

By Geoff Walker

Microsoft MIRA



Tatung Mira prototype



Philips Mira prototype



ViewSonic Mira prototype



“Mira” is yet another Microsoft-championed concept meant to extend the reach of Windows beyond the desktop. With Mira you access your PC with a wireless connection from wherever you are in the house.

MICROSOFT MIRA AT A GLANCE

Mira is Microsoft's code name for a wireless, pen-enabled monitor intended for use with your home PC. Mira extends the use of Windows XP to any room in your house. Mira can be summarized as follows:

- Available Christmas 2002, \$500 to \$800
- 14 OEMs & ODMs are signed up to build Miras
- Two form factors: “main monitor” and “mobile monitor”
- Main monitors are 15" XGA
- Mobile monitors are 8.4" and 10.4" SVGA
- Mira communicates with the home PC via WiFi (802.11b)
- Mira uses Terminal Server software built into XP Pro
- Only one Mira can be used at a time
- Mira doesn't support full-motion video or 3D games

If you're thinking about buying a new monitor or a new PC, you're probably considering getting one with a flat LCD screen.

Microsoft's "Mira" (derived from Spanish for "to watch") simply makes that LCD mobile. Mira is a wireless, pen-enabled monitor. You'll also see it referred to as a "smart display," which isn't a very useful name, since it doesn't mean anything specific. Why would anyone want a wireless monitor? To be able to use a home PC in any room of the

house, or even in the back yard. According to Microsoft CEO Steve Ballmer, "Mira does for monitors what the cordless handset did for telephones." Think about that for a moment – it's a darn good analogy. "Mira," by the way, is only a temporary code name. Microsoft hasn't decided on a final name for product. They'll have to decide soon, though, since Mira products are scheduled to be available in time for Christmas 2002.

Extending the Experience

Think of the applications and features you use on your PC, and then consider whether some of them would be easier or better used away from the desk and room where the PC lives. One of the most obvious uses is reading news and other Internet content (browsing the web). Wouldn't it be more comfortable to do it in an easy chair or on the couch with a Mira mobile monitor? But don't stop there — what about reading and responding to email, doing instant messaging, reviewing your personal finances, planning a trip with mapping software, doing crossword puzzles, viewing and editing photos, playing solitaire, doing minor editing with a productivity application, playing and managing MP3 files, sharing your photo albums with friends, reading ebooks, listening to Internet radio stations, or reading endless documents and presentations from work? Finally, breaking away from the "couch" environment, what about accessing technical information from a CD-ROM for your car while you're in the garage?

The basic concept of the Mira is to extend the Windows PC experience to any room in the home. When you're using a Mira, you're using your PC. This is significantly different from using a webpad. With a webpad, you're limited to browsing the Internet and using a few, limited-functionality CE applications. When you're using a Mira, you have access to all the data and applications that are resident on your PC. This means that the Mira reflects all of your personalized PC settings such as My Favorites, My Pictures, folder settings, etc. It

also means that you have access to all of your PC peripherals, such as printers, CD burners and Zip drives. Mira is your PC, wherever you want it. This is what Microsoft calls "relaxed, casual computing." For a very slick, two-minute Microsoft concept video of a family using a Mira in four different rooms on two different floors of a house, visit <http://www.microsoft.com/windowsxp/mira/video.asp>.

Rationale
The basic concept of Mira is to extend the reach of your PC to every room of the house



base and used anywhere in the house. When it's mobile, it communicates with the PC via WiFi (802.11b) wireless. Most of the

Mira main monitors to be announced in 2002 will use 15" XGA (1024 x 768) LCDs, since that's the current "sweet spot" in LCD monitors.

Initial Form Factors

Most Mira V1 products will be available in one of two basic form factors: "primary detachable monitor" and "secondary mobile monitor." For the remainder of this article, these terms are shortened to "main monitor" and "mobile monitor." The Mira main monitor, as the name implies, replaces the standard CRT or LCD monitor on a PC. When a Mira main monitor is being used next to the PC, it's connected via a VGA or DVI cable, just like any other monitor. However, it can be detached (removed) from its

Mira mobile monitors can be used only remotely from the PC. They can't be connected directly to the PC like a main monitor. They also communicate with the PC via WiFi (802.11b) wireless. Mira mobile monitors will generally have some form of docking cradle (or at least a passive stand) to hold the unit while it is being used with a keyboard and a mouse. Most of the Mira mobile monitors that will be announced in 2002 will use 8.4" or 10.4" SVGA (800 x 600) LCDs, since that's the design center of most webpads.

Figure 1: The Mira log-in screen is the first thing you see on a Mira device. Please note that this is a beta version and may be different in the final product

