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MICROSOFT WEIGHS IN WITH X-BOX

Software Giant to Do Battle With Sony, Sega, and Nintendo

By Peter N. Glaskowsky {4/3/00-01}

Microsoft is entering the console-gaming ring once again, after losing two previous bouts, but it looks like the third time may be the charm. Microsoft has good reason to hope its new X-Box project will succeed where its previous efforts have failed. These efforts include the recent collaboration with Sega to offer a Windows CE–based development environment for Sega's Dreamcast console game and the mid-1980s MSX effort to develop a home-entertainment PC in cooperation with Japanese consumer-electronics companies.

This time, Microsoft is fighting from a position of strength, leveraging the power and flexibility of its Win32 and DirectX multimedia application programming interfaces (APIs). Combined with a new operating system derived from the Windows 2000 kernel, these APIs should create a software environment that is much more attractive to developers than the limited Dreamcast CE system.

The new hardware platform similarly leverages the development of PC processors and 3D-graphics chips to produce a machine that should greatly exceed the performance of competing consoles. Intel will provide a custom x86 processor running at more than 600MHz, while NVIDIA will chip in a graphics processor based on its NV25 core with integrated north-bridge functionality. The NV25 core is three generations beyond NVIDIA's current GeForce 256, aka NV10. Table 1 shows the basic hardware features of the X-Box, notable among which is an 8G hard disk. Previous console games have not included a hard disk for cost reasons, but Microsoft believes that the benefits of having a disk drive justify its inclusion in X-Box.

The X-Box is due to appear in the fall of 2001, but it won't be easy for Microsoft and its X-Box development partners to make this date. Microsoft has never created a new operating system so quickly, and the NV25 core will be much larger and more complex than anything NVIDIA has previously developed. Microsoft has already begun development, using PCs equipped with NVIDIA graphics chips, but complete X-Box development systems are needed by early 2001 to allow time for final software development and debugging prior to the release date.

How to Make a PC Easy to Use

Microsoft's current PC operating systems are incapable of matching the reliability and ease of use offered by gaming

	Microsoft X-Box	Sony Playstation 2
CPU	Custom Intel x86, 600+MHz	RISC/vector core, 300MHz
Graphics Processor	NVIDIA NV25 core, 300MHz	Sony proprietary, 150MHz
Total Memory	64M, 128-bit 200MHz DDR	32M, dual-channel RDRAM
Memory Bandwidth	6.4GB/s peak, 4GB/s* sust.	3.2GB/s peak, 3GB/s* sust
Polygon Rate (peak)	300M polygons/s	66M polygons/s
(practical)	150M polygons/s	33M polygons/s
Storage Devices	4x DVD-ROM, 8G hard disk	4x DVD-ROM
I/O	USB, 10/100 Ethernet	USB, IEEE1394, PC Card
Delivery Date	Fall 2001	Now

Table 1. The Microsoft X-Box will include most of the elements of a PC. It will be the first gaming console to ship with an internal hard-disk drive. Most features are significant improvements over those in Sony's PlayStation 2. (* MDR estimate)

consoles. Some of the shortcomings of Microsoft's operating systems (such as the complex Windows user interface) are the result of design decisions, while others are an inevitable consequence of the need to support a wide range of platforms and peripherals. Though the X-Box hardware platform is similar to that of a PC, it must be much easier to use.

To achieve this goal, Microsoft will create a new operating system for the X-Box that is substantially different from its previous offerings. Though Microsoft is starting with the kernel of its Windows 2000 operating system (instead of Windows CE or Windows 98), the result will be more than just another version of Windows 2000. The new OS will eliminate two elements found in all current PC operating systems—bootup and software installation.

The key to this change is running games from DVD-ROM rather than from the hard disk, just as competing consoles do. When a DVD containing an X-Box game is inserted, the system will be initialized from a memory image stored on the disc, and the game will begin executing immediately. The normal Windows boot procedure—loading the kernel, drivers, and dynamically linkable libraries (DLL) from multiple files spread over the hard disk—will no longer be needed, reducing the boot time from a few minutes to a few seconds.

