Figure 1 Nintendo's latest iterations of its long-running portable-game-console franchise, the Game Boy Advance SP (a), Game Boy Micro (b), and DS (c), square off against Sony's first entry into the category, the PlayStation Portable (d).

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Variations on a theme:

Handheld game systems proliferate, touting varied features and price tags

ENTERTAINMENT CONSOLES ARE GOING MOBILE IN A BIG WAY, FOLLOWING IN THE FOOTSTEPS OF THEIR COMPUTER FORERUNNERS. AT THIS EARLY STAGE IN THE GAME, THERE'S NO SHORTAGE OF OPINIONS ON WHAT DEFINES THE PERFECT SYSTEM, LEADING TO A DIVERSITY OF PRODUCT ALTERNATIVES.

Traditional TV-tethered video consoles are in no danger of obsolescence, but portable counterparts are beginning to supplement and, to a limited degree, supplant them (**Reference 1**). Although mobile units don't directly drive large-screen displays, they don't need to; instead of viewing them from several yards away, players hold them a foot or less from their eyes, and the portable consoles' fine-pitch LCDs deliver lots of detail. They don't hook into a surround-sound speaker system, either, but a set of headphones and sufficient CPU horsepower, which dedicated hardware acceleration often supplements, can deliver an immersive virtual-surround experience (**Reference 2**). And, speaking of CPU horsepower, it, along with graphics muscle, is a fundamental reason for portable consoles' burgeoning success. Potential customers have long appreciated the transportable benefits of a mobile system, but the consoles have only recently become capable of delivering engaging game play, along with high-quality sound and images, while supplying sufficient battery life to justify their "portable" classification.

What characteristics delineate a portable gaming console? That's a tough question to answer; to understand why, look at another rapidly growing mobile-electronics category: the portable computer. Like the portable gaming console, the portable computer has achieved mainstream popularity; look at the computer-store advertisements in your Sunday newspaper if you aren't convinced. Portable computers can finally deliver an adequate amount of storage capacity, processing horsepower, and battery life for the masses. But what's a portable computer? Is it a laptop PC and, if so, in what size, weight, and form factor and with what operating system and application-software

AT A GLANCE

- Price and features define the battle in portable game consoles, just as with living-room-based systems, but, in this case, the added complication of battery life comes into play.
- Nintendo offers a range of systems with various capabilities and prices; the latest DS provides a bridge to the past and a path to the future.
- Sony's PSP (PlayStation Portable) ups the ante on cost but delivers a greater breadth and depth of potential than its Nintendo competitors.
- The Gizmondo and N-Gage are slow out of the gate; did their features not align with consumers' desires, or was their market entry just premature?

suite? Is it a PDA, and, if so, which of the multiplicity of implementation options that currently claim the name "PDA" are valid examples of the portable-computer category, versus being something "lesser," "greater," or "other"? Is a computing-enhanced cell phone or camera—or game console—also a computer?

There's no shortage of opinions regarding what a portable computer is. Similarly, ask 10 people to succinctly define a portable game console, and you'll probably get 10 different answers. This diversity of views reflects the diversity of prod-

(continued on pg 58)

Figure 2 Nintendo's proprietary NiFi 802.11b-based Layer 3 protocol supports close-proximity player-to-player communication (a) and gaming (b); the DS's recently introduced TCP/IP stack expands the system's multiplayer-gaming capability to a worldwide, Internet-based approach (c) that you can even enjoy for free from the comfort of a nearby fast-food restaurant (d).

