PC/104 Technology Expands to Embrace ARM Processors

The migration of ARM CPU architectures to the PC/104 realm is opening new options for low-power, more compact system solutions.

by Susan Wooley, Micro/sys, Inc.

Although the x86 processor is by far the most popular CPU to be used on PC/104 boards, recent industry trends toward smaller, lower power devices have made the PC/104 platform an attractive choice for "non-x86"-based processors. These CPU devices, which include high-performance ARM processors through low cost microcontrollers, are designed specifically for embedded applications.

When an ARM processor is integrated into PC/104 CPU boards, users are able to expand their system by selecting from the large market of stackable I/O modules available to PC/104 users. Or a user may choose to design their own I/O board and power it with an off-the-shelf ARM CPU to run their application. Either way, users benefit from a stable form-factor and footprint around which to build their system and packaging.

Why, then, have x86 processors been so popular on the PC/104 platform, while non-x86 processors have not? Traditionally, x86 processors have offered embedded designers the advantages of the PC world: widely available and popular operating systems, commonly used development tools and a wealth of drivers for I/O peripherals with PC compatibility. However, these advantages have come at a cost and presented a host of challenges: power-hungry hardware, high heat dissipation and resource-hungry operating systems.

Power-hungry hardware has made battery operation difficult to implement at best. Even the lowest-power x86 variants require substantially sized batteries. Excessive heat dissipation, which is related to the power consumption, may mean that fans will be required in enclosures or it may restrict the environments into which PC/104 can go. Many common x86 operating systems were designed for desktop use, not embedded applications, so simple, elegant designs are burdened with the heavy operating system resource requirements, including large amounts of memory or storage. Therefore, many embedded applications were not reasonable for implementation on the PC/104 platform. Handheld devices would be the most obvious example.

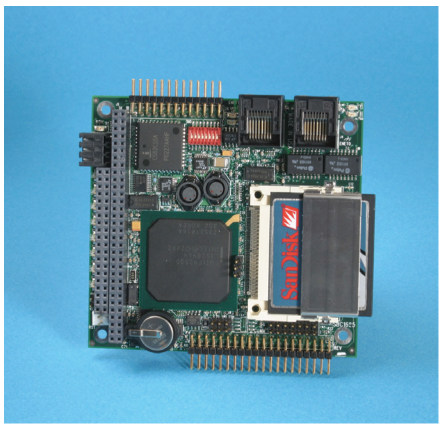

Figure 1 The Micro/sys SBC1625, based on the Intel IXP425, has dual Ethernet and four serial ports for communication-heavy applications.

As CPU manufacturers have targeted specific embedded applications, their chips have addressed these issues. The devices run at faster speeds, require less power and run cool enough to operate in fanless enclosures. In parallel, software vendors have provided easier to use, lower cost runtime environments that leverage off of the developers' knowledge of PC development tools. As a result, processors such as Intel's XScale—based off of the ARM core—have recently begun to make headway into the PC/104 market. Now, PC/104 with its traditional advantages of speed-to-market and debugged development platforms is also opening up new areas into which system designers can take their embedded applications (Figure 1).

Matching CPU to Environment

As with any embedded application, the first step in determining which PC/104 processor board will be best suited for an application includes a careful examination of the runtime environment of the system: the physical requirements, the software environment and the required I/O interfaces.

With a careful examination, the processor of choice often begins to fall into place. The most important factor in determining which CPU to select is whether or not the CPU has the performance to keep up with the application. This is not a simple matter, because it is dependent on the CPU type, clock speed and other factors such as the amount of cache and the chipset. Benchmarks are generally of little use because they rarely measure the things that are critical to a specific application. Therefore, it is always a good idea to get at least twice as much computing power as you may expect to require. This allows for errors in estimation of the processor required, provides room for features to be added later, and for system expansion as the application grows and matures over the years.

The next step is to evaluate each board against two physical constraints of its environment: power and temperature. PC/104 x86 boards have typically ranged from 80C188 processors through high-end Pentiums. The power required for operating such boards, on average, is from 100 mA on the low end through multiple amps for the high-end Pentiums, depending on the SBC board. These power consumption figures, even on the low end, are beyond the range of four AA cell batteries. This creates the need for an AC power connection, a vehicular power source or a more significant battery for these PC/104 boards.

