New Processor Families Join Embedded Fray

Growing Popularity of Core-Based Designs Boosts ARM, MIPS

by James L. Turley

The 32-bit embedded microprocessor market got increasingly crowded in 1994, making it harder than ever to pick a winner. PowerPC went embedded for the first time, Fujitsu and National each created completely new architectures, Intel and AMD expanded their powerhouse lines at the high end, Hitachi produced the world's best-selling RISC chip, three new vendors joined ARMs, and Motorola made a bittersweet announcement for 68K users.

Entirely new architectures are battling with older, entrenched instruction sets, each one aimed at holding onto its niche or carving out a new one in the complex embedded ecosystem. Several companies began offering their CPUs as ASIC cores, signaling a trend that will continue well beyond 1995.

There's plenty of evidence of the cachet of the RISC appellation. Without exception, every new architecture announced this year included the word "RISC" in its description, regardless of applicability. But new importance was also given to issues like power management, static design, code density, and performance scalability.

New Metrics Take on Importance

The ascendance of consumer electronics, PDAs, and handheld devices has turned the spotlight on power and power-management issues. For many applications, MIPS/watt has become an important aspect, and new microprocessors are addressing this concern directly. Battery-powered applications are the obvious driver for these demands, but even line-powered systems often have heat-dissipation limits.

A MIPS/W rating is hardly objective; both performance and power consumption are highly interpretive measures. Nevertheless, it's interesting to note that older microprocessor designs, like American cars, are less power- and space-efficient than some of the newer imports (ARM7, V800, SH703x).

Another aspect gaining importance among many embedded users is the MIPS/mm^2 ratio. Even if MIPS is a questionable dimension, die area is not. Die size affects not only the actual physical size of the device (and therefore how much of a hypothetical ASIC it takes up) but cost as well. Die size is the major factor in the manufacturing cost of a microprocessor, which is represented in the MPR Cost Model and reflected in the figures.

Like desktop applications, embedded code tends to expand to fill the available memory, but adding RAM or ROM to an embedded system is often not an option. Programmers who find themselves compacting code into the available ROM space will appreciate a microprocessor with good code density (bytes/task).

RISC proponents argue that simplifying the instruction set leads to a faster, more scalable processor design. The tradeoff is bulkier code, as intrinsic functions are replaced by software algorithms. Also, a fixed-length instruction word must be large enough to encode any instruction, often resulting in a less-than-optimal use of instruction memory. For embedded applications, the elegance of fixed-length instructions often gives way to the practical consideration of packing as many functions as possible into a given amount of memory.

The code-density steeplechase will become somewhat less important in the coming years as the capacity of memory devices increases. This will be true even as a greater proportion of embedded software is written in high-level languages, eliminating many of the advantages that an assembly-language programmer used to wring out. Indeed, Intel speculates that roughly 1% of embedded code was written in C ten years ago compared with estimates of 50–80% for embedded code written today.

Processor Cores Increasing in Popularity

The practice of offering CPU cores gained popularity during 1994, with Motorola joining traditional ASIC vendors LSI Logic, Sharp, and VLSI Technology. Embedded-core programs offer instruction sets for sale, providing a vital ingredient for the complex ASIC developer. The growth in this arena signals an emerging business model for embedded microprocessors in the years to come. As embedded CPUs shrink, it becomes impractical to manufacture standalone CPUs.

A pure core business transfers the risk of developing and marketing an application-specific device from the ASIC vendor to the ASIC customer—after that risk has already been transferred once, from the processor architect to the ASIC vendor. Presumably, the ASIC customer knows what is needed for its market niche and is prepared to take the risk involved in producing an application-specific microprocessor. Processor design firms become virtual companies, offering pure service with no manufacturing. Operating as structural architects do today, they provide the blueprints and presumably some guarantee that the design will work, but they don't drive any nails.

