MPEG Sales Poised to Take Off

DirecTv Makes MPEG Video a Consumer Phenomenon

by Richard Doherty, The Envisioneering Group

A year ago, MPEG appeared to be a long shot compared with proprietary video-compression algorithms, but the MPEG standard enters 1995 with heady success. In less than six months, the sub-$1,000 DirecTv satellite broadcast system has entered 400,000 homes, making MPEG-delivered digital video the hottest consumer-electronics phenomenon since the home VCR and the CD audio player.

In 1993, the only consumer MPEG systems in the world were the Philips CD-I interactive CD player and a few Japanese karaoke players powered by C-Cube chips. A year later, hundreds of thousands of PC add-in cards for MPEG-1 video-CD playback, along with the 400,000 DirecTv systems, have changed the attractiveness of MPEG drastically. Virtually all the top computer-system vendors are actively exploring the market for MPEG-based set-top boxes, as Table 1 shows.

These decoders typically include a Huffman decoder, inverse quantizer, inverse discrete cosine transformation (DCT), color space conversion, and motion estimation logic. Some add zig-zag and interlace circuits, run-length decoding, and other proprietary tricks, making MPEG a standard only so far as the leading vendor defines it. Add host-processor control, RAM, and video output (either NTSC/PAL analog or PC-standard RGB), and you have a digital video decompressor.

Supplier/Feature	CPU/Video Decoder	Customers/Trials
Apple	C-Cube	British Telecom/U.K.
CLI/Zenith/Philips	C-Cube	Bell Atlantic, others
Digital	Alpha?	Video Dialtone Server head end
DirecTv (RCA/Sony)	Thomson/Sony	continental U.S.
GI/DigiCipher	multiple sources	TCI
Hewlett-Packard	PA RISC/others	US West
IBM	IBM Microelectronics	RBOCs/U.K.
PrimeStar/GI	GI-licensed foundry	regional/national
Scientific-Atlanta	Motorola PowerPC	Time Warner/Orlando
Silicon Graphics	MIPS	Time Warner/Orlando
Sun Microsystems	SPARC with dual MPEG-2	DirecTv, Fortune 2000
Thomson/ Sun Open TV	Thomson	cable MSOs, RBOCs
Zenith	unannounced	cable MSOs, RBOCs

Table 1. Players in the digital set-top box arena include existing cable-box makers as well as the top computer-system vendors.

Data rates range from the 1.2-Mbps MPEG-1 to MPEG-2 levels and profiles (there are dozens!) that start at 3 Mbps and extend to HDTV imagery at better than 20 Mbps. Other than costly lab demonstrations, however, all current MPEG-2 systems run at 3–15 Mbps. Even these systems are awaiting large-scale video-on-demand applications, which are more theory than revenue right now. Until the FCC blesses the North American HDTV standard, which is also based on MPEG-2, few companies can afford to commercialize the upper performance levels.

Because MPEG-2 decoders, by definition, can handle MPEG-1 video streams, most of the recent silicon has focused on low-cost decoders capable of MPEG-2 playback. Few have ventured into the far more complex MPEG-2 encoding engines needed to feed these systems.

MPEG-2 Is Hardly Standard

Although MPEG-1 has been formalized for years, MPEG-2 is in final draft form. With the exception of some audio issues still in debate (Dolby AC3 versus Musicam), MPEG-2 is, for all practical purposes, frozen.

What is far from frozen is how a user implements the encoding rules of MPEG-2. Decisions abound. Zig-zag or diagonal encoding? Square pixels or 4:3 (TV) aspect ratio? Progressive or interlaced video scan and acquisition? And most important of all for a system designer, is the playback screen an interlaced NTSC or PAL television set, or is it a progressive-scan RGB PC or workstation monitor?

Now that the International Standards Organization is about to finalize the core mathematics of MPEG-2, more than a dozen ad hoc industry groups are trying to put their own proprietary stamp on the way the standard is implemented. The leading groups include VESA, IMA, Open MPEG, EIA/Cable Labs, and many others.

