Quantum Computing is Getting Real: Architecture, PL, and OS Roles in Closing the Gap between Quantum Algorithms and Machines

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ABSTRACT

Quantum computing is at an inflection point, where 50-qubit (quantum bit) machines have been built, 100-qubit machines are just around the corner, and even 1000-qubit machines are perhaps only a few years away. These machines have the potential to fundamentally change our concept of what is computable and demonstrate practical applications in areas such as quantum chemistry, optimization, and quantum simulation.

Yet a significant resource gap remains between practical quantum algorithms and real machines. There is an urgent shortage of the necessary computer scientists to work on software and architectures to close this gap. I will outline several grand research challenges in closing this gap, including programming language design, software and hardware verification, defining and perforating abstraction boundaries, cross-layer optimization, managing parallelism and communication, mapping and scheduling computations, reducing control complexity, machine-specific optimizations, learning error patterns, and many more. I will also describe the resources and infrastructure available for starting research in quantum computing and for tackling these challenges.

BIOGRAPHY

Fred Chong is the Seymour Goodman Professor in the Department of Computer Science at the University of Chicago. Chong received his Ph.D. from MIT in 1996 and was a faculty member and Chancellor's fellow at UC Davis from 1997-2005. He was also a Professor of Computer Science, Director of Computer Engineering, and Director of the Greenscale Center for Energy-Efficient Computing at UCSB from 2005-2015. He is a recipient of the NSF CAREER award and 6 best paper awards. His research interests include emerging technologies for computing, quantum computing, multicore and embedded architectures, computer security, and sustainable computing.

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