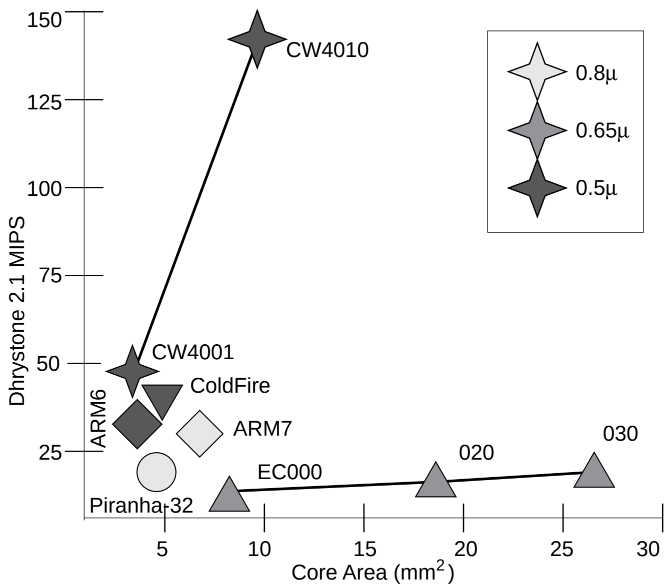

Figure 1. A comparison of available embedded CPU cores. The MIPS processors are exceptionally efficient, providing the greatest performance for the area, due in part to LSI's aggressive process. (Source: vendor data)

ARM has taken this example to its logical extreme: it produces no parts at all. Rather, the company has licensed its designs to a number of vendors with ASIC expertise and compatible fab lines. These licensees then find customers where they may. Like the proverbial 10-year-old overnight success, ARM rose from years of obscurity outside its home to become a big hit for embedded computers, consumer electronics, and personal digital assistants (PDAs).

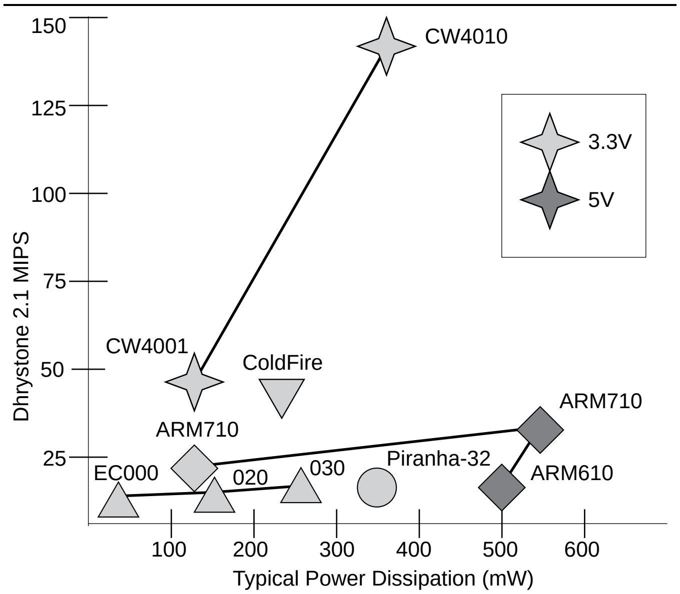

Figure 2. Embedded cores generally dissipate very little power as a percentage of the overall device. Not surprisingly, the low-voltage cores are the most efficient. (Source: vendor data)

Starting out small, the Fab Four (VLSI Technology, GEC Plessey, Sharp, and TI) rocked the embedded world with their newest hit from England. Before the others joined, VLSI had already signed with Apple. VLSI and GEC Plessey were out front supplying ARM610 chips for the Newton, with Sharp providing backup and final production. In 1994, the band was joined by Samsung, Asahi, and Cirrus Logic. Even though the Apple deal didn't produce a million-seller, each of the members was still able to go its own way, producing solo efforts for specialized audiences.

Sharp's focus is on very high volume (100,000+ units) ARM-based devices, in keeping with the company's consumer electronics strength. Asahi keeps mainly to itself, embedding ARM cores in its Asian telecommunications equipment. VLSI has been very busy: it produced the first ARM7 implementation in August and has aggressively shrunk its design to produce cores that are among the smallest and fastest available, as Figure 1 shows. The company also produced two of the earliest standalone ARM chips: the 7500 set-top box controller and Ruby, a CPU integrated with PCMCIA, serial I/O, and ISA bus controllers.

LSI Logic turned out new MIPS cores for the integration-minded. The company added three R4000-based cores to its existing R3000 library as part of its CoreWare development program. Using a 0.5-micron process, the CW4001 weighs in at a tiny 4 mm^2, every bit as small as the smallest ARM core, and includes a unified cache interface (but no cache). As Figure 2 shows, the 3.3-V part consumes just 5 mW/MHz, an impressive performance/power ratio. The midsize CW4010 core is rated at an impressive 150 Dhrystone MIPS yet it consumes no more power or die area than other cores offering less than a third of its performance. LSI's larger, more aggressive CW4100 core is due in late 1995.