DVD-based execution also eliminates the need to install games onto the hard disk before they can be run. Making each game self-sufficient precludes the software conflicts commonly encountered on PCs when a new application replaces old DLLs with new ones that should be, but are not, fully compatible with older applications on the hard disk.

Once running, the application may load some of its files onto a reserved area of the hard disk. For example, a driving game may load 3D models and texture maps for a selected race track onto the hard disk while the user selects a car to drive. This area of the hard disk acts as a cache for the DVD; its contents are not persistent from game to game.

Other areas of the hard disk may be reserved by programs to save the state of games in progress or to store software updates received over the Internet. The latter function may be used to patch bugs or add new information, much as PC games do today. A sports game based on real-world teams could be updated as players are traded or injured, for example. Trial versions of new games may also be downloaded to the hard disk.

The X-Box operating system will support multitasking, but only one application will run at a time. All X-Box games will run in kernel mode, giving them full access to every part of the system. Programmers will be able to manage hardware resources directly if they choose—or leave management tasks to the OS. While the new OS will include API-level support for a graphical user interface (GUI), it will be up to application developers to create one. The familiar Windows GUI will not be used on the X-Box.

Microsoft will support some nongaming applications. For example, the X-Box will be able to play DVD movies. Other possible applications include Web browsing, email, and related Internet functions. Microsoft says its support for nongaming applications depends on user demand, and there has been little demand to date for Internet-access features on competing consoles. Though several consoles have offered add-on modems and communications software, relatively few users have availed themselves of these options.

Microsoft sees a market for what it calls "X-Box Inside" products—systems that include all the X-Box hardware, along with additional components to support other capabilities. Microsoft stresses that all such systems must behave exactly like a standard X-Box when playing X-Box games to ensure software compatibility.

Microsoft has published an endorsement of the X-Box concept by consumer-electronics maker Thomson Multimedia. We believe this endorsement signals Thomson's interest in making "X-Box Inside" products. Thomson currently makes WebTV systems, so it is not difficult to imagine a WebTV set-top box with X-Box compatibility.

An important consideration in the design of such systems is the fact that X-Box hardware resources are not available for other tasks while games are executing. If an "X-Box Inside" system is expected to perform some function at all times, such as acting as a home multimedia server or Internet gateway, this function must be handled by separate hardware within the system.

X-Box Shines on 3D Graphics

The most crucial hardware feature of the new platform will be its support for 3D graphics. NVIDIA's NV25 core should offer at least eight to ten times the raw performance of today's best PC graphics cards, with further advantages due to its unified memory architecture and greatly reduced operating-system overhead.

The new core, which will operate at 300MHz, will include a geometry processor that is greatly improved over the one found in the GeForce 256. Microsoft says the X-Box will be able to process 300 million polygons per second if the polygons are very small (less than one pixel in size) and no color, lighting, or texturing is required. This number is relevant mostly to so-called particle-system special effects such as explosions and smoke. In most architectures, the difference between these ideal polygons and the practical requirements of real games reduces throughput tremendously, but X-Box does not fare so poorly. On nine-pixel triangles with textures and lighting, Microsoft says the X-Box will sustain a throughput of 150M polys/s, roughly two orders of magnitude better than today's PCs without geometry acceleration and about five times faster than the PlayStation 2.

The NV25's rendering engine will be similarly strong, able to apply up to 19.6 billion texture samples per second. We interpret this figure in light of the chip's stated clock speed as implying that the NV25 will issue eight pixels per clock, each with up to eight textures. Such high throughput

should make the NV25 capable of a level of visual realism previously achieved only by offline rendering systems, such as those based on Pixar's Renderman ray-tracing technology.

