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Analog—that computes

Rick Nelson, Editor in Chief -- Test & Measurement World, 6/11/2008 9:13:00 AM

ANAHEIM, CA. It's an analog world. That, surprisingly, is the message that Justin R. Rattner, VP and CTO at microprocessor powerhouse Intel, delivered in his keynote address Tuesday to the **Design Automation Conference**. Not so surprisingly, Rattner advocates a design approach that maximizes the use of digital technology to solve traditional analog problems.

In his address, titled "EDA for digital, programmable multi-radios," Rattner said he would avoid talking about hot topics like multicore processors that attendees might expect to hear from an Intel executive. Intel makes radios—including WiFi and WiMAX chips—as well as processors, he reminded his audience.

He began his address by describing what consumers want—they want to "carry small," he said. That implies that consumer products provide only essential computational resources while maximizing power efficiency. Your hand is worth about three watts of power dissipation," he said.

Nevertheless, he said, consumer preference for diminutive devices doesn't mean that consumers want their experiences with such devices to be small. They want to "carry small," yet "live large"—which Rattner abbreviates CSLL.

To live the CSLL lifestyle, Rattner said, you'll need products that support "anywhere, anytime" collaboration via the Internet, and they must be sensor-based so that they can comprehend the world around you—whether you are at work or play, and whether it's day or night.

The combination of small size and high performance, he said, will mandate a small silicon footprint—combining analog and digital functions within an SOC.

He then focused on the analog/digital divide, saying, "Analog is how we interact with the real world, but the technology favors digital—so we have to bridge the gap between the analog world and digital world. Bridging this gap is going to be extremely important for CSLL."

Rattner noted that the amount of analog circuitry is increasing, commenting that in 2006 more than 70% of SOCs had analog elements. Unfortunately, he said, traditional analog development is not getting any easier. In fact, he said, in the face of transistor scaling, it's getting harder, because of increased mask costs, because leakage and process-variation effects become more troublesome, because output impedance does not scale, because 1/f noise is increasing, and because reduced supply voltages decrease dynamic range. He noted that Intel has attacked leakage aggressively with high-K metal-gate transistors, but he questioned whether the current leveling off of leakage can hold.

Citing the **Rethinking Analog Design** (RAD) industry-supported, Stanford-based research initiative, Rattner suggested reliance on digital gates to improve analog performance in what he called "digitally assisted analog." Key to digitally assisted analog, he said, is to step back and rethink an analog problem from the ground up as a computational problem.

He used photography as an example of how this process could work. Most people, he said, consider digital photography to represent a revolution from the old "analog photography" that relied on film and chemicals. But in fact, Rattner said, digital photography leaves the traditional camera largely intact, with a heavy, expensive lens used to perform a very complex transform on light as the lens focuses light rays onto a CMOS or CCD image sensor. With digital cameras, he said, "We have not fundamentally changed the nature of photography."

But, he asked, what if we stepped back and took new look at photography? Such a new look has been taken by **Refocus Imaging**, which employs what Rattner called “computational light-field photography"—a process that involves using a micro-lens array to capture not a single image but the entire light filed surrounding the lens array. Computational power can then be used to alter the image point of view, for example. The technique also lets you focus an image after taking a picture. “You take the recorded light field,” he said, “and then go to work computationally to compute the final image. That’s fundamentally different from traditional photography.” Moving away from the “analog” optics, he said, to a process that involves computing an optical transform on a light field, offers tremendous potential to simplify camera design.

He then turned his attention to the radio revolution. Yesterday, he said, we had discrete analog radios with multiple integrated circuits combined at the board level. Today, he said, we have single chips that can implement a WiFi or 3G radio. Tomorrow, he said, will bring “integrated multi-radios, agile-programmable to deal with any possible air interface they are presented with.”

The goals, he said, are to exploit the computational nature of radio (as embodied in information theory), to dramatically simplify radio architectures, to allow one radio to act as many all at once—to facilitate seamless handoff between 3G and WiFi networks, for example, and to sniff the radio environment to see if higher performance networks are available.

The benefits, he said, include increased flexibility to speed time to market, lower cost and power, the elimination of analog anomalies, and the ability to employ digital calibration and compensation.

Rattner sketched out his version of a digital multi-radio, showing how the traditional analog receiver signal chain—front-end module (FEM), mixer, channel-select filter, and so on, gives way to a simplified digital approach. He also compared analog and digital transmit signal chains, with the digital version relying on nonlinear mathematical computation to facilitate coordination between a digital power amplifier and other components.

He said that Intel will probably need a year or so to produce commercial versions of such a digital radio, but he noted that the company has built a digital power amplifier in 65-nm CMOS and a fractional-N synthesizer in 90-nm CMOS.

As for EDA tools that could help the development effort, his wish list includes system-level EDA for partitioning and micro architecture selection, automatic systemic behavioral model generation, a diversity simulation engine, process-variation analysis tools, and statistical methods to reduce over-design.

For verification, Rattner said he wanted the ability to incorporate many different analog models: in languages like Spice, C, and Matlab and in forms ranging from behavioral to algorithmic. He also wants support for statistical test benches.

He concluded by again urging his listeners to rethink analog problems as computational problems as they meet the challenges of designing machines that interact with the real world.

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