



# Moore's Law and Ultra-Low-Power Processors

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**Welcome to the November/December 2017 special issue on ultra-low-power processors.**

The Internet of Things (IoT) revolution is happening at a rapid pace. Most projections forecast that the number of connected IoT devices will grow exponentially, easily reaching over 100 billion within the next decade. This revolution leads to a vigorous demand for ultra-low-power (ULP) edge computing devices and associated system-on-chip (SoC) architectures. This special issue includes six articles that highlight some of the state-of-the-art research and potentially viable solutions in ULP processors. I suggest you read the guest editors' column for more details about these articles. I want to wholeheartedly thank David Brooks and John Sartori for their excellent work as guest editors of this special issue. I hope you will enjoy reading these articles as much as I did.

There is one article that I would like to highlight here. Mark Bohr and Ian Young talk about CMOS scaling trends and how Intel has been able to keep Moore's law alive over the past decades. This required continuous innovation in materials and device structures to deliver the performance, power, and cost improvements as expected with each technology generation. The article also highlights new

device options and technology directions to continue scaling in the near future. The excellent keynote Mark delivered at the ISCA 2017 conference instigated this article, and I'm grateful to Mark and Ian for having taken the time to write up this excellent contribution.

This issue also includes two thought-provoking Expert Opinion articles about challenging topics in our field. In the first column, Bobbie Manne, Bryan Chin, and Steve Reinhardt posit that architects should pursue architectural agility to lower the barriers to developing innovative and disruptive solutions in an unpredictable and rapidly evolving technology landscape as we face new technology limitations. They present several ideas for engineers to integrate agility into both processor and datacenter design.

Reetu Das describes two historical waves in processing in memory (PIM) to combat the memory wall, and then argues for moving computation closer to memory—thereby transforming memory into powerful accelerators—which seems like an appealing and promising vision in an era increasingly dominated by data-intensive workloads.

This issue also includes an award testimonial. David Brooks reports on

the 2017 ISCA Influential Paper Award, which was given to “Drowsy Caches: Simple Techniques for Reducing Leakage Power” by Krisztián Flautner, Nam Sung Kim, Steven M. Martin, David Blaauw, and Trevor N. Mudge. This award recognizes the paper published 15 years ago—in this case, 2002—at the ISCA conference that has had the most impact on the field (in terms of research, development, products, or ideas) during the intervening years. The drowsy cache paper made a seminal contribution to power-efficient computing. The paper was written at a time when leakage current was becoming a major concern, especially in large on-chip caches in high-end processors. The paper's key idea was to put parts of the cache into a low-power “drowsy” mode to save energy while retaining the data. Congratulations to the award winners on their groundbreaking research!

Finally, in this issue, Shane Greenstein talks about the “hush-hush norm,” which I will let you discover for yourself in the Micro Economics column.

The IEEE Computer Society will be making some changes to how magazine articles are edited. Unfortunately, this means that our current copy editor, Molly Gamborg, will no longer

be working with *IEEE Micro*. Molly has been *IEEE Micro*'s copy editor for seven years. I have interacted with her for many years, first as an author and then as the editor in chief for the past three years. I'm sure that many of you have interacted with Molly as well over these many years, as an author or otherwise. Simply said, Molly did an outstanding job, both in terms of copy editing magazine articles and in terms of managing deadlines and schedules for the magazine. I've always been amazed by her performance and professionalism. She really made my job as the editor in chief easy and enjoyable. I feel very fortunate to have worked with Molly. At the same time, I feel saddened that she will no longer be part of the team. Thanks a lot, Molly, for your great service—we will miss you!

With that, I'd like to conclude and wish you a happy reading. ■■

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