Highly Energy-Efficient Superconducting Quantum and Classical Information Processing

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The explosive growth of the Internet transformed data centers into large industrial scale computer facilities with extraordinarily high energy demands comparable to a mid-size town. The development of the next generations of high-end computers will not be possible unless a significant improvement in energy efficiency is achieved compared to modern CMOS technology and computer architectures for processing, storing, and moving data between processors and memories. Superconducting single flux quantum (SFQ) circuits with their inherent low power, high speed, lossless interconnect present an opportunity to improve energy efficiency of classical computers. These features are also appealing for the emerging scalable quantum computing systems which need the classical control infrastructure to perform qubit readout, control, and enable low-latency quantum error correction. Moreover, the co-located classical data processing cores are needed for implementing most of quantum algorithms leading to hybrid quantum-classical computing systems. Highly energy-efficient data centers can be envisioned with integration of low-power superconducting classical SFQ and quantum computing modules.