Motorola's FlexCore program, launched in mid-1994, allows customers to embed a 68EC000, 68020, or 68030 processor core into an ASIC. The 68040 and 68060 cores will follow in 1995, after the company massages those designs to make them compatible with its ASIC tool chain. FlexCore opens the popular 68000 architecture for custom development, in essence allowing customers to design their own 68300 device. Two current products (the 68322 and 68307) were developed by Motorola customers in just this way.

Unlike the ARM and MIPS architectures, FlexCore locks the potential customer into just one fab: Motorola. On the other hand, the company throws in a large selection of its successful peripheral modules for use in standard cell designs, making an attractive package compared with those from VLSI, TI, or Sharp. LSI Logic's module catalog is also large but, compared with Motorola's communications- and control-oriented library, has an emphasis on performance accelerators.

Two Cores Stuck at the Low End

All the core contenders offer similar submicron CMOS processes and low-voltage operation to at least 3.3 V; Motorola offers nominal 2.7-V cores as well, a major advantage for battery-powered systems. Where the families diverge is in their perceived growth paths.

The 68K family has already named its final core; users looking to expand past the 90 MIPS provided by the 68060 will have to look elsewhere. For ARM, its established strength may also prove to be its greatest weakness. The family has no real high end, at least not yet. The upcoming ARM8 will raise the family's performance ceiling, but it is still months away. Users looking for performance headroom may find little security in the current crop of ARMs.

The MIPS camp, in contrast, has shown it can produce a core as diminutive as an ARM6 or a processor as mighty as the R10000. Users with their eyes on growth (and the budget for an ASIC) may find a MIPS core an attractive way to bring the MIPS instruction set to a new, lower price point.

As Figure 1 shows, the 68K cores are not the most efficient in terms of performance per silicon area; that position currently belongs to LSI's CW4001 MIPS core. Compatibility with the 68K installed base, though, can be a powerful factor in Motorola's favor.

386 Still Tops with Many

Even with the growing popularity of bare cores, the majority of the market is still focused on conventional, standalone processor chips. For example, embedded renditions of the 386 architecture got a lot of play this year. Both Intel and AMD rolled out embedded 386 chips alongside their conventional 386s.

For starters, both companies left their basic 386 devices alone, the only changes being the addition of static operation and process tweaks to lower power consumption. Intel's Static Intel386SX, introduced this past spring, was quickly renamed Intel386SXSA, SA apparently denoting a static core and a 0.8-micron process (the i960SA notwithstanding). AMD's 386 has used a low-power static core from its introduction, with no changes needed for basic embedded applications.

Intel introduced the 386CXSA, the 3-V 'CXSB, and the 386EX in 1994, all with a smattering of on-chip peripherals and extra-low power-consumption numbers. The CX parts are enhanced with system management mode, A20 mask, and two more address bits. For DOS-compatible systems, either of these chips is a more attractive choice than a vanilla SX, yet there is nothing in the CX that would prohibit its use in a non-DOS system.

Intel's 386EX (strangely, not 386EXSA) is a no-excuses PC-compatible integrated processor. Intel is quick to point out that the EX is not a PC-on-a-chip (no

PDAs on Hold in 1994

After a surge of attention in 1993, personal digital assistants (PDAs, or general-purpose handheld computers) hit some rough times. The much-ridiculed Newton foundered in the consumer market but has found some success in vertical markets. For users such as doctors or salespeople, specialized applications avoid the need for handwriting recognition; in these areas, Newton has done moderately well. Apple refreshed its line last summer, but it does not expect to upgrade Newton to the ARM7 core until 1H95.

AT&T was not as lucky with its Eo communicators: poor sales forced the company to terminate the product line and close its Eo subsidiary. Casualties included AT&T's Hobbit processor and PenPoint OS. Although the Eo systems were well designed, their high cost and immature software prevented mainstream acceptance.

WinPad-based products also hit a snag. Microsoft's handheld operating system is undergoing a major overhaul, delaying its debut until 1996. The current version requires 2M of RAM and a 486 CPU to run at all; Microsoft would like to reduce these requirements to 1M and a 386 processor. A number of system vendors—including Compaq, Motorola, and Toshiba—have lined up behind WinPad, but the lengthy delay may cause some of them to focus on alternate plans.

WinPad's troubles were a major factor in the demise of VLSI's Polar and Draco projects. VLSI had developed these chip sets, in conjunction with Intel, for 386- and 486-based PDAs. Although they were nearly finished, VLSI withdrew them from the market, and dissolved its partnership with Intel, due to lack of customer demand.