TABLE 1 THE HISTORICAL PROGRESSION OF NINTENDO'S GAME BOY LINE

Product	Introduction Date (Japan)	Description
Game Boy	April 21, 1989	Original product, based on Sharp-designed 4.2-MHz Z80 CPU with 160×144-pixel reflective monochrome display
Game Boy Pocket	1996	Smaller and lighter with improved black-and-white display; smaller link port, adopted by all subsequent models until Game Boy Micro
Game Boy Light	1998	Japan-only release added backlit screen to Game Boy Pocket design
Game Boy Color	1998	Color LCD, twice the processor speed, twice as much memory, IR communications port
Game Boy Advance	2001	32-bit, 16.8-MHz ARM processor plus Z80 processor for backward compatibility; 240×160-pixel display
Game Boy Advance SP	2003	Switched to a clamshell design with an internal front light and rechargeable battery; improved backlit screen added in September 2005
Game Boy Micro	2005	4 in. wide, 2 in. tall, less than 1 in. thick. Weighs 2.8 oz. Drops backward compatibility with Game Boy Color and previous titles

UP-AND-COMERS OR WASHOUTS?

The allure of the portable-gaming market is compelling enough that, although Sony's PSP (PlayStation Portable) and Nintendo's product suite currently dominate it, other contenders are also vying for the throne (Figure A). The Gizmondo from Tiger Telematics is one candidate, although it's off to a rough start, having debuted in Europe in mid-March 2005, followed by sales in the United States beginning in late October. From a hardware standpoint, it's a mixed bag in comparison with the DS and PSP. Some would claim that its Samsung-designed single ARM9 CPU leaves it with less processing muscle than the dual-ARM DS, although Gizmondo's ARM9 runs at a much higher, 400-MHz clock rate. Conversely, Gizmondo's Nvidia-developed GoForce 3D 4500 graphics processor, with nearly 1.3 Mbytes' worth of frame-buffer memory, is state-of-the-art.

Gizmondo touts a 2.8-in.-diagonal, 320×240-pixel, color TFT (thin-film-transistor) screen, currently in a 4×3 aspect ratio. However, last summer, *before* the launch of the first-generation unit in the United States, the company indicated that a 16×9-aspect-ratio, wide-screen, second-generation product variant was in the works. Tiger Telematics based Gizmondo on Microsoft's Windows CE. Besides gaming capabilities, it includes multimedia playback, GPS (global-positioning-system) satellite tracking, wireless-Bluetooth PAN (personal-area-network), and GPRS (General Packet Radio Service) WAN (wide-area-network) communications. WAN features include SMS (short-message service), e-mail, WAP (Wireless Application Protocol) browsing, and cellular voice through a Bluetooth headset. Gizmondo also includes a VGA-resolution camera and even a gyroscope that senses and enables applications to respond to the unit's orientation.

The early reviews on the console are lukewarm, the first wave of game titles reportedly isn't engaging or eye-catching, and the battery life is markedly brief. The short battery life is not surprising, considering all of the circuitry the company packed onboard the unit. Tiger Telematics also touts a unique pricing scheme; you can buy a Gizmondo for $229 if you're willing to accept as many as three 40-sec advertisements per day, through GPRS, or $399 with no ads.

Speaking of engaging, no overview of portable gaming systems would be complete without mentioning the Nokia N-Gage series (Reference A). The company in October 2003 introduced the first member of the product family, which it based on a Series 60 phone foundation running Symbian OS Version 6.1 on a 104-MHz ARM CPU with a DSP. Its speaker, microphone, and screen locations made using it as a cellular phone cumbersome: Users needed to remove the unit's battery to swap out game cartridges. The unit's Java-based games were slow and uncompelling, and its multimedia-playback capabilities were limited. Plus, being GSM-only, it couldn't run on CDMA and Japanese cellular networks, a problematic shortcoming given that many game developers are based in Japan.

The follow-on N-Gage QD, which the company unveiled in April 2004, relocated the speaker, microphone, and game-cartridge slot. However, because its developers based it on the same fundamental hardware design as its predecessor, it suffered from many of the same shortcomings. The product family sold approximately 2 million units in 3 years' worth of promotional effort; initial forecasts projected sales of 6 million units in that same time frame. Nokia recently announced that it was suspending further development of the N-Gage hardware platform, although it would continue to offer new games and other software for already-sold consoles, and would consider re-entering the portable-game-console market in 2007 or later. In the meantime, Nokia will focus its efforts on appending gaming functions to its conventional Series 60 cellular handsets.

