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Backgrounder

Ampro's EnCore™ Family of Processor-Independent Modules for Embedded Systems

Ampro's EnCore family of processor modules for embedded systems helps developers shorten new-product design cycles by three to nine months[1] by allowing them to concentrate on the application-specific parts of their systems. The EnCore concept demonstrated its appeal to the embedded community by winning *EDN* magazine's "Innovation of the Year" competition in its category in 2000.

By developing systems around EnCore modules, embedded designers can concentrate on the systems' interaction with the external world and on value-added product-differentiation. "Bringing up" the processor portion of the design, a tedious process that contributes nothing to product differentiation, has already been taken care of by Ampro. Ampro provides a reference "application-specific logic board" (ASLB) design to accelerate target-board development.

Why PCI? Because it is a processor independent bus supported by a wide range of peripherals and delivers reasonable performance.

In announcing EnCore, Ampro said, "EnCore is a new platform for the efficient delivery of high performance CPU technology, enabling accelerated development of embedded systems." The wording was carefully chosen:

- *Platform* implies a product line or product family, with multiple family members. Ampro will have announced five EnCore modules by the end of 2001.

- *Efficient delivery* means that EnCore provides the easiest means of incorporating new generation 32-bit and 64-bit processors into an embedded application. Efficient in terms of project schedule, development resources, cost and software development.

- *High performance CPU technology* means that, unlike most off-the-shelf CPU board products available today, EnCore architecture encompasses more than just Intel architecture CPUs. In fact, a MIPS32-based module has now been announced. The sole bus interface is PCI. The I/O signals are those of standard peripheral devices. In fact, EnCore baseboards are completely CPU-agnostic. As a result it is far more than theoretically possible to remove a Pentium-based EnCore module from a baseboard and replace it with an EnCore module based on a RISC processor and have the hardware come up and run immediately. There are some software issues, but not as many as one might think.

[1] See Page 5 for breakdown.

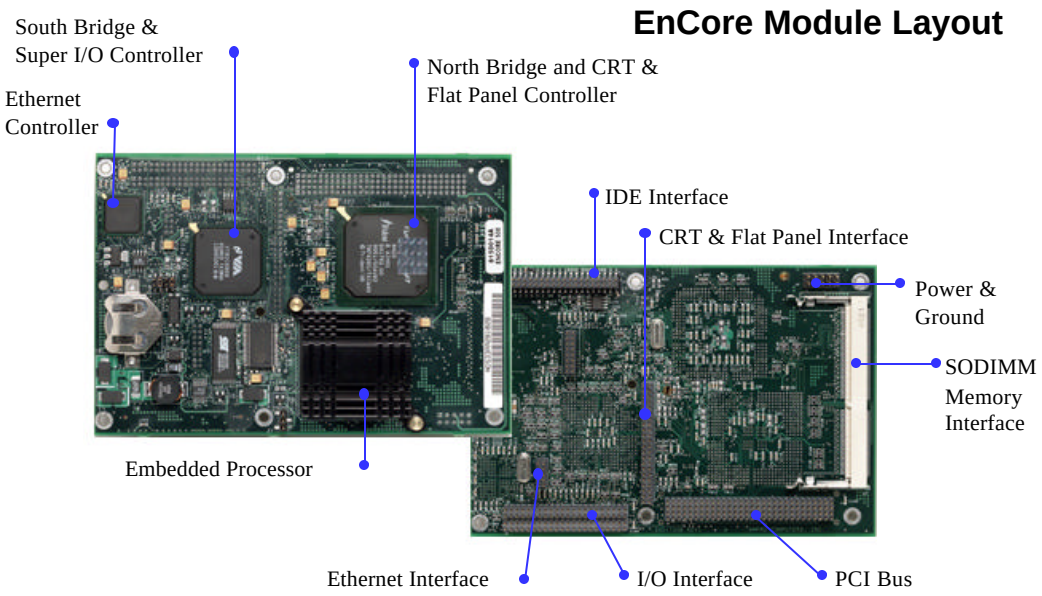
- *Accelerated development* means faster time to market, the embedded system developer's holy grail and key to leadership in any applications market segment.

- *Embedded systems* are the fastest-growing section of the microprocessor market.

MARKET

EnCore establishes the basis for a new segment of the embedded processor marketplace: OEMs who currently design custom CPU boards for their products based on a commercially available microprocessor, but are actively seeking a flexible time- and cost-saving alternative. Industry analysts estimate that in 2005, 500 million processors will be sold into embedded applications this year with barely 2 million of them built onto standard, off the shelf CPU boards. Estimates for 2005 predict over 16 billion dollars in potential revenue for this segment.

A market shift: Historically, Ampro sold its products to developers who essentially performed an integration function; EnCore is for OEMs. Integrators match a CPU board such as Ampro's Little Boards or CoreModules with additional IO boards, an enclosure, a power supply, some disk drives and assemble a system. EnCore is for OEMs, who traditionally design their own boards and do not buy off-the-shelf. OEMs represent a much larger segment of the embedded market than integrators.



DETAILS

Each EnCore processor module (like the Pentium-based EnCore 500 above) comprises a microprocessor, support chips, memory and peripherals, assembled on a compact circuit board with a standard PCI system interface. Ampro also supplies a CD with a correctly configured implementation of selected operating systems. Ampro offers EnCore modules representing a wide range of processor price/performance and power consumption points. Commonality of

interface and form factor, together with volume production using commodity components and standard PCB assembly techniques, make it possible for Ampro to offer EnCore modules at attractive prices.