Contrast this to the XScale 32-bit RISC processors from Intel. The device is implemented with fewer transistors than its Pentium counterpart, directly reducing the die size and therefore the power required to operate the chip. Typically, the XScale runs at 200 – 533 MHz with I/O support for functions such as memory controller, flat panel display, USB client, serial ports, card slot interface, and digital I/O. The typical power consumption for this type of chip will be in the 200 mW to 1500 mW range. For the system designer, speed and I/O approaching that of a PC desktop has become available with a much more attractive power requirement (Figure 2).

With the power requirement so low, the constant challenge of heat dissipation is also made easier. Operation inside an enclosure without a fan (reducing power needs even further) is completely realistic assuming the other components can operate within the specified temperature range. Since PC/104 implementations are often all about size, the packaging is smaller and easier when there is no need to accommodate fans. The reduced heat allows the system designer to simplify and decrease the size of the entire system.

The ubiquitous cell phone and PDA, which run on small batteries and without fans, are obvious examples of the opportunities these processors provide. Applications implemented on the PC/104 platform with an ARM processor can begin to reach into embedded areas that have traditionally been "difficult". These applications might include telemetry, remote data collection, handheld display controllers and solar powered controllers. An off-the-shelf PC/104 processor board, capable of operating on

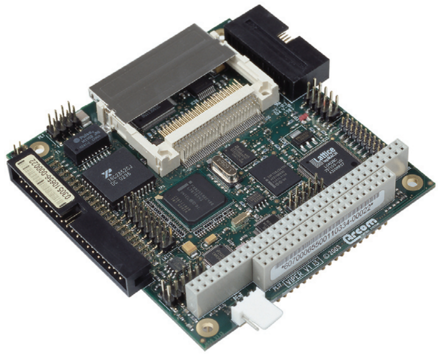

Figure 2 The Arcom Viper, based on the Intel PXA255, has an integrated LCD controller for graphical user interfaces.

batteries and without fans at 400 MHz becomes the building block of these types of OEM applications. And the shorter development cycle that PC/104 users experience can enable them to be in the marketplace in a more timely manner.

Why Has PC/104 Been Slow to Migrate to ARM?

Users of XScale processors must face a tradeoff for not being x86-compatible. Electrically speaking, PC/104 requires ISA-bus signals to communicate in a stackable format. This allows users to add, by plugging in boards, the I/O functionality required in their application. Without the x86 compatibility in the CPU chip, PC/104 vendors must implement the PC ISA-bus signals with additional circuitry and components on the single board computer. This requires space on the board and adds a moderate cost to the SBC.

The implementation of the PC/104 signals can be done at various levels, the most common of which is the I/O level. In the system specification phase of a project, users need to verify that the PC/104 board they plan to plug on to the CPU will have access to the signals needed for supporting the device. This being done, the developer will be able to expand the capability of his XScale processor to meet his control needs.

A traditional challenge for non-x86 processors has been the operating system. Unlike x86 platforms where there are many well-known operating systems such as DOS, many versions of Windows and a plethora of real-time operating systems, the available operating systems for other processors are more limited. Additionally, the operating systems and development tools available in the past were considerably more complex than their x86 counterparts. However, a few alternatives have become more popular. If using the XScale processor, Linux and Windows CE are two of the best-known options.

If using Linux, a special Linux version that compiles for the processor being used will be needed. This should be available with the purchase of the development kit from the CPU board manufacturer. Typically, a bootloader is stored in onboard flash, which allows the user to download applications and run them. With Linux, the developer has access to many well-received tools, such as the GCC compiler. Because many of these same tools are used to develop for a desktop PC, knowledge that is gained developing for the desktop will be helpful in developing for the XScale.

With Windows CE, the development tool chain known as Platform Builder is different than that used for desktop PC Windows variants (XP, NT, 95/98, 2000), but it comes with examples that give a starting point for developing code. As with Linux, there is typically a bootloader that is resident in onboard flash, which allows operating system images to be loaded into flash and executed.

The PC/104 Embedded Consortium's recent moves toward larger form-factors, such as EBX and EPIC, are providing the additional board space needed, on otherwise cramped boards, to implement the electrical interface to PC/104 or provide single board solutions that are ARM-based. Larger form-factors should allow even more complex non-x86 CPUs to find a home on boards with PC/104 expansion.

Users needing lower power and fanless operation will benefit greatly from these new alternatives in CPUs. The growing software choices available to users of non-x86 architectures gives embedded system designers choices in operating systems that would not have been considered just a few years ago. And larger form-factors point toward even more alternatives being available in the future. All this adds up to PC/104 offering more processor choices than ever before, as system designers seek to gain the advantages provided by the wide selection of PC/104 plug-on I/O. ◢

Micro/sys
Montrose, CA.
[www.embeddedsys.com.]