Buses and Boards

Making the right choice

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Abstract

From motherboard to backplane to blade based computer systems, the choices are numerous. This paper will cover the markets and trends within those markets that influence decisions made by board suppliers. Discussion will focus on the various form factors, the development and evolution of industry standards, and the consortia that support and develop these standards, including VITA, PICMG, and others. This paper will conclude with suggestions for choosing the right form factor for your application.

I. Classes of Boards

There are many classes of boards, unfortunately, they do not fit in well-defined buckets. The following is but one way of defining the different classes of boards. This is a guideline at best, many boards crossover between even these definitions.

A. Reference platforms

Reference platforms are designed by semiconductor manufacturers, provided to potential customers as a way to showcase new processors and chipsets. You can use these to shorten your hardware and software development time using their processors and chipsets. There is no set form factor for the industry and very little consistency within options from any particular semiconductor supplier.

The designs are often available for licensing. The supplier can provide you with Gerber files, bill of materials, schematics and other design aids. You can then modify the design to meet your specific goals.

On rare occasions, developers will deploy reference platforms "as is" in low unit volume products.

B. Busboard

Busboards have been around for over 30 years. They are defined as busboards because they use a parallel computer bus over a backplane for interconnection to other boards. Some, like VMEbus and CompactPCI bus, are designed to be inserted into a chassis with card guides to align them to a bused backplace. Others, like PCI bus cards insert into slots on a motherboard. Slot cards is an alternate term for busboards.

C. Blade

Blades are a relatively new class of boards. They are defined by their use of a switch fabric or high-speed serial interconnect instead of a parallel bus. A parallel bus may be used locally on the blade but it is usually not carried to the backplane. Blade configurations have emerged to better address cooling, density, interconnect, and expansion issues. Blades are often used when large amounts of data needs to be routed quickly to multiple destinations.

The big breakthrough has been improvement in Ethernet performance to the point where it has become a reasonable alternative to parallel buses. Ethernet is ubiquitous, inexpensive, and easy to use. Ethernet is the dominate fabric choice, with PCI Express second, and serial RapidIO used in some cases.

All a blade needs to operate as a standalone computer is an external power supply. In this case, it starts to cross the definition to motherboard.

Blades come in three types, general purpose, I/O or network processor, and switching blades. Switching blades are needed to configure a system into one of many different topologies from point-to-point to a full mesh with each blade connected to the next.

Examples of common blades are IBM Blade Servers, AdvancedTCA, MicroTCA, and VPX.

With the emergence of PCI Express, vendors are sure to develop even higher-performance motherboard and blade configurations.

D. Carrier

Carrier boards are designed to be host to some form of add-in module. Carriers have been gaining a lot of interest in the past few years as new mezzanines and modules with processor intelligence have been emerging on the scene, creating demand for host support.

Though most carriers are custom built for a specific application, almost any other class of board could be a carrier. It is not uncommon to see several mezzanines stacked on a VMEbus board or even a mezzanine. Designers are very creative in the use of carriers.

There is no standard for carriers but guidelines for usage are provided in many mezzanine specifications.

E. Mezzanine

Mezzanines are designed to offer modularity to some other form factor. Missing or expansion features are added through mezzanines. Sometimes mezzanines are used to gain extra board space in the third dimension.

Mezzanines have a long history. They originally were very custom to specific suppliers. Over the years, there have been several efforts to provide standards that drive conformance to form factors that could gain widespread use.

Most board companies have several options. We continue to see small custom modules on most any design where functional density is a challenge. Board designers gain real estate by using small modules that fit in any available space. At the same time, PCI boards and PMCs have become more standardized. PCI boards are used in cost-sensitive applications where space is not a major issue while PMCs are used on boards with severe height restrictions. Most slot cards and many blades allow for the addition of a PMC or AdvancedMC form factor.

The xMC series is one of the best examples of standardized mezzanines; PMC, XMC, FMC, and AdvancedMC are just a few of the many choices.

F. COM: Computer on Module

Computer on Module or COM is a newer class of board. The efforts to define standards has gained momentum in the past few years. These are small, self-contained modules that include a processor. They are designed to be small and can operate with or without a carrier. COMs often have a common expansion strategy that allows them to be nested or interconnected in a standard fashion. COM Express is the most common variation, though dozens of others fit this class of board.

G. Motherboard

Motherboards are the grandfather of computer boards. In the early 1990's efforts began to create standards for different form factors within the motherboard class. Many standards have evolved from traditional PC motherboards.

Motherboards are often installed in what many refer to as "pizza box" chassis. These 1U and 2U chassis can be stacked in racks and offer a very high computing density in a small space. They can be connected quickly via Ethernet and replaced without disrupting the entire system. However, pizza box stacks have cooling and density issues that some applications cannot tolerate.

Embedded applications tend to have more rigorous environment conditions and life cycles as part of their requirements. As a result, motherboards designed for embedded applications have more environment options and much longer life cycle commitments from suppliers

Embedded motherboards are heavily Intel Architecture influenced. They also come in a wide variety of styles and sizes.

