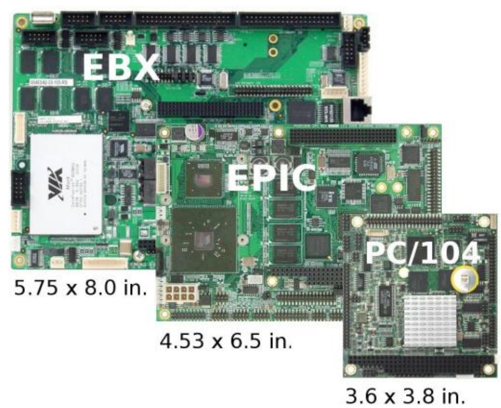
Embedded Computing: The Next Generation

Merging the best of PC/104- and COM-style architectures

Moore's Law Meets PC/104

Much has changed since PC/104 spawned the stackable single board computer (SBC) market back in the early 1990s. On the functional and silicon level, nearly every facet of embedded computing technology has advanced in accord with Moore's Law, doubling in density or performance every two years.

In the embedded PC realm, x86 CPUs have progressed from 32-bit sub-100MHz 386s to 64-bit multicore multi-GHz chips such as Intel's Core 2 Duo. A full PC system's worth of functionality now resides within one or two surface-mount chips. Bulky, parallel system buses and I/O interfaces are dissolving into a handful of high-speed serial signals. Terabyte hard drives fit in the palm of your hand, and multi-gigabyte flash modules are the size of a dime.



The functions of an IBM PC have been crammed into ever-smaller "stackable SBCs"

Despite this rapid evolution in embedded CPU, bus, and interface technologies, advancements to embedded board- and module-level architectures have lagged.

In recognition of this situation, the embedded hardware ecosystem has begun scrambling to define board and module standards that can accommodate new technologies such as Intel's Atom and Core 2 Duo ULV processors, PCI Express, SATA, USB 3, and HD A/V. This impending transition is starting to shatter the mold of the past two decades, as various new (and largely untested) embedded board and module standards have started to emerge.

In this article, we describe one such evolutionary advancement – Embedded-Ready Subsystems – which provides a higher-level embedded system design paradigm than what's come before.

But first, some perspective…

DIAMOND SYSTEMS CORPORATION
1255 Terra Bella Ave.
Mountain View, California 94043 USA

Tel (650) 810-2500
Fax (650) 810-2525
www.diamondsystems.com

Stacking up Solutions

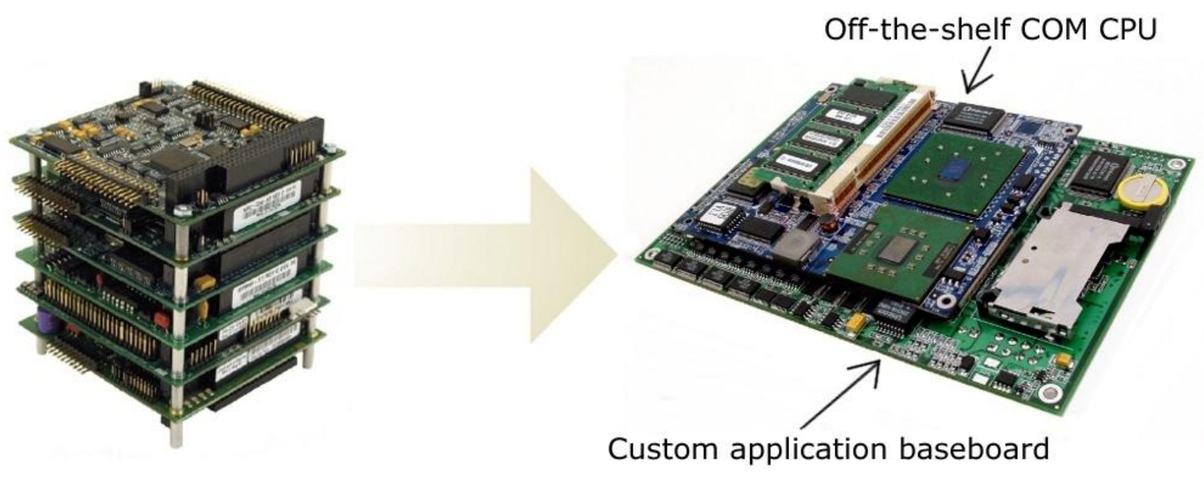
In the traditional stackable-SBC architecture, an off-the-shelf single-board computer – which could be EBX, EPIC, or PC/104-sized, among other form-factors – serves as the heart of the embedded system, and one or more standard or custom PC/104-style expansion modules are added to tailor the system to a particular application.

