The Case for Smaller Form-Factors in Industrial Systems

The time has come for a new set of legacy-friendly small form-factor standards that will give mainstream industrial systems a path forward to adopt these new technologies.

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Over the last couple of decades, computer electronics has spread rapidly beyond the desktop into embedded applications such as medical, industrial, test & measurement, communications, transportation, military, avionics, kiosks and gaming. At several points along the way, new standards for embedded boards have appeared when breakthrough bus and interconnect technologies have emerged. As the performance density of silicon continues to increase, reaching the 65 nm geometry node, the time is ripe for a new wave of small form-factor standards to usher in the latest high-speed serial technologies and smaller components.

Beyond the Board

Especially in long-lifecycle applications, demand for small form-factor boards and components has recently increased dramatically, fueled by the demand for smaller, more portable systems and devices. These burgeoning requirements for new small form-factor systems—such as battery-powered devices and industrial systems—mean that new sets of specifications are needed that take advantage of small-geometry components and take into account several issues beyond the board itself. In addition to the single board computer (SBC), these specifications must also address multiple, competing system-level considerations of smaller systems operating in often harsh environments. These considerations include more efficient thermal dissipation, I/O expansion and reliable interconnects.

Current advances in semiconductor technology are enabling either more performance in the same amount of space, or the same performance in a smaller space with the additional benefits of lower cost and lower power consumption. In many embedded applications an increase in the performance of individual boards or subsystems is simply not needed. Although the high-performance end of all application areas gets the most attention and is well served by multicore CPUs, many embedded systems require only modest processing performance with less power and cost in a smaller space.

At this lower end where processor performance is only a few hundred MHz, the production volumes of systems designed for individual application areas may not be high, but collectively they are significant. These application areas include industrial control, data acquisition, automation and process monitoring. Historically, this market segment has relied on either desktop computers with industrial I/O cards attached, or embedded boards designed with desktop or laptop processors and chipsets. This segment is at the mercy of desktop-style ICs, since the volumes of these secondary markets usually don’t justify the development costs, including design and mask sets, of unique ASICs.

Ultra Mobility

Once the power dissipation of desktop processors rose past 20 watts and never looked back, the creation of the mobile (notebook/laptop) class of processors saved this lower-end, secondary market segment and many others like it. Low-voltage (LV) and ultra-low-voltage (ULV) mobile processors sport thermal/design/power (TDP) ratings of 5W to 15W and allow fanless reliability in embedded applications.

Over time, though, the once lean-and-mean chips designed for mobile systems have gradually become dual-core 20-30W CPUs and hot, high-performance chipsets. Once again, the industrial market is being saved by actions in the consumer and enterprise spaces, made possible by 90 nm and 65 nm process technologies.

The Ultra-Mobile PC runs an entire notebook-class operating system and full-fledged applications, including Web browsers. This emerging category of handheld systems prioritizes longer battery life and smaller footprint over performance (Figure 1). In 2008 and beyond, the smaller, lower-power CPUs and chipsets from this new primary market will lead to a plethora of single-core, low-power, portable and AC-powered embedded systems in the 500 MHz to 1 GHz range.

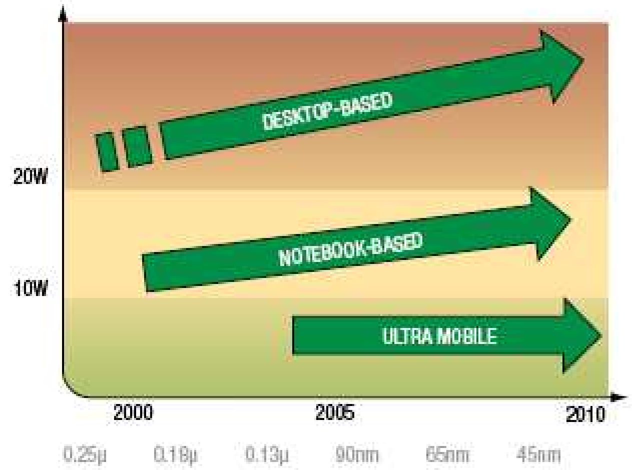

Figure 1 Smaller chip geometries are making possible a new class of lower-power, ultra-mobile compute platforms that prioritize longer battery life and smaller footprint over processor performance.

Here, the modular approach is often used, and the good news is that this trend will continue. In automation and process control, for example, multiple smaller, lower-performance CPU boards or modules are networked together in a distributed system, where not only built-in connectivity but also lower power and cost are vital.

Legacy-Friendly

When the need to upgrade legacy systems is included as a consideration, the situation becomes even more complex. A system designed for long-lifecycle applications may be upgraded several times throughout its lifetime to increase functionality and/or performance. Especially in industrial applications, there are often tighter space constraints in systems that must be fanless for the purposes of high reliability and maximum uptime, but where low cost and modest performance are also important.

New chipsets feature high-speed serial interfaces instead of the low-speed or parallel ones of the past such as ISA, EIDE, COM ports and even PCI, all widely used in industrial applications. Any upgrade to these systems must take into account existing designs and their needs in terms of functionality, interfaces and three-dimensional constraints. A “legacy-friendly” approach focuses on methods that let designers continue to use legacy peripherals and smoothly transition to their replacements over time, rather than forcing multiple, widespread re-designs all at once.

Since many embedded systems and subsystems are physically located in space-constrained environments, often within entirely different fittings, the chassis’s form-factor may be dictated by considerations other than the operation of the system itself, such as pre-existing, non-electronic form-factors or the need to fit into an opening where mechanical components reside. Because thermal constraints are a major factor in the design of small embedded systems, chassis designs must also take these into consideration, including convection-cooling or fan-cooling methods.