Figure A Tiger Telematics' Gizmondo (a) and Nokia's N-Gage (b) pursue the gaming opportunity from a cellular perspective.

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uct offerings now in the marketplace, both from one vendor to another and within each vendor's product portfolio (see **sidebar** "Up-and-comers or washouts?"). For hardware and software suppliers, the $25 billion gaming industry is a gambler's paradise—or, if you prefer, nightmare—fueled by fickle consumers and insistent investors. Guess right, and you're in the pole position for mind-boggling revenue and profits. Guess wrong, on the other hand, and you'll quickly be left in the dust.

REIGNING CHAMPION

Nintendo launched its original Game Boy in Japan on April 21, 1989, and in the United States that August (**Reference 3**). Over the subsequent 16-plus years, the company has made steady, calculated improvements to the platform, culminating in today's GBA (Game Boy Advance) SP, which sells for approximately $80, and Game Boy Micro, which sells for approximately $100 (**Figure 1**). The latest Game Boy Micro, which Nintendo unveiled at last May's E3 (Electronic Entertainment Expo) conference (www.e3expo.com), dropped Z80 CPU support and is therefore the first member of the series that's incompatible with original Game Boy, Game Boy Pocket, and Game Boy Color games (**Table 1**).

The Game Boy line is Nintendo's legacy; the Nintendo DS, which, depending on who you talk to, stands for either Dual Screen or Developer's System, in contrast, is the first platform iteration of the company's portable-gaming future (**Reference 4**). Nintendo launched the DS in the United States—one of the rare occasions in which a game device didn't debut in Japan—on Nov 21, 2004, at $149.99; the Japan introduction occurred two weeks later, on Dec 2. Nintendo decreased the price to $129.99 on Aug 21, 2005, and Target stores sold one color variant for $99.99 during the recently concluded 2005 holiday-shopping season. At 5.85 in. wide, 3.33 in. long, 1.13 in. tall (closed), and 9.7 oz, the DS fits into a large pocket. Nintendo included two displays in the DS; both are 3-in.-diagonal with a 4×3 aspect ratio, constructed of a backlit, 0.24-mm-dot-pitch, 256×192-pixel, semitransparent, reflective, TFT (thin-film-transistor), color LCD array. The lower screen incorporates a transparent analog touch sensor, and both screens can display 262,144 colors.

As with the Game Boy Micro, Nintendo also limits the DS' backward compatibility to GBA-targeted titles. The DS contains two ARM CPUs: an ARM946E-S normally operating as fast as 67 MHz but reportedly able to operate as fast as 200 MHz with 8-kbyte-instruction and 4-kbyte-data caches, and an ARM7-TDMI running at 33 MHz but able to operate at 133 MHz with 64 kbytes of internal memory. Nintendo is characteristically coy about its hardware and doesn't discuss the function partitioning between the processor cores; they share 32 kbytes of memory, and the DS also contains 4 Mbytes of system DRAM. The 3-D-graphics engine can transform as many as 4 million geometry vertices/sec, or 120,000 polygons/sec, and it touts a 30 million-pixel/sec fill rate. The DS includes dual speakers, along with a two-channel headphone jack, and it also embeds a microphone for, among other things, voice-recognition applications.

Figure 3 The PSP's beefy, multicore CPU and graphics subsystem, along with other enhanced hardware capabilities, deliver highly detailed games (a). The system can also function as a USB mass-storage device and as an audio, still-image, and video player (b). The video-player function employs content streamed over or downloaded from the Internet from a Memory Stick or on a Sony-proprietary UMD optical disc (c).