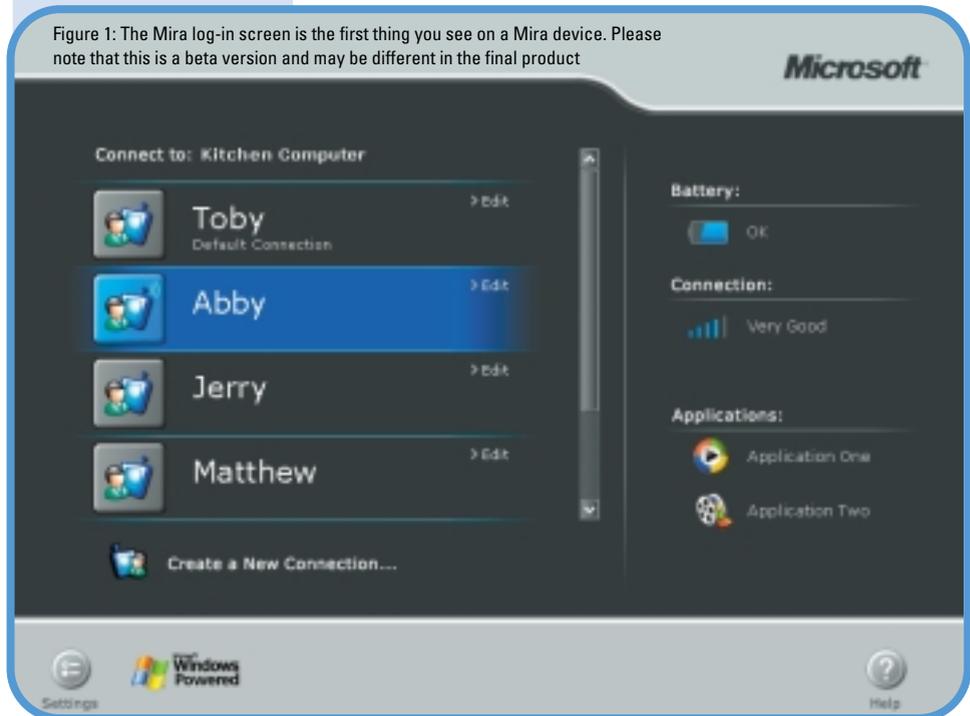


TABLE 1: COMPARISON OF MIRA WITH OTHER TYPES OF PRODUCTS

Characteristic	Mira	LCD Monitor	Internet Appliance	Webpad	Tablet PC	Laptop PC
Positioning	The evolution of the monitor	Desktop monitor	Limited capability Internet access	Limited capability Internet access	The evolution of the laptop	Mobile PC
Target Market	Consumer	Consumer and enterprise	Consumer	Consumer and vertical markets	Mobile professionals	Mobile professionals
PC	No (peripheral)	No (peripheral)	No (competition)	No (competition)	Yes	Yes
User Interface	Windows	Windows	Browser	Browser	Windows	Windows
Mobile	Yes	No	No	Yes	Yes	Yes
Wireless	802.11b	No	No	802.11b	802.11b & WAN	802.11b & WAN
Standalone Apps	Very limited in V1	No	No	Some	Unlimited	Unlimited
Quiet, Cool	Yes	Yes	Yes	Yes	Some	No
Instant-On	Yes	Yes	Yes	Yes	Yes ¹	No
Pen Support	Yes	No	No	Yes	Yes	No
Full-Motion Video and 3D Games	Not in V1	Yes	No	No	Most ²	Most ²
OS	Windows CE .Net	None	Windows CE, Linux	Windows CE, Linux, QNX	Windows XP, Tablet PC Edition	Windows 98, 2000, XP

¹ Resume in two seconds, but boot is still slow ² (some may not have strong 3D support)

The Input Problem

Looks pretty cool, doesn't it? As long as whatever you're doing doesn't require a lot of input, everything's great. Most Mira monitors have will touch

screens (resistive digitizers) for use with a pen, on-screen keyboards, handwriting recognition (Transcriber, the same as on a Pocket PC), and a method of connecting a corded or cord-

less keyboard and mouse (USB, IR, RF, etc.). But what if you want to write more than a one-line response to an email? Handwriting recognition and on-screen keyboards are never

going to be practical for long emails or anything else that requires a lot of input. A real keyboard is the only solution. But how do you actually do it? Do you put the Mira on the

OTHER WIRELESS MONITORS

Mira is unique. There's nothing exactly like it on the market today. However, there are several other wireless monitor products that share some degree of commonality with Mira. These include the AirSpeak Flair, the Xtend from DOT Design Technologies, the Panasonic Toughbook 07 and the Sony Airboard. (See Table 4 for URLs.)

AirSpeak Flair

The Flair is a wireless monitor aimed at the enterprise market rather than the home market. It was initially designed to wirelessly connect to a "corridor cruiser's" desktop PC and provide remote mobile access to the desktop. The Flair is similar to the Mira in that it's a Windows CE device with integrated WiFi (802.11b) wireless, except that the protocol used between the Flair and a desktop PC is proprietary. The Flair is a more open platform than the Mira, since it can also be configured as a wireless thin client or a CE tablet. When the Flair is configured as a thin client, the protocol used between the Flair and a server can be either Microsoft's RDP or Citrix's ICA. When it's configured as a CE tablet, the Flair can support wide-area wireless (CDPD or GSM) as well as WiFi. AirSpeak's primary target markets for the CE tablet version of the Flair are health-care, manufacturing and retail. List price of the Flair is \$1,895 for the wireless monitor or CE tablet version and \$1,695 for the thin client version.



DOT Design Technologies Xtend

The Xtend is closest of the four products in concept to the Mira. Created by a tiny startup in San Mateo, CA, the Xtend is like an enhanced Mira running Linux instead of Windows CE. According to Todd Shafer, President and Founder of DOT Design Technologies, the product is presently in the "virtual prototype" phase of development. DOT's philosophy strongly emphasizes the long-term benefits of an open design based on Linux.



DOT also clearly understands that a device such as the Xtend is "primarily for read-only activities." There are two main areas where the design of the Xtend differs from Microsoft's concept of Mira: RDP and standalone applications. First, instead of Microsoft's RDP, the Xtend uses a proprietary protocol between the wireless monitor and the PC. Second, the Xtend includes a full web browser, an email client and accessory applications such as a universal remote control for audio-visual equipment, a calculator and a notepad. DOT's street price target for the Xtend is \$699.

coffee table and the keyboard on your lap? The screen's hard to read at that distance. Do you put them both in some sort of "portfolio" case and balance the case on your lap? It's clumsy and awkward. With a Mira main monitor, it's impossible because it is too big. The reality is that if you need to use a keyboard, you're going to put the Mira (in a stand or dock) and the keyboard on a table or desk. At least it doesn't have to be in the same room as the PC.

The OOB Challenge

The ultimate target market for Mira is any consumer with a PC. The out-of-box-experience (OOBE, what the consumer sees and does when they first open the Mira box) is therefore very important. Microsoft is going to significant lengths to make the OOB as easy as possible, but it's a challenge. Consider the

case of the consumer who has a PC running Windows XP Home but knows little about it (they just use it). The PC must have an internal or external wireless Access Point installed and configured, and XP Home must be upgraded to XP Pro (more on this later). There may be wireless dead spots in the home due to plaster walls or other problems. In the worst case, the consumer may have decided to upgrade to broadband at the same time, so the broadband configuration may also be added to the mix.

To help minimize this complexity, Microsoft is working with the Mira OEMs to ensure they develop appropriate bundles – for example, a PC and Mira already fully configured. Microsoft is also in discussions with retailers and other organizations about wireless installation services, though they aren't



above: Sony Airboard

Panasonic Toughbook 07

The Toughbook 07 was reviewed in the April/May issue of *Pen Computing* (issue #44, page 40). Like the rest of the Toughbook family of



products, it's aimed at enterprise and government markets, not the home. Typical applications for the Toughbook 07 include law enforcement (e.g., bicycle policemen), aircraft maintenance and "line busting" (using a mobile POS terminal to shorten service lines). The

Toughbook 07 consists of a "brick-like" base module and a handheld wireless monitor incorporating an 8.4" SVGA transfective TFT. The use of a transfective LCD allows operation indoors or outdoors; the wireless monitor is rugged enough to survive repeated four-foot drops to concrete. The Toughbook 07 is a full PC and can run any version of Windows (98, NT-4, 2000 or XP). It uses a proprietary protocol over a standard WiFi (802.11b) link between the base module and the handheld wireless monitor. The Toughbook 07 is sold through VARs and in quantity to large end-users (there is no published price).