For example, in upgrading a portable medical system, designers must consider how boards are plugged into each other and how they relate to the display, as well as other considerations of how everything is positioned in three dimensions within the chassis: where connectors, display cables and power supplies will be located, as well as how the SBC interfaces to the display.

New Technologies Enable Smaller Form-Factors

Among the new technologies available to long-lifecycle system and device manufacturers of smaller systems are chips based on 90 nm and 65 nm processes. This silicon includes lower-power and highly integrated x86-based processors—many with self-adjusting speed and power management options or in fanless ULV versions—as well as low-power core logic chipsets and memory that are enabling sub-10W design platforms for computing and communications systems. For example, board designers can now use the 90 nm 500 MHz Eden ULV processor from VIA Technologies, with a maximum operating power of just 1W and idle power as low as 100 mW (Figure 2).

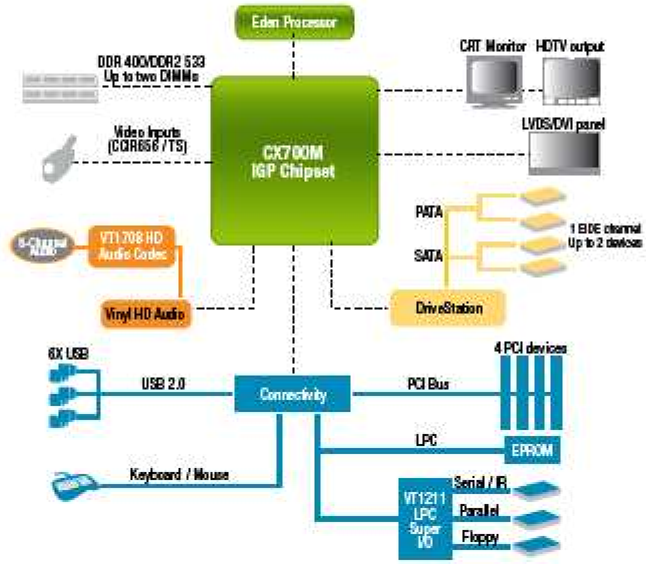

Figure 2 An entire embedded computing and communications system with maximum system power of under 10W can be built using highly integrated CPUs and core logic silicon based on the latest 90 nm process technology, such as VIA Technologies' 500 MHz VIA Eden ULV processor and the VIA CX700M single-chip system media processor.

Even the storage components of these systems must be smaller and more thermally efficient, whether they utilize solid-state storage (SSD) devices or 2.5-in. and 1.8-in. rotating drives with the space-efficient Serial ATA (SATA) interface. For example, there is a variety of embeddable USB-compatible devices and vibration-tolerant disk drives for rugged applications already available.

In addition, higher-density connectors from Samtec and others feature improvements for ruggedness, and high-speed serial interfaces for board-to-board interconnects are available to replace slower, space-consuming parallel interfaces. These newer interfaces include PCI Express, SATA, I^2C and Low Pin Count (LPC) Bus, which is the replacement for the ISA bus in desktop PC architecture. Gigabit Ethernet and USB 2.0 are the key subsystem- and system-level interconnects, and are becoming increasingly prevalent on board processors. Newer board and module formats include SBCs, computers-on-module (COMs) and stackables that bring these serial interconnects to carrier boards or I/O expansion modules.

Especially as boards and systems get smaller and as the number of small form-factors proliferates, it has become more important to focus on robust, high-speed connector technologies than on merely the details of board sizes. The emphasis is on precisely fitting enclosures with a minimum of cabling, which reduces manufacturing costs, a major area of concern. However, the use of off-the-shelf components to speed time-to-market—another major OEM concern—dictates the creation and consolidation of board outline sizes, since it is not easy to design enclosure mountings for different-sized boards with connectors located in different places.

A New Small Form Factor Consortium

In order to make all of this work well, the industry needs standards. A new standards group focused on small form-factors, named the Small Form Factor Special Interest Group (SFF SIG), was formed in September. This consortium has taken as its charter the development, adoption and promotion of specifications for circuit boards and related technologies that will help electronics equipment manufacturers and integrators reduce the overall size of their next-generation systems. The SFF SIG was formed in order to address the broad scope of new market needs, as well as existing specifications that are not yet being managed by a trade group.

Consolidating suppliers around standards, facilitating cross-platform interoperability and developing common expansion schemes are all goals of the SFF SIG. As history indicates, standards with rich “ecosystems” endure the test of time. The SFF SIG also appreciates the extensive investments in off-the-shelf products made by system OEMs and seeks to preserve those investments. The SIG’s philosophy is thus to embrace the latest technologies, as well as maintain legacy compatibility and enable transition solutions to next-generation interfaces. It seeks to enable practical, mainstream, real-world applications rather than extremely high-performance and high-power dissipation systems.

To that end, the SFF SIG has formed three working groups to address product categories that are key to the development of next-generation smaller systems. The SBC Working Group is discussing new small form-factor SBCs. The Modules Working Group is developing a specification for a new, small computer-on-module (COM) form-factor. The Stackables Working Group is developing a legacy-friendly stackable interconnect technology that will apply to a number of existing SBCs for smoothly integrating new, high-speed, serial technologies into legacy systems to preserve OEM investments in I/O, cabling and enclosure designs. In addition, the SFF SIG’s Board reviews specifications created outside the organization and submitted by vendors who wish to establish true, open, managed SFF standards.

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