Multicore Simplified: Single Board Computing

Glenn Beck

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 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.

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 -40ºC to +120º 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

Figure 1: Make vs. Buy Decision Matrix for SBC

Decision Parameter	Full Custom	Module (COM Express, SOM, Custom)	Standard SBC (AMC, PMC, CPCI, VME)
Application	• 100% of needs of fit, form and function	• Ability to meet or little compromise to application requirements	• Potentially not 100% to needs, unless market standard (ie. AMC, VME)
Time to Market	• Longest	• Good time to market	• Shortest time
Engineering Investment	• Engineering intensive • Keeping up with processor evolution	• Simpler application board design	• Low investment • Processing complexity to SBC vendor
Manufacturing Investment	• High and/or management of ODMs	• Module and carrier integration	• System integration
Design Risk	• Highly dependent on complexity, with multiple passes	• Application board only • Complex module design by module vendor	• Low • Focus on value add system integration
Product Life Responsibility	• OEM responsibility for all elements of design	• Only on application board	• Responsibility to SBC vendor
Market Reaction	• None or slow to react	• Ability to react quickly (multiple application boards)	• Potential ability to react quickly
Unit Cost	• Lowest	• Potential low cost due to multiple suppliers	• Highest
Volume	• High volume	• Mid to high volume	• Low volume

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

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

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
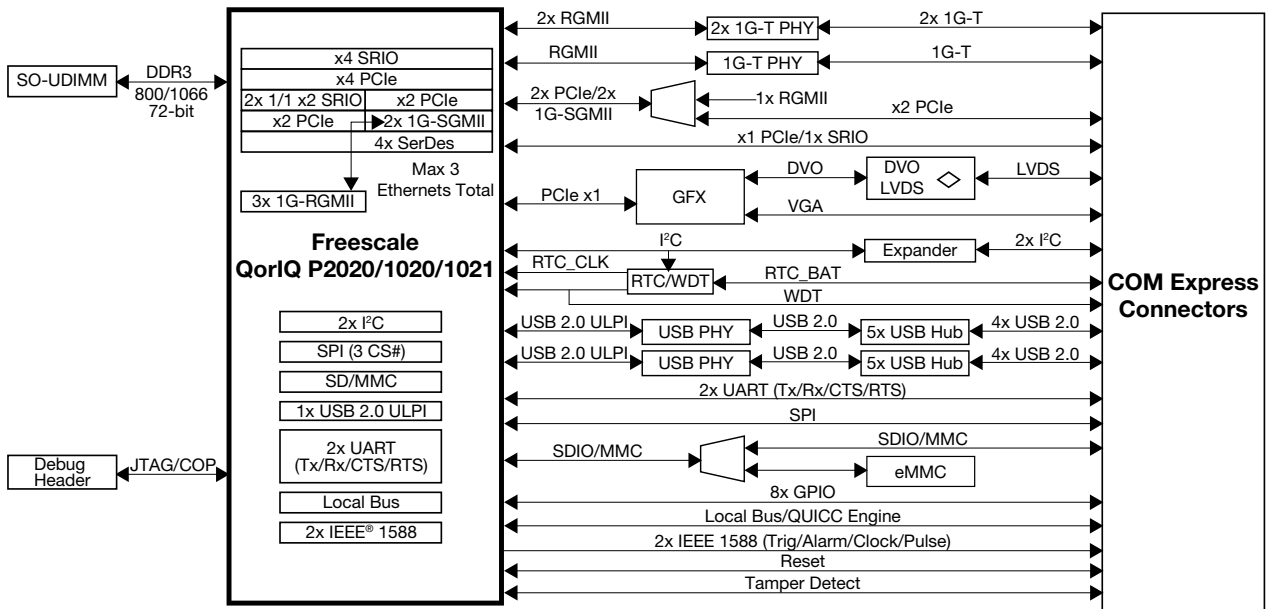

Figure 5: Advantech AMC-4201 AdvantechMC™ Board Featuring QorIQ P4080 Processor

Figure 6: Curtiss Wright VPX6-187 Based on QorIQ P4080 Processor

Figure 7: Block Diagram Example: QorIQ P2020, P1020 COM Express Board

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

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.

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.

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**.

How to Reach Us:

Home Page:

freescale.com

**Power Architecture
Portfolio Information:**

freescale.com/power

e-mail:

support@freescale.com

USA/Europe or Locations Not Listed:

Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
1-800-521-6274
480-768-2130
support@freescale.com

Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064, Japan
0120 191014
+81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:

Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate,
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:

Freescale Semiconductor
Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447
303-675-2140
Fax: 303-675 2150
LDCForFreescaleSemiconductor@hibbertgroup.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright license granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

For more information, visit **freescale.com/power**

BUILT ON

Power