Sony Airboard

The Airboard is a wireless monitor that embodies the convergence of entertainment (TV and other audio-visual sources) and information (Internet access). As such, Sony puts the Airboard in a new

device category called the "IT TV" (information technology television). The Airboard consists of a 12.1" wireless monitor connected via WiFi (802.11b) to a base station (not a PC). The base station contains the following functionality:

- TV tuner for connection to CATV cable or an antenna
- Two video inputs for DVD, VCR, satellite tuner or other AV entertainment devices
- 56 Kbps modem for connection to a phone line
- Ethernet for connection to a cable or ADSL modem
- Router and WiFi (802.11b) access point supporting up to 15 PCs
- Print server supporting a USB printer accessible by the Airboard and the PCs
- Charging for the Airboard's rechargeable battery

The Airboard supports picture-in-picture, so you can be surfing the Internet or checking your email while simultaneously watching TV or a DVD movie in one corner of the screen. The print server allows printing images from the TV, not just the Internet. Unlike Mira V1, the Airboard can be used standalone, for example, in public WiFi hotspots. The Airboard also includes offline email, drawing and photo-display applications. Like Mira V1, only one Airboard can be used at a time, but since the Airboard isn't replacing the monitor on a PC, it's less of an issue. Since the base station contains a router and WiFi access point, the Airboard's broadband connection can be shared by up to 15 PCs.

The Airboard is currently sold only in Japan. Satoru Maeda, creator of the Airboard and head of Sony's Personal IT division, told the author that introduction in the US was being considered but that it required careful, detailed planning in light of the US economy and Sony's recent experience with the eVilla (Sony's Internet Appliance that was pulled from the US market after only two months of sales). The street price of the Airboard in Japan is 130,000 yen (around \$1,000). ♦

ready to talk about any details yet. Intel, who sells WiFi (802.11b) hardware to OEMs building Miras, is also sensitive to the problem. "We're trying to figure out easy mechanisms for setup and connectivity for the wireless system. We want to make it so my mom can use it" (Mike Iannitti, Director of Extended Computer Operations at Intel, in a story in *EE Times*).

User Interface

When you sign on to a Mira, the process is almost the same as signing on to XP. The fact that you're doing it over a wireless link is almost transparent. Figure 1 shows a screenimage of a prototype Mira logon screen. Looks a lot like XP, doesn't it? One Mira can connect (sequentially) to multiple PCs, thus the "Connect to:" field in the upper left corner. The Battery and Connection indicators are self-explanatory, but the Application buttons need some explanation.

Mira is actually a full Windows CE-based computer. It could run Pocket Office or other CE applications. However, Microsoft is discouraging the Mira OEMs from including any standard Windows CE applications in the Mira ROM. Only very simple, consumer-oriented applications such as "TV remote control" or "electronic picture frame" (software that displays photos from external storage cards) are recommended. The user starts these applications

via two dedicated Application buttons – note that there's no other way to start local applications. Microsoft's reason for this limitation seems to be to ensure that the product positioning is crystal clear – it's a remote monitor, and you're running applications on your PC. Period. As soon as you add meaningful local applications and data, then you've introduced a sense of "state," where the user has to think about whether they're working locally or remotely. Microsoft believes that for Mira's ultimate target audience, simplicity is critical.

Not everyone agrees. Probably the most vocal disagreement comes from *The Register*, a UK-based, on-line publication whose slogan is "Biting the hand that feeds IT." Their story, entitled "Microsoft's Mira – take smart display, maim, serve" is worth reading. Visit <http://www.theregister.co.uk/content/archive/24463.html>.

Comparison with Other Devices

Microsoft has put an unusual amount of effort into carefully delineating the differences between Mira and other related products. To some extent, this seems to be driven by Microsoft's Tablet PC project; there is concern about potential confusion between Mira and Tablet PCs. The differentiation was clearly drawn in technical terms in the WinHEC sessions,

but for the keynote-level speeches, Microsoft boiled it down to "Mira is like a cordless phone (you can only use it in the house), while the Tablet PC is like a cellphone (you can use it anywhere)." Paul Thurrott commented on this in his *WinIn-fo Daily Update* (www.winnet-mag.net) on April 19, saying "One problem with introducing new technology to the masses is that you have to dumb it down for the attention-deficit-disorder crowd. Microsoft's recent attempts to differentiate its Mira remote-display technology from the Tablet PC are groan-inducing. Seriously, did anyone actually confuse these products?" Table 1 presents this author's version of a product type-comparison. See the sidebar on "Other Wireless Monitors" for information on related products.

One might ask, is Mira an "information appliance?" Microsoft's answer is a definite no. The Microsoft Mira team is careful never to use the dreaded "IA" word. Information appliances were a hot future product in 1999 and 2000, but they basically died a quiet death in 2001. The IA word is now associated with failure, and Microsoft wants no part of it.

Why Not Another PC?

The main competition for Mira is another PC. After all, if you want to use a PC in the living room, and you want to use a keyboard, why not just buy a laptop? The

answer is cost and complexity. A Mira monitor should be substantially lower cost than a decent laptop, and ideally even lower cost than a low-end PC (more on cost later). Complexity is even more significant. It can be difficult, expensive and time-consuming to keep multiple PCs at the same level in terms of application versions, anti-virus files, favorites, user interface tweaks, downloads, data file synchronization, etc. Setting up a full-scale home network to deal with this just raises the complexity level even further. If the objective is to give your teenager their own PC in their bedroom, and they're going to manage it themselves, then a second PC makes sense. But if the objective is to extend your own use of the PC to other rooms in the house, then a Mira is worth consideration. One final aspect is the "quiet, cool, instant-on" nature of a Mira. It's substantially more comfortable and convenient to use than a laptop (assuming that a high volume of keyboard input isn't required, of course).

Media Reaction

Most of the stories about Mira in the computer trade press have been factual, with relatively few dissenting opinions. This is probably because Mira is a new concept in the consumer space, compared to the Tablet PC. The latter carries a lot of baggage from the last 12 years

TABLE 5: OTHER WIRELESS MONITORS

Spec	DOT Design Techn. Xtend	Panasonic Toughbook 07	AirSpeak Flair	Sony Airboard
Product Concept	Enhanced Mira running Linux	2-piece rugged PC w/ wireless display	Wireless monitor, thin client or CE tablet	Convergence of TV and Internet access
Market	Home	Enterprise & government	Enterprise	Home
LCD	10.4" XGA	8.4" Transflective SVGA	12.1" XGA	12.1" SVGA
CPU	Geode	Pentium III @ 300 MHz	StrongARM	MIPS @ 200 MHz
Operating System	Linux	Windows 98, NT-4, 2000, XP	Windows CE 3.0	VXWorks (Wind River)
Storage Slots	1-CF	None (5 GB hard disk)	2-PC	1-Memory Stick
Size (in.)	9.5 x 9.5 x 1.5	8.7 x 6.4 x 1.2 (LCD) 7.9 x 3.6 x 2.1 (PC)	11.7 x 9.4 x 1.2	14.5 x 9.5 x 2.1
Weight (lbs.)	4.5	1.5 (LCD); 2.1 (PC)	3.3	4.6
Battery (hrs.)	3-5	2	6	2-3

that tends to evoke strong opinions. The majority of the published opinion on Mira so far has been positive. An example of both sides is as follows:

"Mira is a big deal," said Martin Reynolds from Gartner Dataquest. "It's compelling because you have the applications running on the computer itself. There's no need for very fast processors on the Mira pad; that will just burn the battery."