SONY: TOP CONTENDER

After watching Nintendo garner most of the portable-console business for more than a decade, Sony decided to give its living-room-console rival some mobile competition, too. Sony also wanted to give itself a hardware platform to jump-start its media divisions' ambitions by supporting the Memory Stick Duo and 1.8-Gbyte UMD (Universal Media Disc) formats. (Visit the Brian's Brain blog at www.edn.com/briansbrain and read the "Sony versus the hackers" entry for more information.) Sony unveiled the PSP (PlayStation Portable) at the 2003 E3 conference. The company launched the console in Japan on Dec 12, 2004, and in North America on March 24, 2005, although European customers had to wait until Sept 1, 2005, to buy their PSPs. The PSP measures 6.7 in. long, 2.9 in. wide, and 0.9 in. deep; weighs 10.3 oz, including its removable lithium-ion battery and a Memory Stick Duo; and sells for $249.99, including accessories. (Sony sold the device as a stand-alone unit only in Japan for 20,790 yen.) The unit's 4.3-in.-diagonal, 16×9-aspect-

ratio, TFT LCD supports 480×272-pixel resolution and can display 16,777,216 colors. Sony does not specify the display's pixel pitch.

Sony had no backward-compatibility concerns with the PSP, because it was the first in, presumably, a series of portable consoles from the company. However, Sony strove to ease developers' porting of PlayStation 2 games to the PSP, and the distinct PS2 heritage of the PSP's current title suite reflects that simplicity (**Reference 5**). The console contains dual 1.2V MIPS 4KE CPU cores that can operate as fast as 333 MHz but that normally clock no higher than 222 MHz—probably for power-consumption reasons. One core handles most of the system- and game-code processing, and the other, supplemented by 2 Mbytes of embedded DRAM, tackles media processing of audio, still images, video, and the like. The PSP includes 4 Mbytes of embedded DRAM and 32 Mbytes of discrete DRAM.

The PSP's dual-core graphics processor runs at 166 MHz and partitions the graphics pipeline into two classes of tasks: curved-surface and geometry processing on one core and texture-surface and pixel-rendering processing on the other core. Overall specifications, which Sony first revealed at the 2004 IEEE Hot Chips conference at Stanford University, include a peak pixel-fill rate of 664 million pixels/sec and a peak transformed and lit geometry-processing rate of 33 million polygons/sec. Sony also included the reconfigurable-logic-based VME (Virtual Mobile Engine) video- and sound-processing core, which runs at 1.2V and 166 MHz and can implement 3-D virtualization, reverberation, tone control, and other audio-processing functions. Like the DS, the PSP includes left and right speakers and a dual-channel headphone jack, although, in this case, the microphone is an add-on accessory.

WIRELESS VARIETY

The DS and PSP both include WiFi transceivers; the implementation differences lie in the details. Nintendo's design handles only 1- and 2-Mbps WiFi data rates and supports only short-preamble mode. Until recently, it also lacked IP (Internet Protocol) support and, therefore, didn't implement a TCP/IP (Transfer Control Protocol/IP) or UDP/IP (User Datagram Protocol/IP) stack (**Figure 2**). People often refer to Nintendo's proprietary OSI (Open Source Initiative) Layer 3 protocol as NiFi, but that moniker is deceptive. Nintendo implements fully OSI- and 802.11b-compliant Layer 1 physical (wireless) and Layer 2 data-link layer MAC (media-access-control) communications; NiFi's divergence occurs only at Layer 3 and beyond (**Reference 6**).

The discussion about NiFi is now merely academic, though, because Nintendo has just launched its TCP/IP-based Nintendo WiFi network, which you can access through any 802.11b-compatible wireless router or access point. The Nintendo DS doesn't yet offer a Web browser, so networks that require Web-based log-in schemes are normally off-limits, but Nintendo has partnered with Wayport and McDonalds to offer free access in McDonald's US restaurants (see **sidebar** "More at EDN.com"). Other similar wireless-network-access deals are likely to follow.

The PSP, in contrast, implements a full 802.11b-based TCP/IP-network stack at data rates as high as 11 Mbps. It supports both peer-to-peer and infrastructure modes for playing games against other PSP owners both nearby and worldwide. Firmware Version 2.0 added a full-featured Web browser. (Sony previously embedded a limited-function browser within the *WipEout Pure* game.) Version 2.5 firmware included the ability to watch streaming video from the company's LocationFree network-broadcast base station, and Version 2.6 incorporates the ability to access streaming RSS (Rich Site Summary, or Really Simple Syndication) Version 2.0 audio feeds.

