Introduction

OEMs face increasing challenges in new product development. These include diminishing hardware engineering resources, a rise in processor complexity and the perpetual demand for bringing solutions to market faster and at a lower cost. Today, design decisions often include buying silicon and designing a custom board around it, or personalizing an off-the-shelf board from a single board computing (SBC) vendor. Thankfully, SBC vendors can ease these challenges by providing the engineering and manufacturing expertise to jump-start the OEM’s design by providing faster time to market, lower development costs and resolution to the complex processing solutions.

SBC Design Challenges

Customers who develop network-connected devices for industrial manufacturing, power system management, health care facilities, transportation systems or similar applications often require real-time, deterministic, reliable operation in a harsh environment. To meet these requirements, high-performance industrial SBC applications typically come with the following features:

- Performance greater than 3000 million instructions per second (MIPS)
- High level of integration to simplify design for seamless video, voice and network connectivity
- While fan-cooled systems typically require processors that consume less than 30 watts of power, convection-cooled systems typically require processors that consume less than 10 watts of power
- Many different input and output (I/O) options such as Ethernet, RapidIO®, UART, memory interfaces and serial ports
- On-chip floating point unit and encryption engine for stateful packet inspection and manipulation, as well as policy/quality of service (QoS) enforcement

Additionally, they support common industrial and control applications such as:

- Long product life and operation in harsh environments with temperatures ranging from -40°C to +120°C
- Real-time operation to detect state changes and take appropriate actions within an acceptable timeframe
- Deterministic operation to execute instructions in a predetermined order and at a predetermined time
- Reliable operation, often with N+1, 2N or N+M redundancy, depending on the perceived cost of an outage
- Secure operation to ensure unauthorized persons cannot accidentally or intentionally access or change data and manipulate control systems
- Safe operation to ensure the system will not harm people or nearby equipment
- Ruggedized systems to operate in harsh environments such as:
  - Locations that are dirty, dusty or surrounded by dangerous chemicals
  - Environments that contain high levels of electromagnetic radio emissions
  - Remote systems which are difficult to access for maintenance and repair—these systems require designs that minimize parts with higher failure rates, such as fans, to reduce time between system-level failures
  - Systems that are operated by people who are not necessarily technology experts, who may not have access to sophisticated diagnostic equipment, and who often do not have time to read a long instruction manual or take a training course

SBC Market Dynamics

Based on interviews conducted by Freescale with OEMs, hardware engineering resources now comprise 25 percent of total cost allocation for OEMs. Software and system engineers now make up the majority of the OEMs’ investment. Memories have moved from DDR1 to DDR3 in just a few years. PCI was replaced by PCI gen 1 and subsequently by PCI Express® gen 2. SBCs provide a solution to these increasing trends in complexities and development costs for OEM manufacturers. SBC manufacturers have the expertise to deal with high-speed design and challenging multicore processors. They offer a range of standard form factors and semicustom capability for a variety of markets and performance requirements. Combining Freescale’s Power Architecture® solutions with the SBC ecosystem results in a robust mix of form factors built to service a broad range of applications and markets and to ease the “make vs. buy” decision process for OEMs.
Freescale’s SBC Solutions

Freescale’s SBC solutions are specifically designed to address the above-mentioned key challenges for the SBC market. Freescale offers 32-bit processor solutions based on Power Architecture technology, which integrates a high-performance processing unit with controllers and other interfaces in order to reduce the overall circuit board complexity, cost and power consumption. PowerQUICC and QorIQ communications processors integrate extensive network interfaces with performance scaling from 100 to 30,000 MIPS for reliable and flexible converging networks. These products are designed for security-conscious developers needing a high-performance 32-bit microprocessor plus a rich set of on-chip connectivity peripherals including dual integrated Gigabit Ethernet controllers for high-speed network connectivity, peripheral component interconnect (PCI), USB On-The-Go (OTG), UART, SPI and GPIO interfaces, with on-chip security option to protect sensitive data.