"Microsoft thinks you'll carry around an LCD panel as a remote-access device for your home PC. Maybe as a drink tray..." (Stephen Howard-Sarin, writing for *ZDNet's AnchorDesk*).

Reality Check

Whenever Microsoft comes up with a new product concept, the world has learned to ask, "Is it real? Is it going to stick, or is it just another half-baked idea?" Not everything Microsoft tries is successful. For example, take the Auto PC. Have you heard anything significant about it since 1999? On a "realness scale" of 1-10, the author puts Mira at about 6-7. In comparison, the Tablet PC is at about 9. One way of gauging this factor is to look at the number of people on the respective project teams at Microsoft. The Tablet PC team has around 200 people; the Mira team has around 20. However, that's actually a little misleading. Tablet PC requires creating a separate version of Windows, along with many capabilities for creating, managing, manipulating and storing digital ink. That takes substantial engineering resources. Mira, on the other hand, is simply a repurposing and tweaking of existing technologies. Also, assessing Microsoft products requires taking a multi-year view, acknowledging their incremental step-by-step approach, and the fact that Microsoft doesn't care what hardware form-factor wins.

TABLE 2: Microsoft's Mira Partners as of May 2002

Companies Building Mira Monitors

Company	Type and Location	Comments
AboCom	ODM (Taiwan)	Makes 10.4" webpads for three OEMs (top provider)
DT Research	OEM/ODM (Taiwan)	Showed 8.4" Mira prototype at CeBIT Sells webpads/thin clients under own WebDT brand Builds ODM webpads and thin clients Providing hardware for Microsoft's Mira beta test
Fujitsu	OEM (Japan)	Builds lots of pen tablets No webpads, but is developing a Tablet PC
LG Electronics	OEM/ODM (Korea)	Announced they will build 15" Mira as an OEM Considering building 10.4" or larger remote Mira Announced a webpad in 2001 but never completed it ODM for one of the Tablet PC OEMs
NEC	OEM (Japan)	Partnered w/ Tatung on a webpad for Japanese market Developing a Tablet PC
Philips	OEM (Netherlands)	Showed 10.4" Mira prototype at CeBIT Showed 15" Mira ID model at WinHEC, no webpads
Tatung	ODM (Taiwan)	Showed 10.4" Mira prototype at CeBIT and WinHEC Builds ODM webpads, is developing a Tablet PC
Toshiba	OEM (Japan)	No webpads, is developing a Tablet PC
TriGem	ODM (Korea)	Showed 8.4" Mira prototype at WinHEC Considering building a larger Mira Has a joint venture with SOTEC in Japan
ViewSonic	OEM (USA)	Showed 15" Mira prototype at CES Sells 10.4" pre-Mira wireless monitor (AirPanel 100) Sells webpads and pen tablets Developing a Tablet PC Providing hardware for Microsoft's Mira beta test
Wistron	ODM (Taiwan)	No webpads, is developing a Tablet PC
Wyse Technology	OEM (USA)	Showed 15" Mira non-mobile prototype at CeBIT Will also build 10.4" Mira and "remote terminal" Mira No webpads, but resold Zenith CruisePad in late 90's

Companies Building Mira-Enabled PCs

Fujitsu	OEM (Japan)	See above
NEC	OEM (Japan)	See above
Panasonic	OEM (Japan)	No webpads Focused mostly on Japanese market
SOTEC	OEM (Japan)	No webpads Focused exclusively on Japanese market

Technology Companies

Intel	IHV (USA)	Providing XScale CPUs
National Semi.	IHV (USA)	Providing Geode CPUs

Key Technologies

Mira V1 is a classic Microsoft product. It's a set of existing technologies, nicely packaged, well-positioned with strong marketing spin, and defined as a platform on which OEMs, IHVs and ISVs can develop products.

The key technologies in Mira include the following:

- Existing webpad hardware designs
- Windows XP
- Microsoft Windows CE .Net
- WiFi (802.11b) wireless LAN
- Microsoft Terminal Services

Are you surprised to see "webpad hardware designs" listed as one of the key technologies? Webpads and wireless monitors are both "embedded devices." They both need a CPU and an embedded OS to drive an LCD, manage a wire-

MICROSOFT'S CONNECTED HOME



Microsoft's all-encompassing vision of the Connected Home includes entertainment devices, computing devices and communications devices, all connected together via an IP-capable home network that's also bridged to a control network supporting home automation devices. The basic objectives of the Connected Home include the following:

- Make all audio-visual content available anywhere inside and outside the home
- Display relevant information on all content in a consistent manner on all devices
- Make all devices in the home function together as a uniform, automated system
- Make all device user experiences available anywhere inside or outside the home
- Allow trusted suppliers to provide reliable services through the devices in the home

In addition to all of the varieties of Miras described in the main article, the Connected Home includes many other kinds of devices all networked together, as follows (with translations of the Microsoft jargon):

- Standard PCs
- A "network edge device" (a PC or set-top box directly connected to the Internet)
- A "residential gateway" (services on a PC providing DHCP, NAT and a firewall)
- A "media center PC" (a stereo component-like PC that's a focal point for digital media creation, storage, management,

- consumption and streaming)
- A "Freestyle distance user interface" (a PC remote control with an appropriate on-screen interface for use ten feet away)
- An "audio-visual node" (a device that renders streamed audio and video content)
- A "digital audio receiver" (a device that renders streamed audio content)
- Self-amplified, digital speakers containing their own audio codecs
- All existing audio-visual equipment (TV, VCR, DVD, PVR, DSS, etc.)
- Home automation controls and devices connected to a dedicated control network (X10, EIB, Lonworks, Cebus, Jini, etc.)

Some Questions

During one of the WinHEC sessions on the Connected Home, Microsoft showed a short video in which a woman puts a DVD movie into a player. Because everything is networked together, that simple action caused (a) the room lights to be dimmed, (b) the electric blinds to be lowered, (c) the HDTV to turn on, and (d) the DVD to start playing. The audience reaction seemed to be mostly skepticism.

The first question many people have about the Connected Home is "Why would I want computers to do all that?" In one of the WinHEC sessions, Scott Manchester, a Technical Evangelist for the Connected Home, spent a full hour presenting a detailed overview of the Connected Home without even

once offering a single reason why the consumer would want it. The underlying assumption seemed to be "Because it can be controlled by a PC, it should be." It's simply not obvious that it makes sense to use a PC to control room lights, room temperature, electric blinds, etc. Using a complex network to pipe music around the house (albeit, different music in different rooms) seems to be technical overkill. Having all the media content resident on the PC could be interesting, but people want to consume media, not spend time managing it. A PVR works perfectly well alone, what real advantage is there in having the PC control it? These kinds of questions were not addressed in any convincing way.

The second question many people have about the Connected Home is "Is there any chance of it all working correctly?" While everything Microsoft described is technically possible, today's PC is simply not stable and reliable enough to control the entire house. Recognizing this, Microsoft has started working on making the PC "more reliable and trustworthy." In fact, Microsoft has set a goal of making the PC "as reliable as a CD player" (instant on, never reboots, no reset button, quiet, simple to use, etc.) – but it's likely to be a long, slow trip. ♦

Edwards, Director of Marketing for Microsoft's Embedded Appearance and Platform Group (EAPG), Microsoft is "working hard to ensure that consumers will have as few hurdles (both technical and financial) as possible for Mira V1."