Overall, Microsoft says the X-Box graphics chip will perform one trillion operations per second—a figure never before associated with consumer devices, whatever its practical significance. Microsoft would like the world to believe this is some fundamentally new and unique achievement, claiming it enables "photorealistic" rendering. Even at this level, however, the X-Box will still fall short of true photorealism, except on carefully contrived 3D scenes. Performance at least five orders of magnitude higher will be required to reach this point, giving hardware and software developers plenty of work to do over the next few decades.

We believe the financial terms of the deal, which have not been disclosed, are quite favorable to NVIDIA. According to NVIDIA's most recent annual report, Microsoft is to pay NVIDIA $200 million dollars up front "as an advance against graphics chip purchases and for licensing [NVIDIA's] technology." The sum is more than half that of NVIDIA's annual product revenue, currently about $375 million. The company had just $61 million in the bank at the end of January, so the X-Box deal also represents a major infusion of cash.

CPU Choice Illustrates Cost Concerns

By comparison with this impressive 3D subsystem, Microsoft's choice for the X-Box processor seems relatively weak—an illustration of the price premiums that make PC processors more expensive than graphics chips of similar complexity. Microsoft says the X-Box will use an Intel x86 processor running at over 600MHz. This chip will not be a standard Coppermine device, but will be a custom (or at least semicustom) design created by Intel for Microsoft. Intel's George Alfs told ComputerWire (*www.computerwire.com*) that the chip's front-side bus will run at a speed in excess of 133MHz, the limit for current Pentium III processors. Because the X-Box is a uniprocessor system, the electrical and timing margins required for multiprocessor support on Pentium III systems are not needed, and a higher bus speed should be fairly easy for Intel to deliver.

Neither Intel or Microsoft will comment further, but we suspect there may be other enhancements to the chip. By late 2001, a 600MHz Coppermine will represent the very bottom of Intel's product line, with most system sales and software development focused on Willamette. We believe it would make good sense for Intel to integrate the SSE2 instructions scheduled for Willamette (see *MPR 2/28/00-03*, "Quicktake: Willamette Revealed") into the Coppermine core. Although 3D processing is handled by the NV25 core, SSE2 would accelerate higher-level functions, such as physics-based object behavior. Even if the resulting performance falls short of that achieved by Willamette's wider SSE datapath, the instruction-set compatibility would provide a consistent programming model for X-Box and contemporary PCs.

Whatever the details of the new CPU, its specifications (along with those of the other elements of the X-Box design) must be frozen before software developers can get very far with title development. There are a few other elements of the system that must also be finalized, such as selection of an audio DSP. Microsoft says these specifications will be released to developers around the end of this month, with public disclosure sometime later.

Both the CPU and the 3D-graphics subsystem will share a single 128-bit-wide memory array consisting of 64M of 200MHz DDR SDRAM—probably implemented with four 4M x 32 devices. With 6.4GB/s of peak throughput (about 4GB/s of sustained bandwidth given typical PC access patterns), this array will have more than enough performance to support the needs of the other elements of the system.

Though such a unified memory architecture can be a mixed blessing in a PC, it's a good choice in a system like the X-Box. Just as the Silicon Graphics 320 and 540 systems (see *MPR 2/15/99-02*, "SGI Chip Set Powers NT Workstations") used a wide, fast (and expensive) unified-memory subsystem to outperform contemporary rivals, so may the X-Box. DDR SDRAM should reach rough price parity with single-data-rate devices by the second half of 2001, and DDR technology doesn't carry the significant royalty costs of RDRAMs and RDRAM controllers—especially important given that three or four RDRAM channels would be required to achieve the same performance.

Microsoft can also take better advantage of UMA in a closed system such as the X-Box, where it can shortcut the common usage model for 3D textures and other data types on the PC platform. Though a PC must normally move data into main memory before transferring it to the graphics card—resulting in two crossings of the memory bus plus one trip across AGP—such data can be moved from the hard disk or DVD to main memory once, and used from there. This usage model works best when the graphics chip has a large, effective cache. In the absence of a good cache, repeated transfers of texture data to the graphics chip during rendering can result in more memory-bus traffic rather than less.