General Magic released its PDA operating system this past fall, but only Sony is shipping a Magic Cap device *(see **0817MSB.PDF**)*. Motorola's Envoy, which combines its 68349 processor with Magic Cap and wireless communications, has been delayed until early 1995.

In addition to Envoy, Motorola plans to deploy an ARM-based Newton in 1Q95, to be followed eventually by a PowerPC Newton. IBM is said to be developing a PowerPC PDA using a proprietary OS. These PowerPC devices could appear around the end of 1995.

Despite our initial skepticism, Hitachi's SH7032 processor has gained a PDA design win: Amstrad (based in the U.K.) plans to launch such a device this spring. The company currently sells a PDA that uses three Z80 chips to handle the processing load, but the new system will replace the three with a single RISC device.

Although some pundits have claimed that PDAs are dead, we continue to see a strong market for this type of system toward the end of the decade. Current offerings are either overpriced or underpowered for most applications, limiting their sales. Growth will continue to come slowly in 1995, but in the long run, ongoing improvements in silicon technology will greatly improve the price/performance of these tiny computers, allowing them to deliver on their initial promises.

—LG

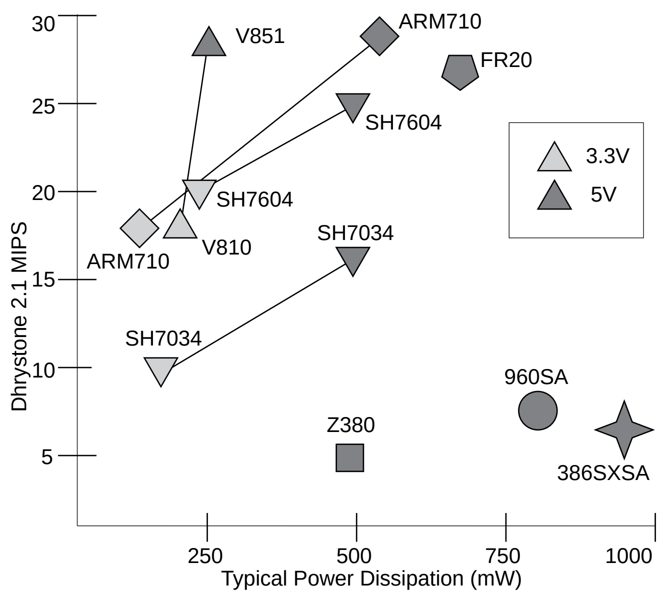

Figure 3. Among 32-bit embedded processors for low-cost products, NEC's V800 family offers good performance but requires little power. Zilog and Intel chips are the least efficient. (Source: vendor data)

ISA or DRAM control logic), but it is too far gone to be used for anything else. The 8259A-compatible interrupt controllers, 8237-compatible DMA controller, 82C54-compatible counter/timers, 16450-compatible serial ports, and PC-compatible address map and chip-select logic make it ideal for those who want to embed the 386 and DOS infrastructure.

Comparisons of Intel's 386EX with AMD's new 386 hybrid, the 386EM, are inevitable but misguided. AMD has chosen to eschew PC compatibility and create an embedded 386 component with on-chip I/O compatible with the venerable 80C186 (which AMD still produces—legally). The 386EM is unique as a '186 upgrade chip rather than just another integrated 386 derivative.

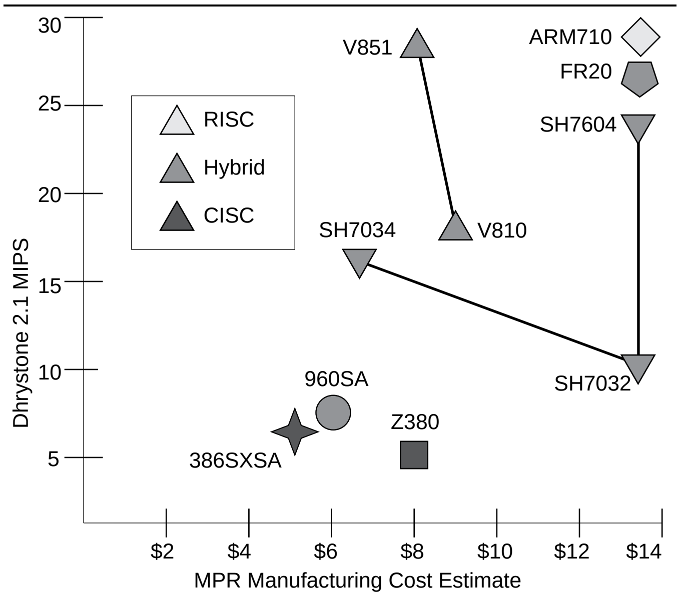

Figure 4. Hybrid RISC/CISC processors from NEC, Hitachi, and Fujitsu dominate the low-end of the 32-bit embedded spectrum, combining RISC-like performance with the low manufacturing cost of a CISC processor. (Source: vendor data, MPR Cost Model)