Windows CE .Net (4.0) is the obvious choice for Mira's embedded OS, since Windows XP Embedded would be overkill for a product as simple as a wireless monitor. A Mira-type product could certainly be built with Linux as the embedded OS, but then it wouldn't be a Microsoft product, would it? (See the sidebar on "Other Wireless Monitors" for an example.)

WiFi (802.11b) wireless is also the obvious choice for the physical communications between Mira's mobile display and the host PC. In Mira V1, the 11 Mbps speed of "b" is plenty fast enough. Intel says they will migrate to a dual 802.11a/b combination next year as wireless hardware costs come down.

Microsoft Terminal Services (often referred to by the name of the protocol it uses, Remote Desktop Protocol, or RDP) is the final obvious choice of technology. Terminal Services provides the "logical" (versus "physical") communications between Mira's mobile display and the host PC. Terminal Services can deliver the Windows XP desktop to almost any client device that has a screen and an input method (keyboard, pen or mouse) – such as Mira.

less link, send and receive data from various ports, accept input from a touch screen, etc. It turns out that today's keypad hardware designs are an ideal starting point for Mira.

Windows XP is obviously a

key technology. Mira V1 monitors will be supported only on XP Pro, because the underlying technology that allows a remote session (Remote Desktop) is only in XP Pro, not XP Home. In addition, XP Service Pack 1

must also be installed, because it includes all the Mira-specific PC technology. In the long term, clearly the Mira technology must be included in XP Home in order to serve the target market. In the short term, according to Aubrey

Terminal Services: the Key to Mira

Terminal Services was originally created in 1997 as a component of the NT-4 Server OS. It has matured substantially since then. Windows XP Pro now uses it to provide remote troubleshooting capability, where one PC can view and control the screen of another PC. You can even use Terminal Services on a Pocket PC 2002 device to log on to a remote PC and display a Windows 2000 or XP desktop on the Pocket PC screen. In the enterprise, products that use Terminal Services are typically referred to as "thin clients" (see the sidebar on "Thin Clients" for more information).

When a user runs an application using Terminal Server, only the keyboard, pen, mouse and display information are transmitted over the wireless link between the "terminal" (Mira, in this case) and the host PC. This communication is quite efficient, since only the pixels that have changed (screen updates) are transmitted, not entire screen images. Since Terminal Services was originally designed to work acceptably over 28.8 Kbps modem links, running it over WiFi (802.11b) wireless at 11 Mbps provides more than enough speed.

RDP has been tweaked slightly for use in Mira. The improvements include improved connection management (e.g., to allow losing the wireless signal

STRONGARM SUCCESSOR: INTEL XSCALE

XScale is Intel's name for a successor to the StrongARM microprocessor. The "scale" in XScale refers to the CPU's ability to dynamically change both frequency and voltage to minimize power consumption. The "PXA250" is the Intel XScale CPU that will appear in some Mira products. In Run mode at 300 MHz, the PXA250 draws about 400 mW of power. In comparison, the StrongARM SA-1110 (used in most of today's Windows CE devices) in Run mode at 206 MHz draws 800 mW. This majority of this improvement comes from a change in process from 0.35 microns to 0.18 microns; the balance comes from architecture improvements.

The core of the XScale CPU incorporates a new version of ARM architecture that is 100% compatible with existing application software. ARM (Advanced RISC Machines, www.arm.com) is a company in Cambridge, England that designs microprocessor cores and licenses them to over 70 semiconductor companies (including Intel). ARM's designs are found in about 75% of all 32-bit RISC microprocessors. ARM's next version (after the one currently used in the XScale) will boost initial clock speeds into the range of 350-500 MHz, compared with 200-400 MHz for the PXA250. ♦

for a fraction of a second without dropping the connection to the PC), simplification of automatic reconnection (e.g., when you walk into and out of an area without wireless coverage in your house), and improved audio and video performance.

Only One Mira

In a server environment, each Terminal Services user sees only their individual session, independent of any other client session. Literally hundreds of sessions can exist simultaneously. The server operating system transparently manages the multiple user sessions. In the current Windows XP environment, Terminal Services is single-user. This means that

only one Mira can be used at a time. This is one of the two most significant limitations of Mira V1. If your Mira is the main display, when you undock it and go to another room in the house, you're still the only user. If your Mira is a mobile monitor, the main monitor is locked out whenever you use the mobile monitor (this is similar to the way Remote Desktop works today in Windows XP Pro). There can only be one user on a PC today, so only one Mira can be used at a time.

Microsoft speaks with different voices about this limitation. Aubrey Edwards said that Microsoft's research clearly indicated that mobility is more important than concurrency

(allowing multiple simultaneous users). On the other hand, in the question-and-answer session after one of his speeches at CeBIT, Steve Ballmer, President and CEO of Microsoft, said, "The [Mira] concept doesn't make sense [without concurrency], so that will be a version 2 feature."

Rick Merritt, writing about WinHEC in *EE Times*, reported that "a senior engineer with one OEM said his company would not make Mira-enabled devices because in their first iteration a user cannot access a home PC and the Mira display at the same time."

Another dissenter, Jack Schofield, writing in *The Guardian*, chimed in with "[You] can't use a remote Mira tablet while another member of the family is hogging the desktop PC... You would be better off buying a cheap notebook PC instead [of a Mira]."

Full-Motion Video

The second most significant limitation of Mira V1 is that Terminal Services (RDP) can't handle full-motion video (or anything that requires fast refresh). This means you can't sit on the couch in the living room with your Mira main monitor on the coffee table and watch a DVD movie playing on the PC in the den. (The legal issue of whether you can transmit the contents of a DVD movie to a remote device is an entirely separate issue.) RDP also can't

TABLE 3: MIRA PRODUCT SPECIFICATIONS

Spec	DT Research	Philips	Philips	Tatung	TriGem	ViewSonic	ViewSonic	Wyse Technology
Base Product	WebDT 380	(New)	(New)	TWN-5213-CU	CE Tablet	AirPanel 100	(New)	3630LE
LCD	8.4" SVGA	10.4" SVGA	15" XGA	10.4" SVGA	8.4" SVGA	10.4" SVGA	15" XGA	15" XGA
Size (in.)	7.9 x 9.6 x 1.1	1.0 thick	ND	ND	0.67 thick	13.8 x 8 x 0.9	ND	14.8 x 15.4 x 7.7
Weight (lbs.)	2.3	ND	ND	3.2	1.4	2.5	7 proto, 5 target	12.5
CPU	Geode	XScale	XScale	Geode	XScale	StrongARM	XScale	Geode
Storage Slots	1-CF	1-SD	ND	1-CF	1-PC	1-PC & 1-CF	ND	None
Battery (hrs.)	2-4	5	ND	2-4	4	5	ND	(AC powered)

handle any software that requires Direct-X, which means that you can't run 3D games of any kind (even relatively tame 3D simulation games such as The Sims or Monopoly Tycoon). RDP's bandwidth is sufficient for typical small-window streaming video from the Web (at 200 Kbps), but that's about it.

