Shrinking Boards for Telecom OEMs

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To keep pace with the expansion propelled by the explosive growth of the Internet and ever-increasing voice traffic, telecom companies are searching for new and better ways to fit more equipment into central offices and wiring closets. While backhoes and ships are furiously laying optical fiber as fast as possible, the same fast pace is echoed in the effort to build more infrastructure to take advantage of that optical fiber. These efforts lead to a situation where telecom OEMs have an increasing need for more function in less space.

PROVIDING CHOICES FOR THE OEM

Manufacturers that supply board-level products to the telecom industry are rallying to meet this need with a variety of options ranging from shrinking board formats and increasing component density to providing innovative space-saving systems that allow more efficient use of rack space. Compact-PCI single-board computers (SBCs) and PC-type motherboards (hereafter referred to as "motherboards") are finding more and more use in the telecom industry as they rapidly adapt to that specialized needs.

Telecom OEMs use long-life motherboards as a low-cost solution for enterprise tasks. These motherboards share the same form factor as those found in desktop PCs but are designed to be more robust and have a longevity of five years or more. Higher quality components are used in their manufacture, and the manufacturer stands by the boards with a solid warranty and an agreement to continue to make the boards and parts available for a pre-determined time. In addition, the manufacturer notifies the OEM in advance of any component changes and works with the OEM to ensure that replacement parts are suitable for the OEM's application.

Although inherently not as flexible as CompactPCI, these boards allow the OEM to take advantage of the rapidly advancing technology features that evolve from the high-volume consumer-driven PC market. It also allows them to use a product that remains current for a longer period of time. The selection of legacy I/O components (serial and parallel ports, video ports, IDE ports, etc.) is carefully chosen to meet the OEM's needs. Additional options, including Ethernet controllers and flat-panel interfaces, are also offered.

CompactPCI systems are designed as part of a modular architecture, giving the OEM more flexibility and ability to upgrade. However, the cost is three to five times more than a motherboard. CompactPCI is finding increased use in central offices and has more specialized options available, such as daughter boards populated with an array of DSP chips for performing functions such as voice compression and echo cancellation (see Fig ?). Dual processors can also be specified to increase performance. Telecom systems using CompactPCI boards are built to NEBS (Network Equipment Building Specification) standards that specify environmental parameters such as shock, vibration, temperature, and humidity. Fundamental to the development of CompactPCI was the ability to leverage the silicon and software developed for desktop systems into more flexible, very dense systems.

Manufacturers are also beginning to offer space-saving chassis options. Motherboards can be housed in 1U chassis, less than two inches high, designed to be stacked in a conventional 19" rack and consume far less space than the traditional 4U desktop chassis. It's now possible to package CompactPCI systems in less than half the floor space typically required (see Fig. ?).

In addition to supplying the OEM with a system of building blocks, including various boards and integrated chassis, manufacturers are involved in a constant process of shrinking footprints and increasing component densities. This is driven by the needs of the OEM, and it is the OEM that must decide when to pay for what. There is an ongoing need for a solution that is flexible enough to be configured in a manner that minimizes upgrading so the product can remain in place longer. Then there is always the need to make it smaller.

THE SHRINKING PROCESS – WHAT THE MANUFACTURER CAN DO

The standard form factor of the PC motherboard has shrunk over a period of years from the ATX form factor to the FlexATX form factor (see Fig ?). While the CompactPCI form factor is fixed, the same process that enables the motherboard to shrink enables the CompactPCI board to carry more function. The goal is always to increase the spatial density of functionality and performance. The process of deciding when and where to do this involves many factors, with the ultimate deciding factor being cost. The following engineering techniques are examples of what manufacturers can do to increase density:

Component integration

Beginning at the lowest level, efforts are made to keep chip counts as low as possible. In addition to using standard off-the-shelf Intel processors and supporting chip sets, custom chips are often designed when they can be cost-justified. The advantage of using custom silicon has to be weighed against additional development cost.

ASICs are used to implement core logic functions such as memory controllers, PCI bridges, and I/O ports. FPGAs are used for tasks such as routing signals and interfacing with the BIOS and flash memory. The designers will often utilize IP (Intellectual Property) modules from various third parties when designing custom silicon.

Multi-layer boards

Once the chip count is minimized, the task then becomes how to place them as closely as possible on the board. Here, spatial density is limited by the real estate required for placing connecting traces. The solution is multi-layer boards. The standard for motherboard design is four-layer boards, for cost reasons. CompactPCI boards, however, will frequently have eight to ten layers, with more possible.

Hand layout

Key to saving real estate is the efficient layout of circuit traces. While sophisticated software tools are available for performing auto-routing, none can come close to the density achieved by a good CAD engineer. The CAD engineer must have a certain savvy for discovering efficient trace routes, and at the same time must have a good understanding of the type of signal on each trace. Good layout is key to proper circuit operation.

Proper use of ground planes and knowledge of how to lay out transmission lines are mandatory to ensure proper signal isolation. As processor speeds increase and traces get closer together, the traces themselves become components in the circuit. The CAD engineer must have a solid understanding of analog design techniques and transmission line theory to ensure that signals are properly decoupled and signal delay times are not excessive.