Consider the example of JPEG, which was established as a standard four years ago. Market development of JPEG was thwarted for many years while silicon and card-level vendors each defined their own methods of image scanning, compression levels, variable-bit-rate encoding schemes, and so forth. Only after Adobe, then Apple (in QuickTime), and finally Microsoft adopted JPEG did these factors have a de facto standard, allowing encoded images to be widely exchanged.

In the MPEG market, there was no CD format for MPEG-1 until Philips adopted the Blue Book standard for its CD-I player. This standard was later enhanced by Philips, Sony, JVC, and C-Cube to form the White Book

VideoCD standard, which is now the de facto interchange standard for PC and consumer video CDs.

For nonphysical (i.e., broadcast) MPEG, things are far from being resolved. For example, the hugely successful DirecTv system—which is backed by Hughes, RCA, and Thomson—uses a different packet protocol than that agreed to by the MPEG-2 working group. So, if DirecTv arrives in millions of homes in 1995 as planned, will its format become the de facto standard for MPEG-2? Possibly. Or the Hollywood studio approach known as Digital Video Disk may win out.

Another source of MPEG confusion is proprietary enhancements. For example, adding more image processing to improve motion estimation or image deblurring could make "standard" MPEG video look better on one enhanced MPEG decoder than on another. Indeed, given the intellectual-property battles surrounding ownership and patent royalties for MPEG-2, the only means a company may have to gain revenue from MPEG-2 expertise is via proprietary enhancements to the standard.

Sadly, there are still more standards committee members than products. Indeed, one MPEG engineering member refers to these groups as "thinly disguised fronts for engineers' travel agencies."

Roll Your Own Silicon

Perhaps the leading proprietary proponent is a four-engineer startup company: CompCore Multimedia. CompCore excited engineers with an MPEG-1 decoder that slims down to just 10,000 gates for MPEG-1 and a promised 18,000 gates for MPEG-2 *(see **0811MSB.PDF**)*. How? Proprietary techniques that we believe are patentable. According to published reports of the company's licensing deal with Cirrus, CompCore charges a cool $500,000 up front plus royalties of 6–7% for its design. Zilog has also signed up, and potential licensees include 3DO and NEC.

The CompCore design can be implemented using Verilog or C tools and delivers video at up to 30 frames per second. Compare that to Digital's proud use of a 275-MHz 21064A processor as a dedicated MPEG-1 playback engine. Or even to the $30–$45 MPEG-2 decoder chips offered by C-Cube and SGS-Thomson.

For those seeking a standalone decoder chip, options abound. AT&T promotes its AV6101 *(see **0801MSB.PDF**)* as an MPEG-2 video decoder, but the chip does not implement the full main profile, lacking the ability to handle "B" (bidirectional) frames. C-Cube offers a number of choices, including its CL9100 *(see **0806MSB.PDF**)*, which decodes both MPEG-2 and DigiCipher video. IBM has entered the MPEG-2 decoder market as well *(see **0811MSB.PDF**)*, while LSI has deployed an MPEG-2 audio/video chip set. Winbond's W9920 *(see **0804MSB.PDF**)* handles MPEG-1 decoding; the company is working on an MPEG-2 upgrade.

Fewer options exist for MPEG encoding. C-Cube has an eight-chip device, the CLM4600, that handles real-time MPEG-2 compression, and IIT offers its programmable VCP chip *(see **080204.PDF**)*.

Another alternative is a software-based MPEG decoder from MediaMatics or Xing Technology, which can deliver acceptable MPEG-1 video on a Pentium PC. These programs rely on DCI (Display Controller Interface) playback, in which several elements of rescaling and color-space conversion are handled by a hardware accelerator. Although DCI requires an add-in card today, S3 and others plan to incorporate this technology in their next-generation graphics chips, making MPEG-1 virtually free for many PC users.

