g., 90% in 90 minutes), it effectively lengthens the battery life in applications where the usage model is "pick it up, use it, put it down."

Finally, the inclusion of a bridge battery is very important in pen tablet design. A bridge battery is a small, internal, rechargeable battery that powers the DRAM during suspend when no main battery is present. This allows the user to suspend the computer, remove the main battery pack, insert a freshly charged battery, resume the computer, and continue working with literally only a few seconds interruption. Without a bridge battery, the user must shut down the computer, change the battery and reboot, which can take several minutes. All Fujitsu pen tablets include a bridge battery. Typical battery life for a bridge battery is at least 5 minutes, and sometimes as long as 30 minutes — more than enough time to change the main battery. The bridge battery is recharged from the main battery automatically, completely without user intervention.

Built-In and External I/O Ports

Determining which I/O ports to include in a pen tablet is always a difficult decision for the designer. Adding ports gives the impression of increased product flexibility, but adding ports can also significantly increase the cost, size and weight of a product. The size issue can be handled by using subminiature connectors, but then the user has to have connector adapter cables, which have an amazing ability to become lost just when you need them. There's also the not-so-obvious issue of subtle pressure from Microsoft(r) to move towards "legacy-free" PCs. (A legacy-free PC is one without any serial, parallel, PS/2, game or FDD ports.) The guiding principle used by Fujitsu is to clearly differentiate between ports that are truly needed when the user is mobile, versus ports that are really only required when the user is desk-bound.

For example, consider the ports on the Fujitsu Stylistic 3500 pen tablet. There is, of course, a set of standard ports that you would expect to find on any portable computer: DC power in, PC Card slot, USB, RJ -11 modem, IrDA, headphone, microphone and expansion (docking) connector. In addition, there's an RS-232 serial port. In a modern computer with USB, the presence of a serial port may be unexpected - until you realize that there are still a lot of legacy scanners and other serial devices in existence that the user is likely to employ while mobile. There's also an IR (infrared) keyboard port. Why not a PS/2 keyboard port? An IR keyboard is much more flexible. It allows use on your lap, in a portfolio case, in a car - almost anywhere, without a cable.

The Stylistic 3500 includes an internal LAN (Ethernet) controller, yet there's no RJ -45 on the core product. Why is that? When a user is connected to a wired network, he's almost always at a desk. Why burden the core product with the cost and space required by an RJ -45 when it makes more sense to put it in a docking station? And there it is, along with all the other ports that you expect to find on a desk-based computer: parallel, monitor (VGA), PS/2 mouse, PS/2 keyboard, serial,
additional USB port and floppy disk drive port. The combination of a highly mobile computer with the ports required to do a fully mobile job, and a set of desktop docking peripherals with all the ports required to do a desk-bound job allow the Fujitsu pen tablets to actually replace two assets. You only need one computer. And in today’s tight economy, that’s a significant advantage.

Other Core Technologies

A number of other core technologies are used in a pen tablet computer, including chipsets (the integrated circuits that connect the CPU, memory, main bus and I/O bus), the video controller, the audio controller, and DRAM memory. Generally speaking, these chips are all similar or identical to those used in notebook computers. Where there is sometimes a difference, it’s in favor of lower power consumption components in the pen tablet.

Housing Design

Pen tablets present a special challenge to the housing designer. Because the user is constantly holding a pen tablet, it must be more durable than a notebook. When you pick up a typical notebook from the desk and put it in a carrying case, the fragility of the typical notebook becomes obvious. The case may “creak” as you pick it up by one corner, the display usually flexes enough to show “blooming”, and sometimes connector doors pop open. The user quickly learns to treat a notebook gently in the few seconds that it’s in transition between the desk and its carrying case.

This same behavior in a pen tablet immediately causes the user to reject the product due to lack of perceived durability. A pen tablet can’t creak when you pick it up by one corner; it has to feel solid any way it’s held. In fact, a pen tablet shouldn’t creak even if the user grabs it on each side and twists it with the motion used to wring out a towel. Connector doors have to snap shut with a satisfying “snap”, stay shut until the user wants to open them, and then be easy to open. And of course, a pen tablet has to be as light as possible and as thin as possible. Making a pen tablet that is both actually durable and perceived as durable is a substantial mechanical engineering challenge. Design details such as an internal magnesium frame, additional case ribs and special plastic material that blends different resins are all often required to meet the market requirements. After designing 17 generations of pen tablets in the last 10 years, Fujitsu is particularly expert in this area. Fujitsu’s pen tablets are highly durable, both in reality and in perception. The failure rate of a Fujitsu notebook is substantially less than that of a typical corporate notebook.