Microsoft minimizes the importance of this limitation. Microsoft's position regarding DVDs is that most families that watch DVDs already have a good viewing setup, usually a big TV in the family room. Microsoft's position regarding gaming is that most people playing 3D games do so either at a desk (with joysticks or other game controllers, 5.1 surround speakers, etc.), or they use a gaming console such as the X-Box.

Hardware

As noted earlier, the Mira V1 hardware design is basically the same as a webpad. Figure 2 shows the block diagram of a generic Mira.

CPU The two primary CPU providers for Mira are Intel and National. Mira is shaping up as a battleground for these two vendors. Intel has announced four Mira design wins for their new XScale CPU (AboCom, Philips, Tatung and ViewSonic), while National has announced three Mira design wins for their Geode CPU (DT Research, Tatung and Wyse). Tatung is doing two designs, that's why they're on both lists. At this point it's impossible to predict which CPU will end up in the majority of Mira designs. (See the sidebar on "Intel XScale" for more information on this new CPU.)

LCD As noted elsewhere in this article, Mira V1 LCDs are mostly 8.4" & 10.4" SVGA, and 15" XGA. PC resolution is moving rapidly to XGA, helped along by laptops

TABLE 4. MIRA-RELATED LINKS AND RESOURCES

AboCom Systems	www.abocom.com.tw/ma1000.htm
AirSpeak	www.airspeak.com/flair_frame.html
DOT Design Tech.	www.dotdesigntech.com
Fujitsu	www.fujitsu.com
Intel	developer.intel.com/design/pca/prodbref/298620.htm
LG Electronics	www.lge.com
Microsoft	www.microsoft.com/windowsxp/mira
National Semi	www.national.com/pf/SC/SC3200.html
NEC	www.necus.com
Panasonic	www.panasonic.com/computer/notebook/html/01a07.htm
Philips CE	www.press.ce.philips.com/cebit2002/connect.html
Sony	www.sony.jp/airboard/indexpc.html
	www.sony-asia.com.sg/news/2001/dec12acnews.html
SOTEC	www.sotec.co.jp/index.html
Tatung	www.tatungwebpad.com
Toshiba	www.toshiba.com
TriGem	www.trigem.com/trigem/front/2002/index.asp
ViewSonic	www.viewsonic.com/products/airpanel100.htm
Wistron	www.wistron.com/index.html
Wyse Technology	www.wyse.com/products/winterm/3630le/index.htm
	www.wyse.com/products/winterm/3200le/index.htm

and LCD monitors, so Mira probably won't stay at SVGA very long. 12.1" XGA may be an interesting LCD size for a Mira. Some OEMs may consider using transfective TFT for improved outdoor viewability. Since fewer than 10% of monitors today can physically rotate to portrait mode, screen rotation in Mira is not a major issue – although it may be a good differentiator for an OEM.

Digitizer Most, if not all, of the initial Miras will use resistive (touch) digitizers. Microsoft's thinking on this is that since the Mira is not meant for heavy data input or extensive use of digital ink, the performance of a resistive digitizer is adequate. Actually, if a significant portion of the Mira's use is for web browsing, then an active digitizer (which has hover and a right-click button on the pen) makes more sense. Recognizing this, but unwilling to force the Mira OEMs to incur the cost premium for an active digitizer, Microsoft has implemented both "hover" mode and "right click" mode in the Mira input panel. This works, but having three

modes for the digitizer is not very user-friendly.

Video Controller The video controller shown in the block diagram is optional, depending on the CPU selected, the resolution of the LCD, and the desired video performance. It's one of those classic cost/performance/battery-life tradeoffs. The bottom portion of the block diagram shows the dock (base) for a Mira main monitor. It provides standard VGA and DVI inputs, which, after appropriate video processing, are "passed through" to the Mira's LCD. Note that the dock also includes USB ports, which makes sense for both Mira main monitors and mobile monitors (keyboard and mouse connections for the latter). The USB port can also be used to upgrade the Mira software from the PC.

Storage External storage (typically a compact flash slot) on a Mira is not required, but is likely to appear in most products since the incremental hardware cost is very low. If you think of the Mira V1 as just being a

screen and an input device, you realize that memory of any kind (internal or external) is almost irrelevant. The user really doesn't care how much memory there is in a Mira because local storage typically won't be used. The user is connected to his PC, so storage is the PC's RAM and disk. The primary reason for Mira's external storage capability is standalone use as an "electronic picture frame."

Battery Achieving sufficient battery life while maintaining light weight may be a challenge for Mira developers. Most webpads today have battery life of around 3 hours, and that's typically with the brightness at medium, the CPU idling most of the time while you're reading web pages, and a light duty cycle on the wireless. Constantly running Terminal Services to reproduce the frequently changing screen of a PC, along with a higher duty cycle on the wireless, is likely to use more power. Screen brightness may be even more of a problem, since the backlight is the largest consumer of power in the Mira. A typical desktop LCD monitor has

a brightness of around 250 nits, a typical laptop is 150 nits, and webpads are typically 100 nits or less. It remains to be seen what combination of brightness and battery life the market will accept in a Mira device.

What Will Mira Cost?

Keith White, Senior Director of Marketing and Business Development in Microsoft's Embedded Appliance and Platform Group, has been widely quoted in the press as saying that Miras will cost in the range of \$500 to \$800.

The chart below shows a simplified breakdown of an estimated hardware bill of materials (BOM) cost for a typical Mira mobile monitor.

Component	Cost
10.4" SVGA LCD	\$140
Geode motherboard	\$70
WiFi (802.11b) wireless	\$45
3-cell Li-ion battery	\$20
32 MB flash memory	\$20
64 MB SDRAM memory	\$15
Resistive digitizer panel	\$10
Housing	\$10
Total	\$330

Starting with the \$330 total from the chart and adding 10% for the ODM's profit margin, then multiplying by 1.5 to account for the OEM's total distribution cost and margin produces a forecasted minimum street price of \$545 for a Mira mobile monitor. This must be somewhat close to reality, since more than one of Microsoft's Mira partners told the author that achieving a \$499 street price for a 10.4" mobile monitor will be a difficult challenge.

In a story published in *EE Times*, Mike Iannitti from Intel said that he expects the Mira hardware to add no more than \$200 or \$300 to the price of a regular LCD monitor.

Using the data from the chart above but eliminating the LCD

and the housing (which are already accounted for in an LCD monitor) yields a cost adder of \$180. Applying the same calculation as above for the mobile monitor produces a forecasted minimum adder of \$297 for a main monitor, right at the upper limit of Mike Iannitti's \$200 - \$300 range. The average street price of a name-brand 15" LCD monitor as of May 2002 is around \$400. Adding the \$297 Mira hardware to the \$400 monitor produces a forecasted minimum street price of around \$700 for a 15" Mira main monitor, within Keith White's \$500 - \$800 range.