Japanese Vendors Double Up on CPUs

Fujitsu, NEC, and Hitachi all expanded their 32-bit embedded offerings in 1994. All three have licenses to high-end architectures, but each has created its own low-end family as well. The strategy has been to offer a well-known, well-supported 32-bit RISC CPU for the high end while developing a proprietary family for the low end. Designing an architecture specifically for low cost and moderate performance has allowed these companies to capture huge volumes through just a few design-ins.

Fujitsu was the odd one out until its quiet introduction of the FR20 processor in Japan this past summer. The FR instruction set is a mongrel mixture of CISC and RISC features designed especially for embedded consumer applications.

At this point, the FR20 has nearly no support infrastructure and, with only one part in the family, no migration path in either direction. The upcoming year will be crucial in the fledgling part's development. The FR20 has sufficient hardware muscle; Fujitsu needs to either build a critical mass of software support or win one big design before the FR can pay off for the company.

In addition to its PA-RISC line, Hitachi nurtures its own SH7000 family. The product line doubled in 1994, adding the high-end SH7604 and the low-end SH7020/7021 twins. The entire SH family achieves enviable code density with its fixed 16-bit instruction size and spartan feature set. The company targets video games, fixed-function PDAs, and other appliances where volumes are the highest. Witness the SH7604, which was designed for Sega's newest game system, as its unusual NTSC-compatible clock frequency testifies.

Thanks solely to the Sega design win, Hitachi's SH7604 now holds the place of honor as the world's highest-volume RISC processor, with shipments reportedly approaching two million per *month.*

NEC boosted the high end of its V800 line by pushing the top speed of the V810 to 50 MHz and introduced the new V851 in Japan. The entire V800 line, and the V851 in particular, are efficient designs with excellent MIPS/watt ratings, as Figure 3 shows. The V851's performance noses ahead of the SH7000 family as well as Zilog's new Z380, easily outdistancing the 386.

NEC's new V850 core (on which the V851 is based) gives the V800 series an edge on technical merit over Hitachi's SH7000 series and FR20. The V851 pays particular attention to power consumption (operating from 5 V down to 2 V) and power management, two increasingly important factors in embedded processing.

Two New Processors from Old Players

Zilog proved a scrappy competitor in the high-volume market, unleashing the Z380 into the dog-eat-dog world of 32-bit embedded microprocessors. This latest addition to the august Z80 line adds such modern features as 32-bit registers, static operation, and context-switch support. Even when operating at 3.3 V, the Z380 breaks into double-digit clock frequencies. Its stately performance places it at the top of the Z80 spectrum, but as Figure 4 shows, it is no match for other parts in its cost range, such as the V851.

National Semiconductor continues to produce its 32000 series, though it has turned its attention to the new Piranha family. Piranha is a near-RISC—like those from Hitachi, NEC, and Fujitsu—designed expressly for low-cost control. Theoretically scalable from 8 to 64 bits, even the existing 16- and 32-bit implementations use different opcodes. National has optimized each implementation to the point of incompatibility.

The company has recently taken an interest in Integrated Information Technology (IIT), a fabless chip company with 486- and 387-compatible designs as well as video compression expertise. The combination of National and IIT technology in a rumored x86-compatible embedded chip may move National into video coprocessors, color printing, or multimedia applications.

Motorola 68K Begins Rite of Succession

Motorola announced the heir apparent to the immensely popular 68K line, surprising many observers by simultaneously admitting that the 68K is running out of steam and offering the logical alternative for when it does. To architecture buffs, the announcement of ColdFire raises as many questions as it answers. The design strips off many of the features and functions of the 68K, leaving a fairly austere instruction set and a simpler exception model. Is this an endorsement of RISC principles in the service of embedded control? Or has Motorola simply jettisoned desktop features that aren't necessary for embedded applications?

