Reed Electronics Group

MICROPROCESSOR REPORT

www.MPRonline.com

THE INSIDER'S GUIDE TO MICROPROCESSOR HARDWARE

FREESCALE'S DESIGNER SOCS

Chipmaker Offers New Design Services—With a Catch

By Tom R. Halfhill {11/17/08-01}

Freescale Semiconductor is exploring a new line of business that has interesting implications for other chipmakers. Starting now, Freescale is offering design services to customers that want a custom SoC. Freescale will offer intellectual property (IP) for the chip, will design the chip, and will manufacture the chip. The customer provides a design specification and money.

At first glance, it looks as if Freescale is merely launching a design-services business, just one more design house among many. But there's a catch. Unlike most design houses, Freescale has little interest in making SoCs entirely new from the ground up. Instead, the SoC must be based on an existing Freescale standard part or use a substantial amount of Freescale's existing IP. To customize the SoC for the target application, Freescale is willing to add or remove blocks and integrate some customer-provided IP or third-party IP.

The result might be described as a "customized standard part," even though it seems like an oxymoron. Freescale calls it a "customer-specific product" (CSP). And there are multiple scenarios. In most cases—especially when the customer contributes proprietary IP—the SoCs will never be sold to other parties. Customers will use the parts to build their own system-level products, modules, or boards. In rare cases, the new SoC may join Freescale's standard-part product line, or the customer may resell the chips as standard parts.

For Freescale, this new line of business is a way to further amortize the engineering invested in its chip designs and perhaps to extend the reach of its standard-parts catalog. For customers, the advantages of using Freescale's design services instead of a traditional design house may not be immediately apparent. Why limit an SoC design to a derivative of an existing Freescale device?

The advantages are subtle but important. Freescale has a large catalog of standard parts that make ideal foundations for new SoCs. By starting with a field-proven design, customers can move a derivative product to market much quicker. In addition, Freescale is opening the doors to much of its IP for these custom SoCs—including processor cores based on the ARM, Power Architecture, and ColdFire architectures. And customers needn't make separate manufacturing arrangements with a foundry, because Freescale plans to handle the fabrication and deliver the finished chips.

Standard Parts As Building Blocks

Over the past 50 years, we've seen the basic building blocks for ICs evolve from individual transistors to functional models as complex as processor cores and peripheral controllers. Now Freescale is proposing that an entire chip design as elaborate as a PowerQUICC III processor can be a building block for a new SoC. Actually, it's not quite that drastic. Freescale's block is divisible, so the design process can be additive or subtractive.

Suppose the ideal networking processor for a particular application is a minor variation of an existing PowerQUICC chip. After studying Freescale's product catalog, a customer decides that the PowerQUICC II Pro MPC8360E processor (diagrammed in Figure 1) is absolutely perfect. Well, almost perfect. To differentiate the system-level end product, the customer's SoC needs PCI Express and High-Speed USB 2.0. Unfortunately, even though Freescale makes 80 variations of the MPC8360E, none have PCIe or High-Speed USB controllers. (See *MPR 3/21/05-01*, "Freescale Quickens PowerQUICC.")

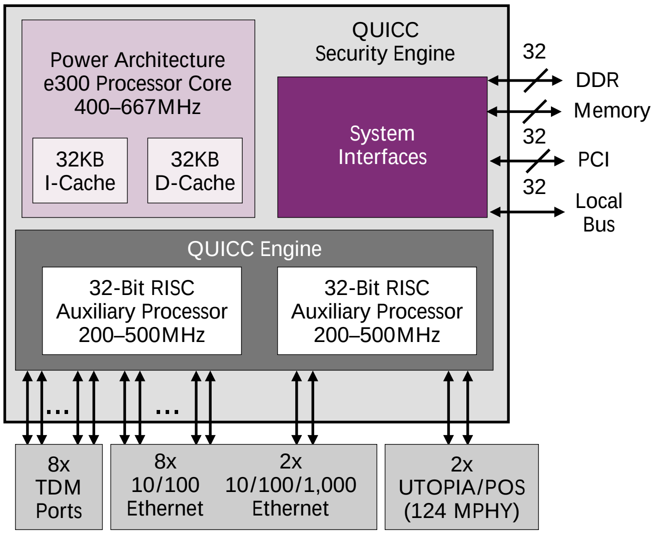

Figure 1. Block diagram of Freescale's PowerQUICC II Pro MPC8360E. Standard parts like this are now building blocks for customer-specific SoCs. Designers can add or subtract features to create their own custom chips.

Solution: Freescale can add the enhanced peripherals to the MPC8360E to make a special SoC for the customer. If Freescale already has the requisite peripheral IP, it's available as part of the deal. Alternatively, customers can bring their own IP or license it from a third party.

Suppose the customer decides that having eight 10–100MB/s Ethernet ports on this chip is an extravagance that needlessly inflates the pin count, especially since the MPC8560E already supports two Gigabit Ethernet ports. Four of the slower Ethernet ports will be plenty. No problem—Freescale can subtract the unwanted Ethernet interfaces while adding the PCIe and High-Speed USB interfaces.