Design Challenges for MPEG Systems

Because MPEG silicon is often surrounded by more costly support chips and RAM, meshing a vendor's MPEG silicon to the host system is the prime factor driving decoder-chip selection. For example, new processors dedicated to MPEG-1 from physical media sources (CD-ROMs, hard disks) require simpler designs than those that receive MPEG over dynamic, electronic media (satellite links, LANs, ADSL-conditioned phone lines.) Making MPEG-1 audio support resident on the processor streamlines the overall system design.

Pulling MPEG data from an error-prone broadcast source rather than from a physical medium requires buffering FIFOs or depacketizing silicon to synchronize and accelerate audio and video data streams that may arrive asynchronously. Both Brooktree and startup NVidia *(see **0809MSB.PDF**)* have demonstrated support silicon to handle these tasks, simplifying the system design.

The standards issues discussed earlier are also a concern to many designers. Some are choosing programmable decoders that can be upgraded easily as standards evolve and content improves, even to the point of allowing upgrades from MPEG-1 to MPEG-2 (assuming sufficient bandwidth is available).

Opportunities for Growth Abound

Hughes has committed nearly $1 billion to building the North American DirecTv system, delivering more than 175 channels to owners of $700–$900 18-inch minidishes with MPEG receivers. The existing MPEG-1 receivers will soon switch to MPEG-2, thanks to software upgrades that will rain down from the sky via Ku-band satellite—no need to take the unit to a service depot. C-Cube supplies the real-time encoding silicon for the 175 channels, while SGS-Thomson has the design win for the MPEG decoders within each DirecTv receiver, making it the volume leader in the MPEG chip market.

Hughes is marketing the satellite-direct-to-home model in many other nations. In the Mideast, the Orbit system uses essentially the same design as DirecTv. And

in Japan, startup DMC plans to deliver MPEG-2 video to millions of Japanese consumers by 1998.

The video-game industry is slowly discovering that MPEG-compressed video is low cost and fast. In addition, shooting live video is easier, faster, and cheaper than 3D rendering, editing, and assembly.

More than half a dozen rivals are defining methods of expanding the capacity of a standard CD, currently 640M, by four times or more. The goal is at least 3.7G of capacity, allowing a feature-length movie of up to 135 minutes to be encoded on a single CD at low MPEG-2 data rates. With dual-layer or double-sided options, capacities could reach 7.4G or more. These products will begin appearing on shelves in late 1995 or 1996. In the meantime, Sony, Panasonic, Philips, Sharp, Hyundai, Samsung and others are manufacturing MPEG-1 video players; some are portable and battery operated.

MPEG's biggest competitor is DigiCipher, General Instrument's bid for digital video delivery. Like MPEG, DigiCipher is DCT-based, so a programmable decoder can use similar hardware but different software for the two competing protocols. GI has a contract with Cable Labs to ship digital video receivers for use by cable TV head-ends and eventually cable consumers.

MPEG-1 to Yield to MPEG-2

No one estimated the pent-up, explosive demand for MPEG-based DirecTv: nearly 700,000 units have been manufactured by RCA/Thomson. This month, Sun and Thomson jointly announced Open TV, an MPEG-2 set-top box (derived from the DirecTv unit) designed to reach hundreds of thousands homes in 1995 through cable providers or RBOCs (telephone companies).

We foresee a rapid move to MPEG-2 video CDs, gated by the successful implementation of quad-density discs. MPEG-1 appears to be a transitionary stepping stone and is destined to be an orphaned standard within a few years at best, at least for new titles, while MPEG-2 media players ensure backward compatibility.

For PCs and workstations, MPEG will be challenged by software-only playback alternatives such as Cinepak, TrueMotion, and Intel's Indeo. None of these alternatives, however, can be encoded in real time, making authoring expensive and difficult. MPEG-1 authoring systems, in contrast, cost about $10,000 per PC host and can encode in real time. Upgrading to real-time MPEG-2 authoring increases the cost to roughly $75,000, still affordable for professional video houses. The lack of real-time authoring will prevent software-playback alternatives from presenting a serious challenge to MPEG for some time to come. ♦

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