Both, according to the company's presentation at the Microprocessor Forum in October. One of the factors limiting 68K performance was the necessity for backward compatibility with a 15-year-old architecture (something x86 users and designers know well). By breaking binary compatibility, ColdFire's designers produced a more efficient (i.e., smaller) core design with vastly better performance that still leverages many of the 68K's design tools as well as users' familiarity with the architecture.

ColdFire is firmly positioned between the 68K at the low end and the company's embedded PowerPC at the high end. This approach provides a stratified spectrum of performance and compatibility: ColdFire works almost like a 68K processor, with nearly the performance of a PowerPC chip.

It is unlikely that Motorola will license the ColdFire core to other vendors a la MIPS and SPARC, though the core will appear in the FlexCore program in 2H95 for any vendor interested in producing a custom part.

High Integration is High Risk

It was a rocky year for some integrated chip makers, proving that, while high integration might be attractive to designers, it's not always an ideal solution for the processor vendor.

Some of the bravest and boldest high-integration designs disintegrated during 1994 (see PDA sidebar). On the other hand, both Motorola and AMD are doing well with their application-specific microprocessor families. This dichotomy underlines the uncertain nature of producing—or using—a part that's too narrowly focused.

The economics of producing a highly integrated microprocessor are tricky, and the fate of Polar versus that of the 68300 and 29200 families shows how different the PC-compatible market is from the embedded world. Margins on x86 processors are fat, while the prices of PC-compatible chip sets are cut to the bone.

In the embedded marketplace, the opposite is true. Standardized chip sets are not the norm, and most applications are significantly different from one another, making customization necessary. The life span of an embedded system is measured in years, not the quarterly half-life of desktop systems.

Where Motorola has the breadth of product line, AMD has the performance edge. There are only five 29200 variations, and most are very similar, but they all outperform the 68300 family and give midrange 960 and embedded PowerPC chips a run for their money. AMD's emphasis has been on more generally required functions like DRAM control and DMA channels rather than specific timing, A/D, or communications features.

Intel has shown with its 960 that the traditional standalone embedded microprocessor is not dead. Simply offering a broad, compatible line of processors with no peripheral integration has won many converts.

PowerPC Gets Embedded for the First Time

Moving now into the more rarefied strata of embedded performance, IBM and Motorola simultaneously announced derivative PowerPC processors specifically for embedded control. Both offer low-voltage (3.3-V) operation and on-chip features that differentiate them from simply being smaller versions of the 601. IBM's 403GA is the weaker performer of the two devices but will be available sooner. Its peripheral mix (integrated DMA, interrupt logic, bus sizing) makes it more of a controller compared with the Motorola 505's more general-purpose features (FPU, larger caches). At about $40, both parts

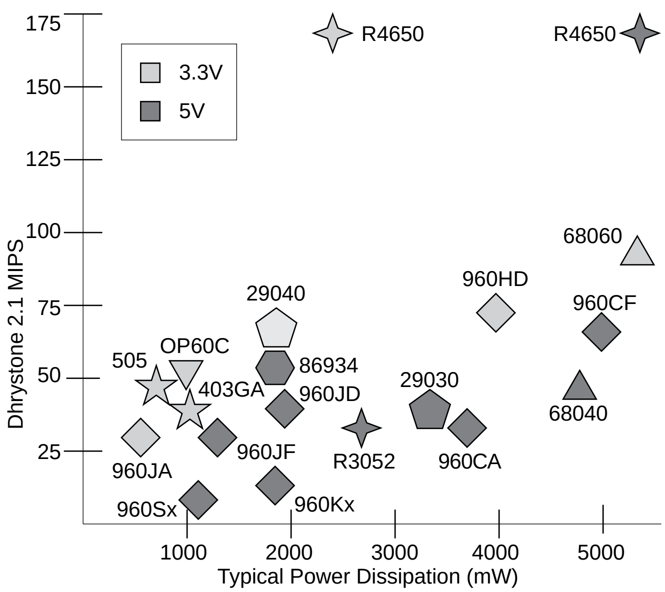

Figure 5. The field of high-end embedded microprocessors is crowded. The 3.3-V and 5-V parts each follow a predictable performance/power trend, but IDT's R4650 processor stands out from the pack. (Source: vendor data)

have been priced very competitively against other chips in their performance range.