A Closed X-Box Ensures Compatibility

The X-Box will be a closed box—there will be no internal expansion or upgrade capabilities. This characteristic eliminates any risk of incompatibilities due to mismatched CPU speed, memory or disk capacity, or other hardware features.

External expansion is also relatively limited. Four connectors on the front of the box will support game controllers. These connectors will carry USB signals but be much more rugged than the USB connectors found on PCs. Another USB connection on the rear of the box will provide the only external expansion interface, but it is likely to be used primarily for a USB keyboard and mouse. We also expect to see a USB modem for dialup Internet access.

Also included on the X-Box is a 10- or 100Mb/s Ethernet jack. Ethernet will be used to connect multiple consoles

in the same room for multiplayer games, and for digital subscriber line (DSL) and cable-modem Internet access devices.

A proprietary audio/video-output connector will carry NTSC or PAL video, depending on the market; RGB video for computer monitors; and Y-Pr-Pb component video for consumer HDTV sets. The last capability should be a first for video-game consoles. Component-video and HDTV support will give the X-Box a clear advantage over the PlayStation 2 for households that already have HDTV sets—or plan to get them. Because the PlayStation 2's Graphics Synthesizer chip uses embedded DRAM for its frame buffer, it cannot achieve full performance at high resolutions. While HDTV support matters little to consumers today, this capability will become more important over time.

Gamers often criticize the audio quality on console games, especially older systems that lack the storage capacity or processing power necessary for CD-quality sound. Microsoft plans to silence critics by giving the X-Box a high-quality audio subsystem, presumably derived from similar circuitry found in PCs. The system will include an audio DSP integrated into the south-bridge chip. The DSP will handle audio synthesis and mixing functions, and implement the "I3DL2" standard for environmental acoustic modeling, making it easier for developers to simulate specific acoustic environments—subway tunnels, concert halls, and so on. The A/V connector will support line-level audio signals suitable for connection to stereo gear and high-end televisions.

The X-Box will lack an IEEE 1394 digital-video I/O port as found on the PlayStation 2, however. Sony included this feature to support its digital camcorders and is likely to release home-video-editing applications on the PS2. Microsoft has little involvement with digital-video applications of this type and presumably left the feature out of the X-Box for cost reasons.

Microsoft will include an 8M flash-memory card like those used with some of today's consoles to store personal data like high scores and game-character definitions. Though the X-Box's hard disk can store much more information of this type, it cannot be removed from the system. The card allows personal data to be moved from one system to another. Microsoft has not said if this card will use an industry-standard format such as Compact Flash or SmartMedia.

Microsoft says it may also develop an enhanced memory card similar to Sega's Dreamcast Visual Memory Unit (VMU). The VMU is a cross between a memory card and a handheld game machine. It allows players to move personal information between machines, play games when not connected to a Dreamcast console, and view private data on the VMU screen when the VMU is plugged into a Dreamcast game controller.

Royalty Model Reduces Console Cost

Because Microsoft will collect royalties from game publishers on X-Box titles, the company will implement a security scheme to prevent the X-Box from running unauthorized titles. Since the X-Box software-development environment is so much like that used to make PC software, such a scheme is essential to prevent developers from bypassing Microsoft's licensing requirements. We expect the solution to be similar in concept to the digital certificates commonly used to identify Microsoft-authorized software on the Internet.

Like other console-game companies, Microsoft will work closely with game developers from the concept phase through final release. Developers of X-Box games must have their work approved by Microsoft at each stage. Though restrictive compared with the more-open development process for PC applications, in which Microsoft is rarely directly involved, Microsoft believes this cooperation will give X-Box games the same consistent quality and value found on other consoles.

Careful supervision will be necessary to avoid problems with the system. An errant instruction could reformat the hard disk or erase the flash card. A bug of this type is causing problems for PS2 users in Japan today—one particular game will occasionally corrupt the flash card used by the PS2 to hold DVD-playback software and other data, forcing customers to reinitialize the card using a DVD-ROM that Sony wisely includes with each unit. This is a relatively minor problem compared with an accidental loss of the data on the X-Box's hard disk.