These are elementary examples, but they gain significance after skimming Freescale's voluminous online product catalog. There are hundreds of PowerQUICC I, PowerQUICC II, PowerQUICC II Pro, and PowerQUICC III devices in all sizes, shapes, and speed grades. And the PowerQUICC families are only four branches of an even larger family of chips based on Freescale's Power Architecture e200, e300, and e500 processor cores. Those chips include a wide variety of devices for automotive, consumer, industrial, and networking applications. They are being joined by Freescale's newest QorIQ devices, which are expected to supersede most PowerQUICC parts. (See *MPR 7/7/08-01*, "Freescale's Multicore Makeover.")

Architectural Diversity Expands Options

For customers not enamored with the Power Architecture, Freescale has several families of chips based on the popular ARM architecture. Among the ARM chips are devices using the ARM7, ARM9, ARM1136, and ARM1176 processor cores. These include Freescale's i.MX application processors based on ARM9 and ARM11 cores for smartphones, portable media players, and other trendy products. Freescale's MAC7*xxx* family includes dozens of parts with ARM7TDMI-S processor cores and are specifically designed for the automotive market, one of Freescale's strengths.

As Freescale introduces new ARM-based standard parts, those chips will also be available for derivative custom designs. For instance, Freescale has licensed the ARM Cortex-A8 but hasn't yet announced any products using that core. Someday, Freescale chips based on the Cortex-A8 may join the CSP program. (See our two-part coverage of the Cortex-A8 in *MPR 10/25/05-02* and *MPR 11/14/05-01*, "Cortex-A8: High Speed, Low Power.")

Another 32-bit CPU option is the ColdFire microcontroller architecture, a close cousin of the original Motorola 68000 (68K) architecture. Freescale sells numerous ColdFire parts for networking, industrial, consumer, and automotive applications. They include devices based on the ColdFire V1, V2, V3, V4, and V5 instruction-set architectures.

All these chips and cores—as well as their peripheral controllers and other IP blocks—are available to SoC customers through Freescale's CSP program. Essentially, Freescale is offering the bulk of its product catalog and IP library as building blocks for new SoCs.

What's excluded? Freescale doesn't regard its 8- and 16-bit microcontrollers, 32-bit MCore controllers, or older 68K-based processors as likely platforms for new SoCs. Sales volumes and prices for such small chips probably wouldn't be high enough to justify spinning custom silicon. However, Freescale will consider integrating a microcontroller into a design derived from a larger Freescale device. In other words, microcontrollers can be building blocks, but probably are not the foundation.

Freescale Keeps Design Work In House

Freescale is maintaining control over its valuable IP by managing the SoC design internally. Although CSP customers can use much of Freescale's IP, they can't always take it home with them, except as finished chips. There are a few exceptions, such as the ColdFire V1 core that Freescale already licenses through IPextreme's Core Store. (See *MPR 2/11/08-01*, "Buy SoC IP Like MP3s.")

Naturally, customers have input. They provide design specifications and high-level supervision. They can contribute their own proprietary IP or third-party IP. But at the engineering level, Freescale handles the design work and manufacturing. Some customers may pay Freescale's nonrecurring engineering (NRE) expenses and buy the finished chips. Other customers may simply buy the chips, with Freescale's NRE factored into the price. Terms are negotiable. Freescale can manufacture the chips in 130nm, 90nm, or 65nm CMOS processes, with 45nm planned to debut in 2009.

Freescale expects most CSP customers to commission the design of a custom SoC that will differentiate a system-level product otherwise confined to using off-the-shelf parts. These custom SoCs probably won't be as elementary as the example described above. Most likely, the customer will contribute some IP that truly sets the SoC apart from commonly available standard parts.

In those cases, the CSP customer will probably want exclusive access to the finished chips, perhaps in perpetuity. But if Freescale thinks the design has broad appeal, another possibility is that the customer gets exclusive access for a time, after which the device joins Freescale's product line as a standard part. Freescale offers all these options, subject to negotiation. In general, the less exclusivity the customer wants, the lower the price will be.

Another issue is CPU core licensing. Freescale owns the Power Architecture and ColdFire cores in its chips, but not the ARM cores. Nevertheless, CSP customers can commission an SoC around any ARM core in Freescale's product stable without obtaining their own ARM license. Because Freescale is the actual designer, manufacturer, and supplier of the chips, any royalties due ARM are factored into Freescale's chip price to the customer. In these respects, custom SoCs are like standard parts—Freescale's ARM license covers everything. Customers need their own processor-IP licenses only if they want to use a third-party processor core not currently available in Freescale's product line.