While this works fine in many cases, the stackable-SBC approach can't satisfy the size, weight, power, thermal, and complexity restrictions of many OEM applications. In addition, stackable systems generally are not cost-effective for large volume applications.

Consequently, SBC vendors have been forced to develop custom, application-specific SBCs for many of their customers. Because this process bears the burden of high development costs, time-to-market uncertainties, and component obsolescence nightmares, it's only appropriate for high-volume applications that will require several thousand boards or more.

The COM Compromise

In an attempt to alleviate the need for full-custom designs, another board-level computing approach arose: the combination of standardized "computer-on-modules" (COMs) -- which encapsulate CPU and generic system I/O functions – with custom COM baseboards that integrate real-world I/O and other application-specific functions.



Converting a PC/104 stack into a two-board sandwich

The COM + baseboard approach offers several key advantages, including:

- **Reduced development costs/risks/time** – restricts custom design requirements to application-specific functions, thereby reducing development costs and risks, and shortening development cycles

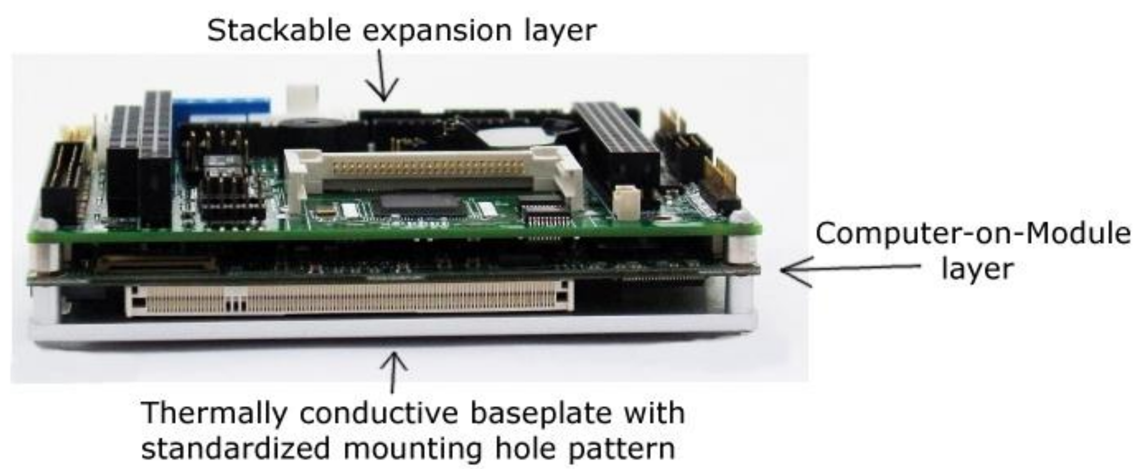
- **Advanced core computing technology** -- immediate access to the latest CPU and system I/O technologies, without having to invest in reinventing the wheel
- **Performance flexibility** -- a single base design can be offered in a range of price/performance models, or can be upgraded in the future
- **Cost reduction** – standards-based COMs have achieved high-volume commodity status, especially in contrast to most SBCs
- **Increased time-in-market** – having the computing core on an interchangeable COM protects against component obsolescence and facilitates lifecycle extension

Despite its many benefits, however, the COM + baseboard approach bears a substantial price tag: the time, cost, and risk of designing – and maintaining – the requisite custom application baseboard.

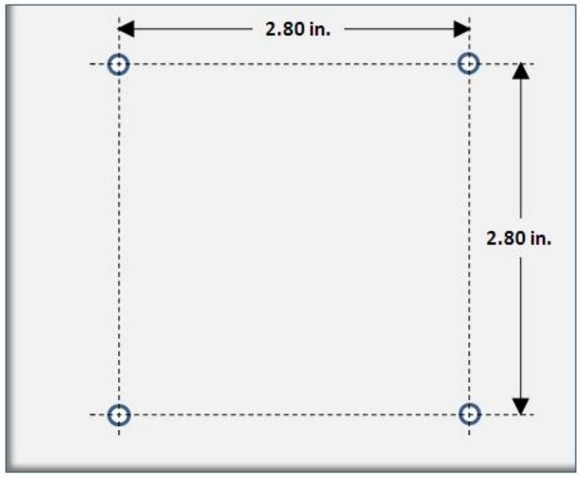
Introducing the "Embedded-Ready Subsystem"

A new approach offers the best of both the SBC and COM worlds. The "Embedded-Ready Subsystem" builds a bridge between the two, by integrating a selected COM standard (e.g. COM Express) plus a selected modular expansion standard (e.g. SUMIT-ISM), along with a reliable mounting and thermal management solution.