To comply with the various ways OEMs develop systems, Freescale supports both the customers wanting to design boards from scratch or the customers requiring ready-made solutions from a broad spectrum of SBC suppliers and form factors. Freescale works with a large number of single board computer manufacturers delivering a variety of form factors such as VME, VPX, AdvancedTCA®, AdvancedMC™, CompactPCI®, COM Express® and many more. For a selector guide detailing the boards offered to the market, go to freescale.com/SBC.

Figure 1 above shows various decision parameters used by OEM manufacturers during the make vs. buy decision. The rest of this article discusses how Freescale’s solutions using Power Architecture technology processors help OEM manufacturers to ease the make vs. buy decision by offering them solutions for each of their specific needs.

QorIQ Development Systems with COM Express® Modules

Freescale's modular development systems provide OEMs with yet more design decision flexibility. Production-ready COM Express® compatible boards from Emerson Network Power and Eurotech are designed around Freescale's QorIQ P4080, P2020, P1022 and P1021 multicore communications processors. These development systems help eliminate the board-level design step from the architecture decision process, easing the make vs. buy decision.

COM Express is a PCI Industrial Computer Manufacturers Group (PICMG) standard for a computer-on-module (COM) form factor with PCI Express® interconnects. Originally developed for x86 processors, the COM Express specification supports the push toward high-speed serial interfaces and supports more interfaces than PMC boards. Freescale's COM Express development kits do not change any physical form factors of the standard. However, Freescale has created a Power Architecture user-friendly pin-out for the COM Express module that takes advantage of Freescale’s QorIQ system-on-chip (SoC) solutions.
### Figure 2: Production-Ready COM Express Modules

<table>
<thead>
<tr>
<th>Manufacturer: Emerson</th>
<th>COMX-P4080</th>
<th>COMX-P2020</th>
<th>COMX-P1022</th>
<th>-</th>
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<tbody>
<tr>
<td>Manufacturer: Eurotech</td>
<td>Adbc7515</td>
<td>Adbc7517</td>
<td>-</td>
<td>Adbc7519</td>
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<tr>
<td>Form Factor</td>
<td>COM Express Basic (125 x 95 mm)</td>
<td>COM Express Compact (95 x 95 mm)</td>
<td>COM Express Compact (95 x 95 mm)</td>
<td>COM Express Compact (95 x 95 mm)</td>
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<tr>
<td>Processor</td>
<td>P4080–1.5 GHz</td>
<td>P2020–1.2 GHz</td>
<td>P1022–1.0 GHz</td>
<td>P1021–1.0 GHz</td>
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<tr>
<td>Number of Cores</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Memory</td>
<td>• Up to 4 GB DDR3 (ECC SO-UDIMM)</td>
<td>• Up to 2 GB DDR3 (ECC SO-UDIMM)</td>
<td>• Up to 2 GB DDR3 (ECC SO-UDIMM)</td>
<td>• Up to 2 GB DDR3 (ECC SO-UDIMM)</td>
</tr>
<tr>
<td></td>
<td>• MicroSD slot for on-board storage</td>
<td>• MicroSD slot for on-board storage</td>
<td>• MicroSD slot for on-board storage</td>
<td>• MicroSD slot for on-board storage</td>
</tr>
<tr>
<td>Ethernet</td>
<td>• 1 x 1 GbE with integrated PHY</td>
<td>• 1 x 10GE XAUI</td>
<td>• 4 x SGMII ports available via SerDes links</td>
<td>3 x 1 GbE with integrated PHY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 x 1 GbE with integrated PHY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 x 1 GbE with integrated PHY</td>
</tr>
<tr>
<td>USB 2.0</td>
<td>4 with integrated PHY</td>
<td>4 with integrated PHY</td>
<td>4 with integrated PHY</td>
<td>4 with integrated PHY</td>
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<tr>
<td>UART</td>
<td>2 with flow control</td>
<td>2 with flow control</td>
<td>2 with flow control</td>
<td>2 with flow control</td>
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<tr>
<td>SPI</td>
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<td>1 with 4 chip selects</td>
<td>1 with 4 chip selects</td>
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<tr>
<td>GPIO</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>I²C</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>PCIe/Rapid IO</td>
<td>• Up to 2 x4 SRIOv2 ports</td>
<td>• 2 x4 PCIe v2 ports available via SerDes links</td>
<td>x2 PCIe + x1 PCIe</td>
<td>x2 PCIe + dual x1 PCIe</td>
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<td></td>
<td></td>
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<td></td>
<td>x2 PCIe + dual x1 PCIe</td>
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<td>IEEE® 1588</td>
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<td>Yes</td>
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<tr>
<td>QUICC Engine Technology</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Yes</td>
</tr>
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</table>