The DS and PSP not only support wireless, multiplayer game play, but also claim to support so-called game-sharing mode—that is, the ability to temporarily download a subset of a game to another console's RAM to enable multiplayer mode with someone who doesn't own the game. (Nintendo refers to this feature as single-cartridge/multiplayer.) However, although DS titles widely support game sharing, no PSP titles yet implement it. (The single-cartridge/multiplayer feature extends back to the GBA, although before the existence of the GBA DS, multiplayer mode was possible only through a wired connection between consoles.) The PSP does allow game sharing, however, to download demo versions of games from promotional kiosks to PSPs. (The DS also supports this feature.) At least one PSP title, *Namco Museum*, also supports the download-a-demo-to-another capability, and several PSP titles enable you to download extra postpurchase features, such as *WipEout Pure*'s additional race tracks, features, and soundtracks, from the Internet.

FLEXIBILITY VERSUS PRICE

You might expect that the PSP's greater hardware apportionment and higher price than the DS would translate to not just beefier games, but also broader and deeper features, and you'd be right (**Figure 3**). The console's Internet- and multimedia-related capabilities include audio in WAV (Windows Wave), MP3, AAC (Advanced Audio Compression) within an MP4 wrapper, ATRAC (Adaptive Transform Acoustic Coding) 3plus, and WMA (Windows Media Audio) formats. Both the ATRAC and WMA support are available only without DRM (digital-rights management). The console also supports still images in BMP, GIF, TIFF, and JPEG formats and video in both MPEG-4 Part 2 (Simple Profile) and Part 10 (Main Profile Level 3, also known as MPEG-4 AVC and as H.264) formats.

For complex game-play scenarios, the

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PSP incorporates more control inputs than does the DS, including an analog joystick. An infrared transceiver supplements the console's WiFi capabilities, and the unit also supports a USB 2.0 wired connection. When you connect the PSP to a computer, a Memory Stick Duo card in the PSP mounts on the computer as an additional drive. The PSP has a more expansive suite of available accessories from both Sony and third parties, reflecting its more comprehensive features. These add-ons include the microphone, protective cases and automobile mounts, amplified speaker-inclusive stands that enable easy viewing of UMD- and Memory Stick Duo-housed movies, extended-life batteries, video-out converters for connecting the PSP to an external display, 3-D-viewing supplements, and adapters that enable the PSP's use of higher-capacity, small-form-factor hard-disk drives through the Memory Stick Duo interface. You can even buy solid-state PVRs (personal video recorders) that record television and dub input videos directly to a Memory Stick Duo in a PSP-resolution-friendly MPEG-4 format for later viewing on your console.

The DS' recent embrace of TCP/IP opens the door to a number of possible expansions of that console's features. The robust artificial-intelligence ability of games such as *Nintendogs* is a testimonial to the system's processing potential. You can view videos on the DS using its Game Boy-compatible cartridge slot and Video Paks from Majesco, although they're of low quality because software running on the CPU decodes them and because of the cartridges' 32-Mbyte capacity. The hardware-accelerated Play-Yan (now Play-Yan Micro) audio (MP3) and video (MPEG-4) adapter, which interfaces to SD cards, is now available only in Japan. The GBA Movie Player third-party adapter mimics the Play-Yan's features and adds e-book support.

Will Nintendo ever offer a Web browser for the DS? Feedback from the company at an early November briefing in Redmond, WA, was contradictory. A public-relations representative indicated that a browser, should it ever appear, would likely come from a third party, but, Reggie Fils-Aime, executive vice president of sales and marketing, later suggested that Web-browser support would be a "provocative idea." He added, "How can we bring new people onboard to buy DS and play DS? Having a Web browser would be highly disruptive. I would love to do it" (**Reference 7**).EDN

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