

Quantum Computing and More!

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Welcome to the 2021 September/October Issue of *IEEE Micro*. This issue presents two themes: 1) the Special Issue on Quantum Computing and 2) the Special Issue on Commercial Products 2021.

While there has been work in quantum computing for decades, we have reached an important point in time, where the public can use a 16-qubit quantum computer on the web via the IBM Quantum Experience effort.¹ Google, Microsoft, Intel, and others are investing significant amount of resources into building quantum computers.

Quantum computers rely on the inherent uncertainty of quantum particles, such as atoms or electrons, to perform calculations. Quantum computing involves the exploitation of collective properties of quantum states, such as superposition and entanglement, to perform computation. While quantum computing is not going to become a replacement for all traditional computing, it is considered to hold a lot of promise for a class of problems in physics, chemistry, and other fields that standard computers cannot solve. In 2019, Google claimed achieving a particular calculation on a quantum computer in just minutes that would have taken a classical computer more than 10,000 years to complete.

While there are many challenges to solve before the advent of practical quantum computing, it is also thought that a lot of work needs to be done on all the intermediate layers that go from algorithms to quantum devices. In order to make quantum computing for real-world problems, ability to map high-level algorithms onto practical devices in efficient manners need to exist. The architecture community has been putting research effort into solving various problems in the quantum computing hardware–software stack.

The seven articles in the quantum theme include Qureshi and Tannu's compilation of promising strategies for noise- and connectivity-aware application mapping, Humble *et al.*'s views on how to integrate

quantum computers as accelerators in HPC systems, Bertels *et al.*'s exploration on new application domains for quantum computers via quantum simulation on supercomputers, and Tomesh and Martonosi's best-practice guide on hardware–software codesign in the quantum computing world.

The special issue also presents Baker and Chong's article on emerging quantum building blocks such as two-level qubits, memory-equipped superconducting qubits, and neutral atoms, which enable long-distance qubit interactions. In the final two articles in the quantum theme, Rodrigo *et al.* discuss how quantum computers can communicate with each other, and Rieseboos *et al.* discuss how quantum systems can be controlled and calibrated in the presence of changing operating conditions.

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Ulya Karpuzcu of the University of Minnesota served as the guest editor for the quantum computing theme. Dr. Karpuzcu did an excellent job acquiring submissions to the issues and presenting this wonderful collection of seven excellent articles. She has written a guest editorial giving a more detailed introduction to the seven articles on this topic. Read her introduction and the seven articles in the quantum theme to get a good understanding of the state of the art in quantum computing, challenges, and the ongoing research to solve the problems.

The above articles are followed by the Special Issue on Commercial Products 2021. This is a new tradition we started in 2020. The International Symposium on Computer Architecture (ISCA) is running an industry track starting in 2020 for industry products. Several excellent articles were spotted from the submissions to

the industry session at ISCA, and a few selected authors were encouraged to submit to *IEEE Micro*. After the review process, five articles were selected. The first article in this theme is on Kunpeng 920, a LEGO-style, chiplet-based SoC architecture with CC-NUMA fabric, enabling low cost and design reuse for various applications across computing, communication, and AI. It is followed by an article on I-DVFS from Intel, which is an “instantaneous frequency switch during dynamic voltage and frequency scaling” that has been employed by Intel’s Tiger Lake and Ice Lake CPUs. The third article is on the Alibaba Collective Communication Library (ACCL), for scalable distributed model training in datacenters, particularly useful for all-reduce operations and the end-to-end performance of model training. The fourth article is from Facebook describing the low-precision arithmetic techniques and a tool suite to optimize the use of quantization support, balanced floating point (FP), and integer (INT) performance, etc., in Facebook’s production recommender systems. The fifth article is also from Facebook describing performance optimization opportunities across the entire execution stack for graphical processing unit (GPU) fleet in Facebook’s datacenters.

Dr. Hsien-Hsin Lee of Facebook served as the guest editor for the Special Issue on Commercial Products’21. He has written a guest editorial giving a more detailed introduction to the five articles in the commercial products theme. Read it to get a glimpse of the articles to guide your reading.

The theme editor for Commercial Products 2021 followed standard practices of conflict of interest with the Facebook articles (and other conflicting articles) that were in the submission pile. During the ISCA 2021 Industrial Track Program Committee meeting where the preselection to *IEEE Micro* happened, the conflicting articles were handled by other members of the program committee (PC). The preselection for *IEEE Micro* was done jointly by the PC members. The theme editor did not know the outcomes until after the whole PC meeting concluded.

I take this opportunity to thank Ulya Karpuzcu and Hsien-Hsin Sean Lee for their efforts in getting many submissions in the respective themes and selecting an outstanding collection of articles. It is the effort of such dedicated guest editors and authors that result in the excellent articles that we present to you.

In addition to the theme articles, this issue also features a Micro Economics column by Shane Greenstein of Harvard Business School titled “Economic dependencies in integrated circuits,” where Greenstein analyzes imperfections in forecasting, with respect to the recent shortages in semiconductor

chips. The theme is what did analysts miss that led to not forecasting these shortages? Read the article to see Greenstein’s thoughts on the matter.

Michael Mattioli’s Security column article titled “PCs take a page from Xbox with Pluton” describes Microsoft’s “Pluton” technology targeted at strengthening the security of PCs. Pluton is a derivative of the security enhancements in the Xbox video game console. Pluton protects keys as they move around the SoC using dedicated silicon referred to as Secure Hardware Cryptography Key (SHACK), and implements the Device Identifier Composition Engine (DICE) and Microsoft’s Robust Internet of Things (RIoT) specifications to perform strong device attestation with a hardware root of trust. Microsoft’s soon to be released Windows 11 is designed to exploit Pluton. Another interesting aspect is that Pluton leverages existing open standards and technologies.

Joshua Yi, *IEEE Micro*’s newest editorial board member, presents an article titled “Analysis of historical patenting behavior and patent characteristics of computer architecture companies,” analyzing computer architecture companies’ patenting behavior for the last 25 years. During this time frame, SiFive, a new company, has had 12 patents and Samsung has had 129,382 patents (IBM is a close second to Samsung). Read Yi’s article to understand trends in patenting.

Please join me in welcoming Joshua Yi into the *IEEE Micro* Editorial Board. He will serve as a department editor writing columns on Micro Law and Micro Innovation. Although a patent lawyer, he is one of our own, with his Ph.D. in computer engineering. Although he wrote a guest article in the last issue, this is his first article as department editor. Welcome Joshua!

Enjoy these articles. Hopefully they help you understand ongoing work in quantum computing and interesting developments in the computer industry circa 2021.

Happy reading!

REFERENCE

1. IBM Quantum Experience. Accessed: Aug. 4, 2021. [Online]. Available: <https://quantum-computing.ibm.com/>

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