Standard EnCore I/O includes 10/100BaseT Ethernet, AC97-compatible sound, USB, serial, enhanced parallel ports, as well as floppy and IDE controllers. Other options can include video and flat panel support.

EnCore modules have no direct I/O cable connections. All the I/O is clustered onto three 44-pin connectors mounted on the *bottom* of the board (for connection to an application-specific logic board or baseboard), along with separate 10-pin connections for Ethernet and power/ground. A separate 120-pin connector brings the PCI bus from the EnCore module to the baseboard.

Generally, an OEM would use an EnCore module along with its own custom baseboard that brings the I/O off the board. This provides application-specific logic such as specialty networking, an FPGA or ASIC, DSP or other types of I/O. The PCI bus provides the basis for adding application-specific logic, in the form of PCI-bus compatible ICs on the baseboard. While Ampro can quote the design of a custom baseboard, most users will design their own.

HISTORY

The EnCore family is an outgrowth of Ampro's nearly 20 years of experience in the embedded business – years in which the company contributed the PC/104 and PC/104-Plus standards and the EBX form-factor Little Board for non-backplane, single-board computers to the embedded community.

However, all these products, and their equivalents from other vendors, operate as stand-alone computing systems (or can be adapted with other off-the-shelf I/O boards), which means they require direct connection of power supply, utility and other I/O cables. This fills the boards with connectors, adding to cost and limiting the amount of logic that can be included.

To enable designers to add their own custom logic, developers began asking Ampro for full-custom processor boards or semi-custom modifications of standard products. However, custom designs do little to improve time-to-market or resolve software-porting issues. Semi-custom designs based on standard products frequently meant removing unused connectors, and replacing those that are used with stack-through or vertical versions, which results in up-front non-recurring engineering and setup costs that must be amortized over relatively small production volumes.

Ultimately, Ampro came to realize that it would be far more efficient to design a standard, general-purpose platform to interface to customer's application-specific logic boards. This approach provides all the efficiency that had previously been lacking.

Two factors contribute to this efficiency. One is the ability to offer a variety of processor architectures, performance levels, and price points with a common form-factor. The other is that, thanks to PCI's penetration as a system-bus architecture, driven by its stature as the de-facto

personal computer standard, there is now a system interface that scales from x86 to the highest-end architectures in the embedded processor arena.

Ampro feels that the ability to offer a variety of processors will be critical to EnCore's success. For one thing, embedded developers tend to be loyal to specific processor architectures. They learn their strengths and weaknesses (and the work-arounds for those weaknesses) through successive product development cycles and invest in processor-specific development tools. Consequently, each architecture has its devoted following. However, pushing against this loyalty is a new set of advanced microprocessor architectures (including MIPS, ARM and others) that have captured significant mind and market share with embedded developers. Ampro believes it can play a significant role in bringing these new architectures to a whole new class of embedded developers who develop products with annual sales volumes in the 500 to 50K unit range.

HOW ENCORE SAVES DEVELOPMENT TIME

Most embedded systems use a single logic board (or at most two) to reduce cost. When designing the logic to drive the application, the design team must design what is essentially a CPU subsystem, including memory interface, bus structure and fundamental peripheral devices. Although this part of the design is almost incidental to the key elements that will differentiate the product in the market, the CPU subsystem is by far the most complicated and time-consuming part of the design. Modern CPUs, especially the high clock speed integrated ones, are notoriously difficult to work with.

Software for embedded applications can be divided into two categories – system software development and application software development. For developers developing their own custom CPU logic, perhaps the most onerous part of the design is the task of bringing up a CPU from scratch and porting system software, including an RTOS (Real Time Operating System), to the custom CPU design. Bringing up a CPU from scratch is a significant design and debug task, requiring specialized tools.

Issues include configuration of the operating system for the CPU *as utilized* in the design, including memory map and I/O ports. Initialization logic must be included for each of the key peripherals or bridge chips used in the design, and all of these may be different, or may not have been used before in this combination. Debug at this stage is frequently a guessing game as the designer strives to find the right combination and initializations of on-chip registers to move to the next step. Modern, integrated CPUs can have hundreds of registers requiring initialization.

After this step, drivers must be written for peripheral devices. Drivers may already exist for the chips being utilized, for the selected OS or for other OS, or drivers may need to be written from scratch. The drivers and initialization code need to be gathered into a complete Board Support Package, and the OS built and tested as a system.

The EnCore platform allows developers to skip all these steps. Major popular OS are already configured to run on the module and are fully supported by Ampro. For the EnCore 500, supported OS include QNX, VxWorks from Wind River, embedded Linux variants from REDSonic and LynuxWorks, and Microsoft's Windows 98, Windows 2000, Windows NT and Embedded Windows NT.

A reasonable breakdown of development time saved by using an EnCore module might include:

Development Function	Time Required
• Design CPU	4 – 12 Weeks
• Configure and Port OS	2 – 10 Weeks
• Bring Up, Debug, and Verify CPU	2 – 6 Weeks
• Simulate and Debug OS Configuration	2 – 12 Weeks
• Total Delay Before Application Code Integration can Begin:	10-40 Weeks

COMPETITION

While most of EnCore's competition comes from in-house development, other companies have validated Ampro's vision by introducing products somewhat similar to EnCore. Ampro intends to compete vigorously on both features and price, which should be welcome news for the embedded systems community.

In terms of functionality, EnCore modules look like some of the so-called card PCs, but offer more integration. For example, no card PCs are available with a Pentium CPU at this time. Also, unlike so-called "system on chip" devices, EnCore actually provides higher integration, including up to 512MB SDRAM, 3D graphics, LCD support, Ethernet, sound, and more.