Based on Motorola's backing, large peripheral library, and embedded marketing savvy, PowerPC could grow into a major force in the embedded community, much as it is threatening to do in the desktop market. While a PowerPC implementation will probably never be as small as a streamlined MIPS or ARM core, it can get small enough to be competitive. And, like MIPS, SPARC, and the 386, the attraction of an embedded processor

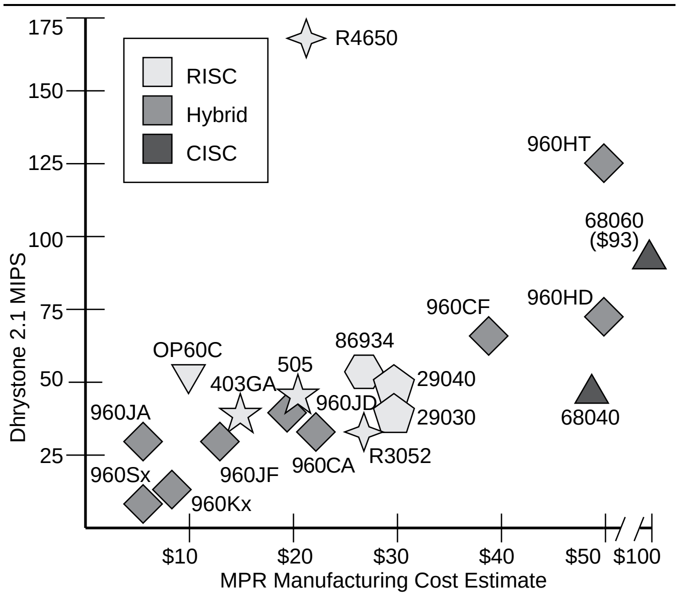

Figure 6. Intel's 960 series covers a broad range of performance, while Motorola's 68040 and 68060 are struggling to keep ahead of advancing RISC components. (Source: vendor data)

compatible with desktop CPUs and their tools can be hard to resist.

The number of PowerPC camp followers grew in 1994, embracing both new design wins and new semiconductor backers. Sending a mixed message to a neighboring ARM'd camp, both Apple and Panasonic are moving future products toward PowerPC chips. Oddly, both will continue to use ARM as well: Apple's Newton for low-range PDAs, and Panasonic's 3DO player because it's cheaper to include an ARM chip for compatibility than ROMs for the emulation software. Finally, two defectors joined the ranks in 1994: Hitachi (a card-carrying PA-RISC devotee) and Toshiba (holder of MIPS and SPARC licenses), though neither has plans to enter the embedded market with PowerPC.

Intel Obsoletes Own Chips

Intel strengthened its leading embedded RISC position by nearly doubling the selection of 960 family parts in 1994. First, the high-end 960CF got a process shrink and attendant speed increase from 33 to 40 MHz. Then, in midyear, the company effectively obsoleted its own midrange 960KA and KB—the chips that started the family—by announcing the J-series, which delivers twice the performance at about the same price. Finally, the 960 H-series was unveiled at the Microprocessor Forum, topping the entire line with three all-new devices.

The new 960 products give Intel the the broadest compatible line of any embedded processor family, as Figure 5 shows. With prices ranging from $10 to more than $160 in 10,000-piece lots, Intel has positioned the 960 as the answer to nearly any question. The hardest part for users is keeping them all straight, with more than 13 different—and often mutually competitive—implementations to choose from.

AMD left its seven-year-old 29000 RISC family essentially untouched throughout 1994, with the exception of one new chip aimed directly at Intel's heart. The 29040 holds no surprises but does offer a huge performance improvement over the 29030 in a pin-compatible socket. Figure 6 shows how a 50-MHz 29040 outruns the previous top of Intel's line, the i960CA, at the same clock frequency. The 29040 even cuts into H-series territory, battling the clock-doubled HD head to head.

The company gave a peek at the new superscalar 29K core in October, confirming that the 29K family has plenty of headroom yet. The 29K line now has almost as many variations as the 960. It also borrows a page from Motorola's marketing book, offering the more highly integrated 29200 series of parts against the 68300 family. Intel still offers no integrated 960 devices.

IDT is the only MIPS company offering standalone embedded parts rather than embeddable cores. In addition to its R30xx line, the new R4650 emphasizes IDT's already strong presence in high-bandwidth applications that require a high degree of processing power. The R4650 provides a low-cost opportunity to grow into higher performance MIPS chips. As Figure 6 shows, the IDT processor delivers exceptional performance, yet its manufacturing cost is no more than that of many slower chips.