Environmental Specifications

Some pen tablets are designed to be “rugged,” meaning that they can be submersed in water, used in a dust storm, or mounted on a military tracked vehicle. Tablets designed to survive these extreme environmental conditions are generally large, heavy and expensive. Fujitsu pen tablets are designed to be “durable,” meaning that they can survive years of normal use in corporate project-based applications where the user is highly mobile. Fujitsu pen tablets are small, light and moderately priced.

However, in some applications a pen tablet may require additional protection against inclement weather and against being dropped from significant heights. Fujitsu’s approach to this requirement is the Harsh Environment Case (HEC). While Fujitsu does offer a standard HEC, more often than not the customer chooses to use a customized HEC. By varying the materials and the construction of the HEC, the customer can literally dial in any desired amount of protection — at minimal additional cost.

When designing and testing a new pen tablet, Fujitsu goes to extraordinary lengths to ensure that the product is highly durable. This involves designing the product to handle a wide range of environmental conditions, and then testing the product to make sure that it meets the design specifications. Some of these environmental specifications are not published in a product data sheet; they’re just part of making a highly durable product. The range of environmental specifications includes the following:
• Acoustic noise
• Altitude, operating and non-operating
• Bench handling, operating and non-operating
• Electrostatic discharge (ESD)
• Humidity, operating and non-operating
• LCD display permanent marks
• Resonance search
• Shock, operating and non-operating
• Temperature, operating and non-operating
• Thermal mapping (avoiding “hot spots” on the product)
• Torque, pressure and bend
• Vibration, operating and non-operating

Operating Systems and Pen Support Software

The operating systems supported by pen tablets are the same as those on a notebook. In fact, the range of operating systems on a pen tablet is often actually wider than that available on many enterprise-oriented notebooks. For example, Fujitsu’s Stylistic 3500 supports Windows 98, NT-4, 2000 and XP. This wide range of support is driven by enterprise needs. Corporate project-based applications often have to integrate closely with legacy software and operating environments. There may also be demanding corporate IT standards for mission-critical applications. Typical notebook users running productivity software such as Microsoft Office don’t face any of these obstacles; they’re perfectly happy to have the latest and greatest version of Windows on their laptop. Pen tablets in the enterprise must support everything that Microsoft supports — and sometimes even older Microsoft software, depending on the needs of specific enterprise customers.

It’s a fact of life that no version of Microsoft Windows fully supports the pen today. Windows 98 still contains a remnant of Windows for Pen Computing from 1995 (called “Windows Pen Services 2.0”), and some pen tablet applications still use it, but there’s clearly no native pen support in Windows NT-4, 2000 or XP. (This will change in the second half of 2002 with the introduction of Windows XP Tablet PC Edition. See the Fujitsu white paper on the Tablet PC for more information.) Most pen tablet vendors, including Fujitsu, have adopted “PenX” from Communication Intelligence Corporation (CIC) as the solution to this shortcoming in Windows. This add-on software enables the pen to be used everywhere in Windows. It includes handwriting recognition software, so that, for example, the user can handwrite a file name when saving a file, handwrite comments in a survey form, or handwrite alphanumeric digits when recording a license plate.

Summary

This paper has provided detailed information on the technologies used in pen computers, including CPUs, displays, digitizers, storage devices, batteries, built-in and external I/O ports, other core technologies, housing design, environmental specifications, operating systems and pen support software. The common theme through all of this information has been that pen tablet technologies are slightly and subtly different from notebook technologies. The fact that pen tablets are used in truly mobile applications affects their design in many ways. The corporate project-based application focus of pen tablets also affects their design in many ways. By explaining and illustrating these differences, this paper has attempted to educate the reader in order to enable intelligent purchasing decisions about pen computers.

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