Competition With IBM

Freescale's CSP program opens another field of competition with IBM, with which Freescale shares an odd relationship. The companies are both business partners and competitors. They collaborate on things like Power Architecture specifications and fabrication technology. At the same time, they compete with each other to license Power Architecture cores and sell chips. Now they will compete to design third-party SoCs. IBM Microelectronics has been designing and manufacturing chips for customers since the 1990s. Freescale's CSP program resembles IBM's, but there are a few differences.

Whereas IBM will entertain requests to license any of its Power Architecture cores, Freescale will not only license cores but also offer entire chip designs as foundations for custom SoCs. Imagine if IBM's 5.0GHz Power6 server processor or Cell Broadband Engine were available as starting points for new designs. (Although the Power6 may be overkill, Cell is a versatile design that lends itself to customization.) Freescale's strong presence in some vertical markets—especially networking, automotives, industrial, and consumer—should reduce the customer's development risk, development cost, and time to market.

Another difference between Freescale and IBM is the variety of processor cores available. Freescale offers CSP customers its own Power Architecture and ColdFire cores, plus some ARM cores. Since 2004, IBM has been licensing its Power Architecture cores. (See *MPR 4/26/04-02*, "IBM Loosens Up CPU Licensing.") Customers can bring CPU cores licensed from a third party to an SoC project at either Freescale or IBM. However, IBM requires customers to obtain separate licenses from the IP providers of those cores. Freescale does, too—unless the customer wants an ARM core that Freescale already uses in its standard parts. In that case, customers needn't obtain an ARM license.

IBM has longer experience designing chips for customers, and IBM's Blue Logic library contains a great deal of licensable IP. In addition, IBM has superior chip-fabrication technology. Last year, however, Freescale joined IBM's Common Platform alliance for joint technology research and development. Someday, Freescale's CSP customers may benefit from this collaboration.

Other Chipmakers Could Follow

As SoC design continues to become more complex and costly—beyond the reach of many companies that need SoCs—it might make sense for other major chipmakers to follow in Freescale's footsteps. Large semiconductor companies have greater resources and more experience than do most startups and small companies. And they can always decline projects that threaten to compete with their own standard parts.

Another reason for large semiconductor companies to offer design services is to keep their engineers busy. Retaining key engineering talent is often difficult during economic recessions.

For additional reasons, Intel is a possible candidate for a design-services business. Embedded processors outsell PC processors by about 50 to 1, yet the x86 is the only major CPU architecture unavailable for licensing in the embedded market. (A few exceptions are very old x86 cores that have been cloned, such as the 1980s-vintage 286.)

Intel terminated its third-party ASIC business a few years ago. Recently, however, Intel has shown renewed interest in pushing the x86 architecture into the embedded market. Right now, the only way to get an x86-based SoC is to buy an Intel-branded chip. But Intel makes only a few SoCs, and only for the highest-volume markets. (See *MPR 8/18/08-01*, "Intel's New SoCs.")

Freescale's CSP program suggests a way for Intel to license the x86 without going as far as ARM's license-to-anyone business model. By offering design services as a sideline, Intel could make its latest x86 cores available to the embedded market while retaining control over the chip designs and applications. Intel wouldn't have to worry about spawning another AMD.

Hazards for Freescale

Freescale's CSP program is not without risks. One is that outside SoC projects may distract Freescale's engineers from developing their own new products. Another is that if Freescale underestimates the difficulty of a project, the costs could devour the profits. All design houses bear the latter risk, but the former is unique to a semiconductor company engaging in design services as a sideline.

One unlikely risk is that a custom SoC will cannibalize sales of Freescale's own standard parts, such as the device on

For More Information

Freescale Semiconductor's Customer-Specific Product (CSP) program is under way now. Prices and terms are negotiable. For some projects, Freescale expects to be reimbursed for its nonrecurring engineering (NRE) expenses, in addition to selling the finished chips. For other projects, Freescale absorbs the NRE and factors the costs into the price of the chips. For more information about the CSP program, see:

- *www.freescale.com/webapp/sps/site/homepage.jsp?nodeId=012100*

which the custom project is based. Usually, the integration of additional IP will make the derivative custom part more expensive than the existing standard part, so Freescale should make more money on the sale. The customer still saves money, because the custom part presumably eliminates the need for additional chips or FPGAs. The total bill of materials will be lower.

Freescale's CSP program isn't for everyone. Customers needing an entirely new SoC cut from whole cloth are better advised to employ a full-service design house. Even if a derivative design is satisfactory, Freescale's price might be too high for some clients. Of course, the price greatly depends on the scope of the project. For a simple design in older-generation 130nm or 90nm process technology, the cost could be less than $1 million—a genuine bargain for an SoC. Complex designs requiring state-of-the-art fabrication will cost millions of dollars, as they would anywhere else.

Overall, the CSP program looks like a good venture. Freescale can leverage its processors, peripheral cores, chip designs, and engineering resources while generating additional revenue and propagating its platforms. Many customers will need software, too—software that Freescale has already written or has the expertise to write. For a company still struggling to grow revenue after its divestment by Motorola in 2004, any new business is good business. ◇