Best of all, *this approach does not require developing a custom baseboard!*



In this manner, the Embedded-Ready Subsystem combines the benefits of COMs with the flexibility of modular, stackable expansion. Additionally, its large thermally-conductive baseplate serves to provide a standardized mounting-hole pattern, similar in concept to that defined for VESA displays.



The Embedded-Ready Subsystem's heat-conducting baseplate features a standardized mounting-hole pattern

With the Embedded-Ready Subsystem approach, choice of CPU form-factor (ETX, COM Express, PC/104, EPIC, EBX, etc.) and expansion bus type (PCI-104, SUMIT, PCI/104-Express, etc.) become less important than overall functionality requirements. Essentially, it's bus and CPU format agnostic, thus opening up the system architecture to a wider range of options ("It's the mounting holes, stupid!").

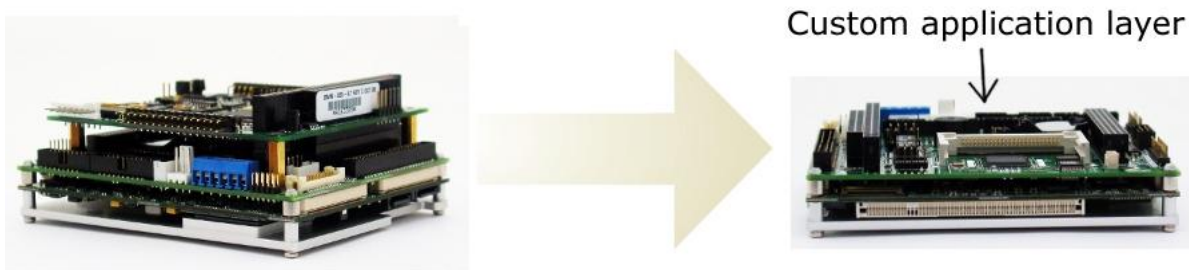
Consequently, embedded system developers have a much wider range of off-the-shelf options available, from which to assemble the target system's embedded electronics. This enables enhanced focus on the application's *unique* requirements – typically value-added real-world interfaces and operational software -- and reduced distractions from *generic* embedded computing issues, such as keeping up with state-of-the-art CPUs, chipsets, memories, interfaces, buses, and relevant BIOS technologies.

The overall advantages of Embedded-Ready Subsystems relative to conventional stackable-SBC and COM+baseboard alternatives are summarized in the table below.

Advantages of Approach	Stackable SBCs	COM + Custom Baseboard	Embedded-Ready Subsystems
Protection from component obsolescence	Yes	Partial	Yes
Multi-sourced components	Yes	Partial	Yes
Fast time to market	Yes	No	Yes
Fully off-the-shelf solution	Yes	No	Yes
Comprehensive thermal management solution	No	Yes	Yes
Access to latest CPU and system I/O technology	No	Yes	Yes
Bus and form-factor agnostic	No	No	Yes
Standardized mounting across multiple formats	No	No	Yes
Support latest buses/interfaces within one footprint	No	No	Yes

Beating Custom at its Own Game

What about applications where cost, space, or power consumption constraints demand a more optimized solution than what's available with off-the-shelf components? In this case the Embedded Ready-Subsystem's stackable expansion layer plus one or more expansion modules (below left) can be replaced by a custom application layer, which integrates the application's unique functions and interfaces (below right). This architecture would still retain the use of COM modules because of the overwhelming advantages compared to a full custom all-in-one design.



Optimizing an Embedded-Ready Subsystem via a custom application layer

Despite being burdened by a costly development cycle, for annual volumes of several thousand units or more, this partially custom Embedded-Ready Subsystem approach provides many significant benefits over traditional full-custom SBC designs:

Advantages of ERS-based custom design	**Disadvantages of ERS-based custom design**
Compact shape with standardized mounting holes	Lifecycle maintenance of a custom board
Efficient thermal solution	
Easy upgrades for increased performance or avoiding CPU obsolescence	

Conclusion

For several decades, core embedded technologies have continually advanced in density and performance, in general agreement with the principles of Moore's Law. Board- and module-level embedded approaches, on the other hand, have done little to keep up with this trend. A new approach – Embedded Ready Subsystems – promises to enable modules-based embedded development to keep pace with new advances on an ongoing basis.

The Embedded-Ready Subsystem approach to embedded system integration incorporates the best of what the industry has to offer at this time. Plus, it's flexible enough to keep pace with new developments as they arise.