What price point would cause the Mira mobile monitors to fly off the shelf? Probably \$299. This seems to be a magic price point for consumer electronics in general. Microsoft seems to agree. In a video interview on CNET News.com, Keith White said "The [Mira mobile monitor] price points have to come down to a very reasonable \$200 to \$500 range [instead of \$500 to \$800] before they'll really be

widely accepted."

What would the installed cost of a Mira mobile monitor be? It depends on the buyer's starting point. If the user already has a WiFi (802.11b) wireless network in the house and is already running XP Professional, then the installed cost would be only \$500. According to Aubrey Edwards, the initial target market for Mira V1 is "early adopters and technical enthusiasts," so this is the most probable scenario. Forecasting the installed cost for a user without wireless and with XP Home isn't possible yet, since as noted above, Microsoft hasn't decided how they're going to minimize the upgrade cost from XP Home to XP Professional.

Adding broadband Internet access (about \$50 per month with a rented cable modem) is not required for a Mira, but it would make the user experience a lot better when browsing the web on the couch.

Mira Partners

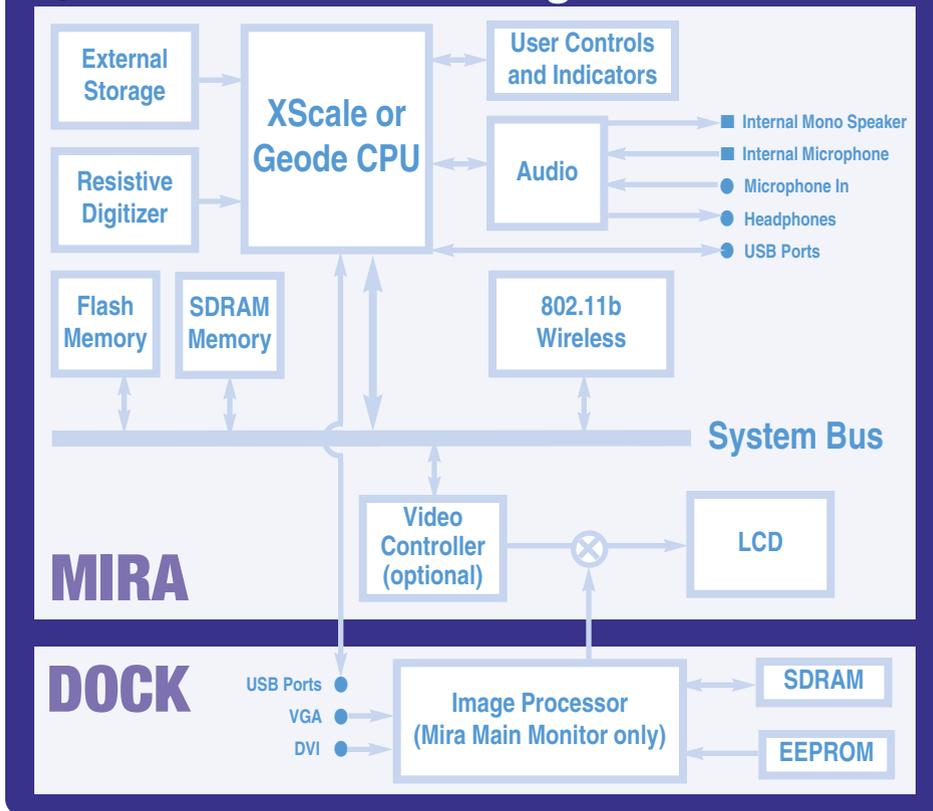
As usual, Microsoft has assem-

bled a group of companies who have agreed to kick-start the Mira program. Table 2 lists all the players, along with their business model (OEM/ODM), location and the author's comments. It's interesting to note that of the companies who have announced they're developing Mira monitors, 58% of them are also developing Tablet PCs, 42% of them build or sell webpads, and 25% of them do both webpads and Tablet PCs. It's also interesting to note the total absence of all of the Tier-1 PC OEMs: Compaq, Dell, Gateway, HP and IBM. Actually, it's not surprising. Mira is, after all, a form of pen tablet computer, and you know how most of the Tier-1 OEMs feel about pen tablets!

Mira Prototypes

As of May 2002, eight Mira prototypes or mockups have been shown in various public forums. See Table 3 for summary specifications on these prototypes. Some of the specs are shown as "ND" (not disclosed)

Figure 2: **MIRA** Block diagram



THIN CLIENTS

Technically, Mira is a “thin client” in Information Technology (IT) terms. According to National Semiconductor, whose Geode processor has more than 85% of the thin client market, a thin client is “a desktop device with nominal on-board computing power optimized for information access from a central server.” Windows CE .Net running on a Geode or Xscale processor provides “nominal on-board computing power” compared to the Pentium 4 in a full PC (“fat client”). Remote Desktop Protocol (see the main article for more information) is what makes Mira “optimized for information access from a central server.” In the case of Mira V1, it’s a single-user server (the home PC). You won’t ever see Mira referred to as a “thin client” by Microsoft, however, since it’s an overly technical term that’s incompatible with a friendly, home-oriented marketing pitch.

Thin clients are used in enterprise because they reduce the Total Cost of Ownership (TCO) of a computing

solution. Thin client hardware is typically more than twice as reliable as a PC. With applications and data resident on a central sever, the per-user cost of management, support, downtime, backups and upgrades is reduced substantially. New versions of software are distributed to all thin clients simultaneously, which improves data exchange and collaboration. Thin clients don’t need hard drives, CPU upgrades, or large amounts of memory, which makes them cheaper than a PC. Since there’s no hard drive, data can’t be lost due to hard drive failure. Thin client systems can grow by adding CPU power, memory and storage to the central server rather than upgrading every PC in the company. Thin clients are inherently more secure than PCs, since there’s no removable storage.

The downside is that thin clients demand more (or more powerful) servers, and they tend to generate more network traffic. Knowledge professionals aren’t good prospects for



A number of Geode-based products

thin clients due to the wide range of software and processor-intensive applications they often need. Thin clients are especially appropriate in environments where there is heavy use of template applications, such as in the completion and processing of forms. The top six markets for thin clients are healthcare, financial services, retail point-of-sale, education (K-12), transportation and government agencies. The next time you’re in a retail chain store such as Mattress Discounters, check out the “PC-like” device on which the salesperson is entering your sale. Chances are it’s a thin client, probably one made by Wyse Technology, since they have more than 50% of the thin client market. ♦

first shown at CeBIT, is based on the existing Tatung TWN-5213-CU webpad. The really unique aspects of this webpad are that it can withstand at least a 5-foot drop onto carpeted concrete, and it’s splash proof. Tatung demonstrated the shock resistance several times during WinHEC by dropping it from shoulder height onto carpeted concrete (the typical trade show aisle). Tatung’s mobile Mira should be very attractive to consumers who want to use it in the kitchen or other PC-hostile locations.