DESIGN CHALLENGES FACED BY THE MANUFACTURER

As board density increases, so do the design challenges. Increasing component density raises the following concerns:

Thermal

Because components are so closely packed, it is imperative that the subject of heat dissipation be addressed early on in the design. In the case of motherboards, a temperature profile is constructed by using temperature probes placed on hotspots around the board. Software simulation can also performed to identify trouble spots early in the design phase. Typically, the boards are designed for a 55° C ambient airflow over the board. In some situations, the manufacturer may also specify additional requirements, such as the volume of airflow required across a board or the spacing between cards, to ensure that the temperature of individual components remain within their specified operating range.

In all cases, the burden of meeting the environmental parameters specified by the manufacturer falls on the OEM. Careful cabinet design and fan placement become an integral part of the system design process.

Power

As boards evolve towards more dense functionality, the overall trend is towards more power per square inch. Within that trend, however, is a sawtooth effect. As more and more components are squeezed onto a footprint and as processor speeds go up, power requirements tend to also go up. Then, at some point, new technology steps in with a decrease in line width and a subsequent lower power demand, and the power levels go back down. Then the process starts over again.

Power usage often becomes an issue when the latest high-performance desktop processors are used in a design. For example, in CompactPCI systems, where each slot is rated for a finite amount of power, a board with a "hot" processor may not be usable without giving up another slot to satisfy power rating and airflow requirements.

EMC

Designing for EMC (Electromagnetic Compatibility) is still largely a black art, requiring a solid understanding of analog circuit theory, as well as a large resource of practical experience. As performance and speed increases, there is more potential for EMI (Electromagnetic Interference). Aside from proper layout of the board itself, special consideration must be given to shields around I/O connectors and how these shields contact the chassis after the board is installed.

Prototype boards are pre-scanned and relative EM measurements made in-house to determine problems early on. Independent testing labs are then utilized to characterize pre-production boards. Finally, the production boards must be tested and certified to pass FCC and CE requirements.

DESIGN TRADEOFFS

Some tradeoffs that the manufacturer and the OEM must consider are:

Quality vs. cost

In most cases, the OEM makes this decision according to the market it serves. For example, the component that will probably fail first on a motherboard is an electrolytic capacitor. This is because the electrolyte will eventually dry out over time. Tantalum capacitors do not have this problem, but they have a longer lead time and are more expensive. Given the current availability of tantalum capacitors, it doesn't make sense to use them for motherboard designs, although they would be the preferred choice. In the case of CompactPCI, however, cost is a lesser issue, so the lead time for obtaining tantalum capacitors would be the determining factor.

Deciding what features to add or drop

The manufacturer will typically start with standard definitions and try to design platforms that appeal to a large market, then listen to what the OEM wants. If the customer wants something different and has the volume to justify the cost, then the manufacturer will add or remove features as the customer desires. Some examples are whether to include one or two Ethernet interfaces, additional serial ports, or custom expansion interfaces such as PMC (PCI Mezzanine Card). In the end, the OEM decides.

ENSURING SUCCESS

In addition to a good design, the manufacturer must take additional steps to ensure the quality of the final product:

Working with component suppliers

It is extremely important to build strong relationships with component suppliers, especially when the customer wants the manufacturer to agree to produce the product for a specified number of years. Parts must be qualified and suitable replacements found if a supplier obsoletes a component. From supply, cost, and quality perspectives, a good relationship is imperative should problems arise.

Qualifying parts and maintaining an AVL (Approved Vendor List) gives the manufacturer control over component prices and the overall quality of the product. The customer can be notified of any changes to the AVL so he can determine how it might impact his use of the product. EMC issues and software driver performance are also areas of customer concern affected by part changes.

Testing

At the design phase, DVT (Design Verification Testing) is utilized. The DVT group works to validate third-party drivers (network, video, audio, chipset, etc.) for a variety of operating systems such as Windows 98*, Windows 2000* Windows NT*, Solaris*, varieties of Linux*, and real-time operating systems such as VxWorks*.

The boards themselves are "designed for test" and laid out to accommodate ATE (Automatic Test Equipment). During the manufacturing process, the board is placed on a "bed of nails" and test points accessed by automated measurement equipment.   This diagnostic tool tests for short circuits and open circuits and measures component parameters.   In addition, a functional test is run on every board after it is manufactured, dramatically lowering the failure rate in the field.

Four-corner testing is performed in an environmental chamber. During this process board voltages are cycled between their extremes while the ambient temperature is cycled between its extremes.

Burn-in is often done on CompactPCI boards when requested by the OEM, but hardly ever on motherboards. Because the manufacturer uses qualified parts and does extensive testing during manufacture, the number of fall-outs that would show up during a burn-in is not high enough to justify the cost.

The Option of IPMI

The manufacturer makes IPMI (Intelligent Platform Management Interface) an option on CompactPCI boards. This is a system feature that allows the OEM to query the status of various components in the system. It was designed initially for large server systems and addresses the management of large and complex computer platforms. At the board level, it incorporates a microcontroller on the board that acts independently of normal board functions. It is not currently an option on motherboards, but future motherboards designed specifically for the telecom market may include this feature.

In summary, physically shrinking boards is not the total solution to meeting the growing demand for capacity and infrastructure in the telecom industry. The manufacture offers the OEM the building blocks and options that allow him to design the best solution to fit his need. It must not only allow him to maximize performance per square foot but also deliver the flexibility required to design a system that is upgradeable and long-lived.
