Design and Optimization of Quantum Electronic Circuits

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ABSTRACT

Quantum electronic circuits where the logic information is processed and stored in single flux quanta promise efficient computation in a performance/power metric, and thus are of utmost interest as possible replacement or enhancement of CMOS. Several electronic device families leverage superconducting materials and transitions between resistive and superconducting states. Information is coded into bits with deterministic values – as opposed to qubits used in quantum computing. As an example, information can be coded into pulses. Logic gates can be modeled as finite-state machines, that emit logic outputs in response to inputs. The most natural realization of such circuits is through synchronous implementations, where a clock stimulus is transmitted to every logic gate and where logic depth is balanced at every input to achieve full synchrony. Novel superconducting realization families try to go beyond the limitations of synchronous logic with approaches reminiscent of asynchronous design style and leveraging information coding. Moreover, some superconducting families exploit adiabatic operation, in the search for minimizing energy consumption. Design automation for quantum electronic logic families is still in its infancy, but important results have been achieved in terms of automatic balancing and fanout management. The combination of these problems with logic restructuring poses new challenges, as the overall problem is more complex as compared to CMOS and algorithms and tools cannot be just adapted. This presentation will cover recent advancement in design automation for superconducting electronic circuits as well as address future developments in the field.

CCS Concepts/ACM Classifiers

Hardware, Electronic design automation

Author Keywords

Superconducting circuits, single flux quantum; SFQ; adiabatic quantum flux parametron; AQFP; reversible quantum logic; RQL

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BIOGRAPHY

Giovanni De Micheli is Professor of EE and CS at EPFL. He is credited for the invention of the Network on Chip design automation paradigm and for the creation of algorithms and design tools for *Electronic Design Automation* (EDA). His current research interests include several aspects of design technologies for integrated circuits and systems, such as synthesis for emerging technologies. He is a *Fellow* of ACM, AAAS and IEEE, a member of the *Academia Europaea* and an International Honorary member of the *American Academy of Arts and Sciences*. Prof. De Micheli received numerous awards, including the 2019 ACM/SIGDA Pioneering Achievement Award, the 2016 EDAA Lifetime Achievement Award, and the 2016 IEEE/CS Harry Goode award.

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