### Figure 3: COM Express Development System
COM Express Development System Components

The Freescale development systems provide an I/O-rich carrier blade whose personality comes from the QorIQ processor embedded in a plug-in COM Express module. This module/carrier combination provides unparalleled flexibility in development. Figures 2 and 3 demonstrate COM Express modules and development system.

Each development system contains following:

- Hardware
  - COM Express module with QorIQ processor and memory, carrier blade, chassis enclosure, universal bench ATX power supply, cables (serial UART, USB, CAT5 Ethernet), CodeWarrior USB TAP

- Software
  - U-boot, Linux® BSP from Mentor Graphics®, GCC tools (compiler, debugger), CodeWarrior evaluation copy

- Documentation
  - Quick start guides
  - Linux OS and CodeWarrior tool manuals
  - Design workbook

Figures 4 to 6 demonstrate an AdvancedTCA™ and VPX form factor the SBCs based on Power Architecture technology processors.

**Figure 4:** Emerson Network Board Featuring COM Express-Compatible Module Based on QorIQ P2020 Processor

**Figure 5:** Advantech AMC-4201 AdvantechMC™ Board Featuring QorIQ P4080 Processor

**Figure 6:** Curtiss Wright VPX6-187 Based on QorIQ P4080 Processor
Benefits of Having QorIQ Processors on COM Express Modules

Each COM Express module plugs into the carrier blade to provide embedded functions (Figure 7). All connections, including custom I/O, are via the carrier card. Inherently rugged pin and socket connections make these modules suitable for industrial and military use. Some of the key features and benefits of QorIQ processors on COM Express modules are:

- **Off-the-shelf**: Emerson and Eurotech take the complexity of designing with multicore, and provide production-ready solutions
- **Extended temperature range**: COM Express QorIQ processor modules are suitable for industrial automation, medical, networking, telecom and military applications
- **Embedded graphics**: Integrated on-board support for VGA and LVDS further simplifies the design process while providing for human-machine interface (HMI) applications
- **Low power usage**: Reduces power usage for minimal consumption specs
- **Future-proof**: QorIQ processors are part of Freescale’s Product Longevity Program, ensuring a long life cycle. For Terms and Conditions and to obtain a list of available products please see freescale.com/productlongevity
- **Reduced size**: Small footprint supports a broad range of solutions such as battery operated or space-constrained embedded applications

In addition, Freescale is an active member of standards committees that support this industry, such as Power.org™, RapidIO® Trade Association, PICMG® and The Multicore Association™. These standards bodies work with other industry participants to provide specifications that allow for richer and more cost-effective market solutions. Freescale’s participation allows for a broad ecosystem that enables Freescale technologies and products.

**Freescale’s SBC Enablement**

Freescale not only supports silicon development but also works to establish a strong relationship with OS and tool vendors to ensure that customers have access to complete solutions. Enea®, Green Hills®, Mentor Graphics, QNX® and Wind River® help in fulfilling the software requirements of Freescale’s clients.

Get More Information

While COM Express is one of the increasingly popular form factors, there are numerous SBC vendors and form factors available with Power Architecture and ARM® processors from Freescale. Freescale provides a Web page with a sortable selector guide of production-ready SBCs. The user may sort by architecture, manufacturer, processor type, number of cores and form factor. The site presently supports 13 manufacturers and over 125 production-ready form factors. For more information, go to freescale.com/SBC.
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