TriGem This 8.4” prototype, first shown at WinHEC, is the result of new development. It’s a stunner in terms of size and weight. It’s incredibly thin – only 0.67 inches, and at only 1.4 pounds, holding it is effortless. TriGem is a Korean ODM in a joint venture with SOTEC, a Japanese computer OEM. As a result, the prototype was labeled with the SOTEC brand. SOTEC, on the other hand, has been identified by Microsoft as only building “Mira-enabled PCs” (a Windows XP Pro PC with integrated WiFi wireless), not Mira monitors, so it’s un-

because it’s a little too early for some of the OEMs (and Microsoft) to have all the details nailed down.

DT Research This 8.4” prototype, first shown at CeBIT, is based on the existing DT Research WebDT 380 webpad. DT Research has been building webpads and thin clients for

several years, and they have a broad range of products in this category. Developing one or more Miras is a natural and obvious direction for them.

Philips Philips has shown two Mira prototypes, both of which appear to be based on new development. The first, a working 10.4” mobile monitor, was

shown at CeBIT. Multiple photos of this prototype are available on the Philips website (see Table 4 for the URL). The second, a 15” main monitor mock-up, was shown at WinHEC. It’s quite elegant in appearance, and quite thin. It would look great on the coffee table.

Tatung This 10.4” prototype,

ViewSonic Mira prototype



TriGem Fermata



Tatung prototype



Philips Mira prototype



clear who will finally brand this really cool product.

ViewSonic ViewSonic has shown two Mira-related products. The first, a prototype 15" main monitor, is the poster-child prototype. It was in the initial Mira announcement at CES, it appears in Microsoft's Mira concept video, and Bill Gates is holding it in the Mira publicity photos. The second product isn't a prototype, it's a real product. Called the AirPanel 100, it's a "pre-Mira" wireless monitor product based on ViewSonic's current webpad, the ViewPad 100. According to Marc McConaughy, ViewSonic's Senior Vice President of Advanced Technologies, the AirPanel 100 was developed to explore the concept and establish the legitimacy of the wireless monitor. It's a form of market development. ViewSonic is more aggressive and quicker-moving than many OEMs; quickly bringing a wireless monitor product to market for the knowledge to be gained from it is typical of their style.

Wyse Technology This 15" prototype, first shown at CeBIT, is based on the existing Wyse 3630LE Winterm (Windows-based terminal). Unlike any of the other prototypes, this one is non-mobile. It's in a form factor that hasn't been mentioned so far in this article – Microsoft calls it a "remote station."

Mira Version 2 (V2)

Mira V2 is targeted to include concurrency (multiple simultaneous users) and streaming AV (audio-visual) support. According to Aubrey Edwards, Microsoft's desire is to ship a new version of Mira every year in time for Christmas. However, Microsoft never commits to a V2 date until V1 is out the door, so it is unknown if the 2003 Mira will be V1.5 or V2. Some other

areas for possible Mira enhancements in V2 include the ability to use the product away from the home (e.g., at a public wireless hotspot), more support for standalone applications, enhanced audio input and improved administration.

Additional Form Factors

Concurrency may change the Mira usage picture substantially. In addition to enabling the use of multiple mobile monitors simultaneously anywhere in the house, it allows additional stationary Miras to be located (for example) in the kids' bedrooms. Concurrency changes the single-user home PC into a "residential server", without all the complexity of a true server operating system. (The licensing issue of whether multiple users can share a single copy of an application on the PC is an entirely separate issue.) Microsoft has already proposed two additional Mira form factors that could be argued only make sense with concurrency.

The first is called a "remote station." It's basically a 15" desktop LCD monitor with the Mira hardware integrated inside (without a touch screen). Wyse already makes a very similar product designed for use on wired networks, the Winterm 3630LE. Street price of this product as of May 2002 is around \$1,150. Jeff McNaught, Vice-President of Market Strategy at Wyse Technology, says that his target for the Mira version of this product is less than \$1,000.

The second proposed form factor is called a "remote terminal." This is simply the Mira hardware in a small box with no display and no battery. It's meant to be used with new or existing monitors and keyboards. Again Wyse Technology already makes a very similar product designed for use

on wired networks, the Winterm 3200LE. Street price of this product as of May 2002 is around \$350. Jeff McNaught says that his target for the Mira version of this product is less than \$300.

If you add the \$300 for the Mira version of the 3200LE to the current \$400 average street price of a name-brand 15" LCD monitor, and throw in \$50 for a good keyboard and mouse, the total is \$750. Why not buy a second PC for the same money? The answer's the same as above. It depends on what your goals are for home computing, and how much money, time and effort you want to spend managing multiple home computers.

Finally, going one step further, Microsoft proposes that Mira hardware could be embedded in a flat-screen TV or in a presentation projector. In both cases, the devices can be considered displays in a different form-factor. Adding Mira hardware turns them into wireless displays. This may be a case of technology looking for a problem to solve, but it's an interesting idea.

Audio-Visual Streaming

The second major enhancement in Mira V2 is audio-visual (AV) streaming. This is the ability to view full-motion video and listen to high-quality audio on the Mira, as well as play 3D games. AV streaming is a fundamental part of Microsoft's Connected Home vision (see the "Connected Home" sidebar for more information). Adding AV streaming to a Mira generally means adding an MPEG decoder chip (DSP), which adds cost.

Alternatively, instead of adding another chip, it's possible to include support for AV streaming in a new CPU. At WinHEC, ATI (one of the two top vendors of video controllers) announced a new, highly inte-

grated, low-cost "super CPU" called Xileon. It includes both a 300 MHz MIPS CPU (supported by Windows CE .Net) and a complete video processor that handles AV streaming (MPEG-2), Direct-X/3D graphics, dual display with picture-in-picture, TV output, etc. This super-CPU could be used as the core of a Mira V2 device, or of an "AV node" device.

Summary

Mira V1's primary advantage is mobility. It extends the use of a home PC to any room, while avoiding the hassles of managing multiple computers. For some home PC owners, this may be a substantial advantage. The primary challenge that Microsoft and the Mira OEMs face is the out-of-box-experience. Installing and configuring the WiFi wireless (and possibly a broadband connection) must be made foolproof and extremely simple. The two main limitations of Mira V1 are that only one Mira can be used at a time, and that it doesn't support full-motion video or 3D games. Microsoft intends to eliminate both of these limitations in Mira V2. Another significant limitation of Mira V1 is that it requires XP Professional on the PC; Microsoft is working on ways of reducing the cost impact of upgrading from XP Home. Mira will cost between \$500 and \$800, with mobile monitors (8.4" and 10.4") at the lower end and main monitors (15") at the upper end. Overall, Mira V1 is a good start on a multi-year development program. Unless the concept totally bombs in 2002, we can look forward to increasingly capable new Miras every Christmas. ♦

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