Examples include; EBX, ETX, ITX, and PC/104.

II. TRENDS

Many trends impact the decisions that board suppliers make when defining their roadmaps and developing new products.

A. Fragmentation of markets

By the very nature of the wide range of usage models for embedded computing, the market is very fragmented. The fragmentation will only get worse as new uses for computers are discovered. In most cases, the needs of the users are diverging with little opportunity for convergence

In cases where form factors target specific application segments there is some convergence and the industry players are working to define products that can be used by a broad range of designers. The telecom industry is a great example of how an industry has worked with suppliers through PICMG to define board and system technologies to address the greater cause.

Market fragmentation causes the more choices to emerge but because there are so many choices, prices tend to stay high.

B. Embedded is moving mainstream

Only two percent (2%) of the world's microprocessors go into PCs; the other 98% are embedded systems according to Jim Turley, Embedded Technology Journal.

For years, the embedded market has taken a backseat to the desktop and server markets. Now, as those markets have reached saturation, suppliers are looking for new outlets for their products. Both Intel and Microsoft have made very bold moves recently that help them establish beachheads in the embedded markets. Intel is more aggressive with longer product life cycles and in developing processor technology that is more suited for embedded applications. The news of Intel's acquisition of the leading real-time operating system supplier, Wind River Systems, further strengthens Intel's position.

Microsoft is not to be left out. Recent Windows 7 announcements have included the embedded strategy at the same time as the desktop and server products announcements were made. They have also worked diligently to consolidate and improve the embedded Windows roadmap.

Becoming mainstream could lead to larger players in the market with lower prices and but with fewer options. Innovation could increase as competition heats up.

C. Impact of SoCs and FPGAs

Advances in systems-on-chip (SoC) processors and FPGAs are putting a real squeeze on board designers. In the past, it used to take complete boards of one size or another to provide the functionality required by an embedded computer. SoCs and FPGAs now have the capacity to incorporate much of this functionality and maintain the level of necessary performance at the same time. Throw in the fact that FPGAs are relatively easy to customize and off-the-shelf boards start to become obsolete except as host carriers for the SoC and FPGA silicon.

Common board types, especially mezzanines and small form factor boards can be easily replaced by either a SoC or FPGA. This could reduce further the number of commercial board suppliers and products in the market.

D. Consumer electronics trends to watch

The Consumer Electronics Association has highlighted four trends in the consumer electronics space that are having the greatest impact on electronics.

Green as a Purchase Factor: Materials and packaging; energy efficiency; recycling programs. Consumers are embracing the green movements and demanding products that are environmentally friendly.

Evolving Command, Control and Display: Touch screens; voice activation; motion sensing; 3D displays. The man-machine interface is a major challenge. As devices become smaller and more functional, connecting to humans is difficult. We will see a lot of innovation in this interface in the coming years.

(No) Strings Attached: Cutting cords; attaching services; shifting usage locations. It is all about being mobile. Devices of all types will have wireless connections changing the usage models.

The Embedded Internet: Localization; utilities and services; communication and commerce. Devices of all types are being enable with browser capability making it possible to exchange data in ways not thought possible. Intel talks about 15 billion connected devices in their embedded computing campaigns and is pushing this revolution.

The consumer market is the single biggest influence on electronics. Other application markets will need to adapt and then adjust as necessary to take advantage of the buying power of the consumer electronics market.

E. Customization

All board suppliers offer custom products and design services to some degree, some more than others. For most vendors, it is a majority of business. Mass customization is the next natural evolutionary step for boards.

Lower cost customization processes could lead to more appropriate choices for lower unit volume users. Prices could move higher if improved processes for customization are not developed and implemented by board manufacturers.

III. Consortia and Forums

There are dozens of consortia that contribute technology to the embedded computing markets. These range from those doing components such as processors and chip sets, to those doing board and system standards, and software.

VITA: Creates and promotes standards used by developers and users having a common market interest in critical embedded systems using real-time, modular embedded computing systems. www.vita.com

PICMG: Develops open specifications for high performance telecommunications and industrial computing applications. www.picmg.org

Blade.org: Developers and users dedicated to expanding the blade ecosystem and to accelerating the growth and adoption of innovative technologies and solutions in the blade market. www.blade.org

PC/104 Embedded Consortium: Develops and promotes the PC/104 standard for embedded computers. www.pc104.org

VXIbus Consortium: Supports and promotes the VXIbus for the test and measurement community. www.vxibus.org

PXI Systems Alliance: Promotes and maintains the PXI standard. www.pxisa.org

Power.org: Developers, tool providers, and manufacturers united to lead open hardware innovation for industry standards and applications based on Power Architecture technology. www.power.org

For a complete list visit: OpenSystemsMedia's consortia list at www.embedded-computing.com/consortia.