Philips Semiconductor had shown little interest in moving upscale into 32-bit microprocessors, but that ended in October when the company bought HDL Systems (Sunnyvale, Calif.), which has a MIPS core. Philips, like Zilog, has a strong presence in the low-end (8- and 16-bit) microcontroller market. After sitting on a SPARC license for years, Philips now has access to a leading 32-bit architecture to round out its line.

A Scramble for 68K Sockets

The past year has been a pivotal one for business moves as much as for chip announcements. For Motorola, ColdFire may be too little, too late. Any self-aware embedded designer has known for some time that the 68060 would likely be the end of the 68000 dynasty, and years of easy upgrades would be over.

Given the typically long design cycles for embedded applications, those engineers have been looking for alternatives for many months, all the while deafened by Motorola's silence about alternatives. Redesigning hardware and software for the company's PowerPC line is no simpler than for any other new processor, so the blinders come off, and any vendor's chips are suddenly worth considering. Users of the 68000 are faced with multiple forks in the road; by the time ColdFire devices are shipping, many will have already chosen another path.

In a position to capitalize on that uncertainty are Intel and AMD, and to some extent, the MIPS and SPARC proponents. The first two companies offer broad, compatible embedded-processor lines; the latter have desktop processors with embedded versions for sale.

Intel's strength with the 960 family is its broad choice of parts that blanket the sweet spot in price/performance. Except for very high or low end systems, a 960 user has the comfort of knowing there is room to grow (or shrink). Knowing a part is currently available with 5× the performance necessary for today's needs is like looking into the future: as applications inevitably grow larger and more complicated over time, the designer is reassured, knowing a processor will be there when the time comes.

Development Tools Hold the Key to Success

The popularity of the 386 is not due to its raw performance, which is clearly mediocre compared with other microprocessors in its price class. Rather, the attraction is in the wealth of development tools built up over the years for PC developers. With little adjustment, that infrastructure is now serving the hungry embedded market, just as the 386 itself is.

Embedded Events of 1994

Motorola finally unveils 68060 *(see **080502.PDF**)* and reveals the genesis of ColdFire at the Microprocessor Forum *(see **081405.PDF**)*. Company enters CPU core business with FlexCore *(see **0807MSB.PDF**)*.

IBM and Motorola announce embedded PowerPC 403GA and RMCU505 *(see **080601.PDF**)*.

Intel trumps 960 line with J-series *(see **080803.PDF**)* and again with H-series *(see **081302.PDF**)*.

Hitachi's SH7604 takes over from i960 as world's best-selling RISC processor, thanks to Sega *(see **080203.PDF**)*. The SH7020 and 7021 also debut.

AMD spins 386 chips for embedded control *(see **0803MSB.PDF**)*, and again with 386EX *(see **0813MSB.PDF**)*.

The 29040 gives AMD a boost *(see **080805.PDF**)*, then RISC line goes superscalar *(see **081404.PDF**)*.

Sharp and VLSI present ARMs *(see **0803MSB.PDF**) (see **0805MSB.PDF**) (see **0813MSB.PDF**)*.

Fujitsu adds FPU to SparcLite family *(see **080804.PDF**)*, and sneaks out its embedded chip *(see **081305.PDF**)*.

National follows with Piranha *(see **081502.PDF**)*.

Zilog's Z380 proves there's still life in the old workhorse *(see **080901.PDF**)*.

LSI Logic gets the nod from Sony for PlayStation *(see **080902.PDF**)*.

NEC releases first V850 part *(see **081303.PDF**)*.

R4650 leaps into MIPS lead *(see **081504.PDF**)*.

The SH7000, V800, and FR20 families enter the market as relative newcomers. They all offer excellent performance for the price, but superior performance is the minimum cost of entry into a crowded market such as this. What these competitors need is a larger support base: more compilers, more debuggers, more hardware tools, and more knowledgeable local support staff. Apart from one or two strategic design wins apiece (primarily in video games), none of these chips has the broad support necessary to make embedded designers want to take the plunge.

Piranha is in much the same boat as the Japanese contenders. National is no longer a household name in the embedded world, and it will take all the company's attention to make Piranha a viable alternative to entrenched leaders from Motorola, AMD, and Intel. Alternatively, National could follow the stealth marketing approach that has worked so well for Hitachi and try to garner one or two big design wins, making broad-based support irrelevant.

During 1995, PowerPC will become a significant force, and still more 960 and 29K chips will appear, battling over the same territory. But even as sales of mainstream embedded processors grow, the real volume will be in consumer electronics, and those designs will go to the companies with the smallest and fastest cores. ♦