Full access to the hardware is common in other console games, however, and it may be expected by potential X-Box game developers. Though most developers will use Win32 and DirectX as hardware abstraction layers, kernel-mode operation leaves the door open for more sophisticated programmers to wring additional performance out of the platform.

Though Microsoft's role in selecting and authorizing X-Box title development will likely reduce competition, the console-gaming market is less concerned about this risk than is the PC market. Indeed, Microsoft says console-game developers are more concerned about the risks of too much competition. Console-game development can be very expensive, and these costs make sense only when a successful title can be expected to sell a large number of units. Unrestricted competition from "shovelware"—cheaply developed games sold at very low prices, as seen on the PC platform today—could discourage some developers from supporting X-Box. Microsoft is likely to seek the same balance sought by other console-game makers: they want enough title variety to attract gamers, but enough exclusivity to attract developers.

Revenues from game royalties will allow Microsoft to forgo profits on sales of the console itself, just as Sony does on the PlayStation 2. Microsoft will sell the console under its own brand rather than through PC or consumer-electronics OEMs, which were not interested in selling a product with little or no profit potential. Microsoft is likely to use a contract manufacturer for the X-Box, but it has not yet identified any candidates for this role.

The total market for console games is quite large. In 1999, console-game titles accounted for some 120 million units sold, with retail prices ranging from $20 to $60. Only about half as many PC games were sold that year—and at lower average prices. The most popular console titles sell as many as 1.5 million copies each, twice as many as any PC game program.

Microsoft says it expects to develop about 30% of all X-Box titles itself, with the remainder provided by third-party developers. This is in line with other consoles. According to the NPD Group (*www.npd.com*), Sony sells about 25% of all PlayStation titles, while Nintendo accounts for 45% of Nintendo 64 software sales.

Demonstrations Show Promise

The X-Box announcement, part of a keynote speech by Bill Gates at the Game Developers Conference in San Jose, Calif., included demonstrations of the sort of 3D features and performance planned for X-Box. Most of the demonstrations ran live on what amounted to a standard PC with NVIDIA's next-generation NV15 graphics chip, a platform that falls well short of the capabilities of the real X-Box hardware. One demonstration was generated on a simulator and played back at the full planned frame rate, but even this demo was said to represent only about 25% of the X-Box's capabilities.

Our impression, shared by others we interviewed after the presentation, was that all of these demos—even those run on the NV15—looked notably better than most of the demos we have seen from Sony for its PlayStation 2. If the X-Box retains this advantage when it ships, it is likely to be very successful. Sony is surely working hard to improve the quality and performance of PlayStation 2 titles, however. Today's games for the original PlayStation look much better than early titles, and similar improvements to PS2 games are inevitable.

Price & Availability

Microsoft has not given a price for the X-Box, which is due out in the fall of 2001.

Sony has several advantages over Microsoft in this market. Sony makes two of the most successful video-game consoles on the market, and it has years of experience dealing with gamers and console-game developers. Sony also owns a movie studio that allows it to create games based on movies (or vice versa). Even more interesting is Sony's ability to produce crossover material—an entertainment program produced like a movie but presented like a game. There have been previous attempts in this genre, none of them successful, but the DVD support in the PlayStation 2 may make the difference.

Just as Sony was regarded as the outsider with little relevant experience when it introduced the PlayStation, Microsoft is the underdog in this new competition. The company is making the right moves today, but whether it can continue to do so is another matter. We do not expect Microsoft to deliver a knockout blow. The PlayStation 2 will be too strongly entrenched by the time the X-Box arrives for Microsoft to squeeze it out. Fortunately for Microsoft, the console-gaming market has room for at least two major players. We believe the X-Box will join the PlayStation 2 in many living rooms. It is Sega and Nintendo that should be most concerned about the X-Box, which may displace Dreamcast and Dolphin in the hearts and minds of console-game buyers. ◇