IV. Factor This: Board Selection Criteria

What should a designer look for when selecting a board form factor? Consider the following issues:

- **Backplane versus motherboard**: This is a key decision. Factors to consider include I/O management, expansion, cooling, and ruggedness. Many of the newer backplane solutions, commonly called blades; use serial networking interconnects so that single boards can operate in physically separated boxes or in a larger chassis with several boards together. Larger systems that require a lot of expansion capability tend to lean toward the backplane choice. Smaller, more constrained applications use a motherboard of some style. Sometimes a large product line will use motherboards at the low end and backplane style for the high end. Be sure to understand the range of your product needs.

- **Size**: Size is always important. Some applications are very space constrained. Every square centimeter is prime real estate, and its use must be optimized. Larger boards tend to be less costly because they present fewer manufacturing challenges, but they do consume valuable space. Do space studies to determine which trade-offs make sense for your project.

- **Chassis choices**: Selecting a form factor is not the only step. Do you need a chassis? What will you be using for an enclosure and power supply? Will you be managing one as part of your project? Many form factors have a great selection of chassis. Busboards, slot cards, and blades are dependent on the chassis to provide the mechanical support they need for good selections. PC-style motherboards are well supported, but they may not be as appropriate for embedded applications. Many of the small form factor board standards leave the chassis decisions and design up to you.

- **Functionality Expansion**: Will you need to add more functionality later? How that decision is made can dramatically influence the form factor choice. Does the board use a standard interface that already has a large selection of add-in options, or is it proprietary or limited in choices? Some expansion options take a large chunk of valuable real estate while others are low profile and space efficient. Be sure to check how well accepted the expansion option is if you think you need or will need it. Expansion options are a great way to add functionality to an already deployed system, improving chances to gain revenue from upgrades.

- **I/O management**: Some form factors are better than others on I/O management. Improvements in the location, number, and type of I/O have shaped the evolution of PC motherboards. As new types of I/O such as USB, flash cards, SATA, and IEEE 1394 have taken over the serial and parallel connections of the past, board designers have made appropriate changes in the way I/O is managed by the board. Small form factor boards have even more unique choices better suited for embedded applications.

- **Power**: Something seemingly as straightforward as getting power to the board can be a huge obstacle. Backplane-based boards have power pinouts as part of the standard, but motherboard-based solutions are all over the map. Some are better than others when it comes to defining the power connectors and required voltages. The best solutions allow designers to use commonly available power supplies and connectors. It can be frustrating to have a "paperweight" that cannot be conveniently powered for lab development, so be sure the power solution is understood beforehand.

- **Thermal Management**: How does a particular form factor handle cooling? For some applications, this is a minor concern, but the majority will have some issues to consider, especially if you are using high-end processors for the project. Some form factors give you the choice of air, conduction, or even liquid cooling. Some are built into the board specification while others require some creative mechanical design and plumbing.

- **Ruggedness**: Into what type of environment will your product be deployed? Standard PC market boards do well in benign home or office environments but are not suitable in mobile, industrial, or military applications. Picking a form factor that can handle your environment is high on the list of items to consider. Some form factor specifications have shock and vibration options over a range of environments. Again, form factors designed specifically for embedded applications tend to do a much better job managing rugged requirements.

- **Standards**: Form factors endorsed and managed by a standards organization can be very important to many applications. A standard-supported form factor is more stable, well thought out, qualified, and usually has a planned evolution path. All this can help you manage future life-cycle issues as you improve and evolve your design. Standards developed by an established organization have the inputs of many technical experts who have had a chance to test and vet the design inputs. Ecosystems for well developed standards tend to be larger and more robust giving you better product choices.

- **Suppliers and Support**: Having choices in suppliers is just as important as choice in form factors. While our focus is mostly on de facto and true standards-based form factors, many are proprietary to a single company. This is less of a risk for one-off products that have a limited life span, but having a solution supported by several suppliers gives you options for prices, support, and life-cycle management. Who is the real target audience of the supplier you choose? PC market board suppliers are by definition focused primarily on the PC market. In choosing these boards for embedded use, you may be stuck with difficult revision management issues with these suppliers. Many companies with an embedded computing focus offer PC-style motherboards, providing support and life-cycle management while still leveraging PC motherboard technology. This comes at a slight cost premium, but the return on investment can be beneficial farther down the road.

- **Operating Systems**: The software landscape has evolved to keep up with the changing needs of the embedded computing industry.

Real-time operating system choices blossomed in the late 1990's. They number of suppliers has consolidated the past few years but the solutions are very mature.

Linux became a solid embedded operating system solution with release 2.6 where a number of key real-time features were made part of the base kernel. Now several companies are building on that base plus adding some extensions of their own. Linux has firmly gained a foothold as a solid choice.

Embedded Windows has gone through several improvements since Windows was first considered for embedded applications in the mid 1990's. Now Embedded Windows 7 is a key part of the Microsoft operating system strategy.

V. SUMMARY

As you can see, the choices abound. If all else fails, many of the vendors also will customize a board leveraging an existing design and adding features and sizes suitable to your application. In fact, many of the "standard" form factors emerge from such projects. Choose wisely.