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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.

PRODUCT CATEGORY	TARGET MARKET	PC	USER INTERFACE	STORAGE	OPERATING SYSTEM	RUNS LOCAL PROGRAMS	EXAMPLE
Webpad	Consumer & Enterprise	No	Standard browser	Flash memory	Windows CE, Linux, QNX	Only via browser plug-ins	Honeywell WebPAD II
CE Tablet	Enterprise	No	Specialized applications	Flash memory	Windows CE	Yes	Fujitsu PenCentra
Pen Tablet	Enterprise	Yes	Windows & specialized applications	Hard drive	Windows 9x, NT-4, 2000, XP	Yes	Fujitsu Stylistic
Pen-Enabled	Consumer & Enterprise	Yes	Windows	Hard drive	Windows 9x, 2000, XP	Yes	Fujitsu LifeBook B Series
Tablet PC	Consumer & Enterprise	Yes	Windows	Hard drive	Windows XP Tablet PC Edition	Yes	Many under development

Table 1: Categories of Pen Computers with LCD Displays of Six Inches or Larger

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 (800x 600) 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 (1024x 768) 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

different sizes. For example, a 10-point font looks very similar on the two displays. The difference is that on the 10.4-inch display, you can see more characters. This is especially obvious if a map is displayed - the map detail on the two displays is very similar. The 10.4-inch display just shows more of the map's extent. This information can be useful when deciding on the tradeoff between a smaller, lighter tablet with an 8.4-inch (SVGA) display and a larger, heavier tablet with a 10.4-inch (XGA) display.

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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