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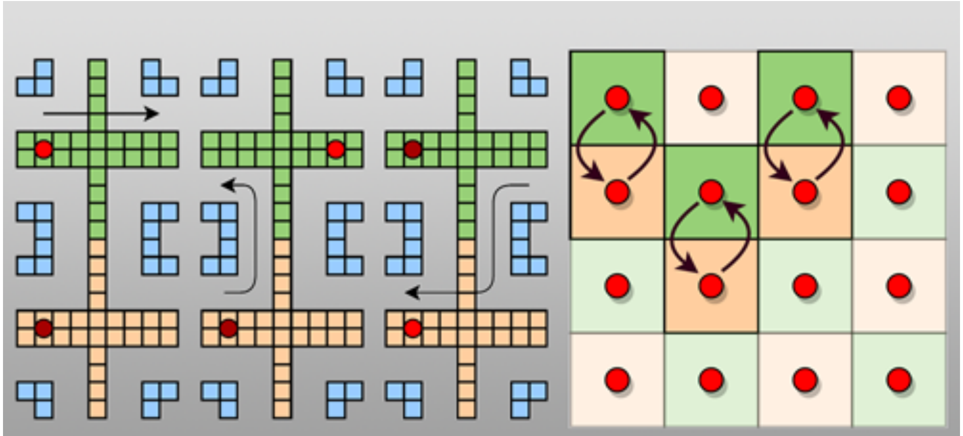
NTU Q

HOW TO WIRE A 1000-QUBIT TRAPPED-ION QUANTUM COMPUTER



Source: Malinowski et al.

The central challenge in realizing a quantum computer is well-documented: the quantum states of its building blocks, the qubits, must be long-lived and resilient against environmental disturbances. However, even robust qubits are of limited use without the ability to combine them in sufficient numbers. In a significant breakthrough, Maciej Malinowski and his team at Oxford Ionics, UK, have addressed this dilemma with an efficient control architecture for qubits. By introducing their "Wiring using Integrated Switching Electronics" (WISE) approach, tailored specifically for trapped-ion qubits, they have outlined a design for a quantum computer featuring a staggering 1000 qubits, a significant advancement from the few tens of qubits found in the largest commercially available trapped-ion devices today.

Trapped-ion quantum computers share solid-state chip technology with classical computers, yet they add a layer of complexity. While classical computers use straightforward signals transmitted via a small number of electrodes to read and write bits, trapped-ion qubits demand more intricate, diverse signals that are delivered through up to ten separate electrodes per qubit. As the quantum computer's qubit count increases, the challenge lies in accommodating these electrodes and managing the heat they generate.

The WISE approach, conceived by Malinowski and his team, is a game-changer. It streamlines control by reducing the number of signal generators and relocating them off the chip. Instead of each qubit having its own dedicated control structure, a single signal generator sends signals to multiple qubits via a minimal number of local switches. This innovation not only opens the door to quantum computers with 1000 qubits but also allows for their construction using existing semiconductor fabrication techniques.

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NEW QUANTUM FACTORING ALGORITHM THAT IMPROVES SHOR'S ALGORITHM

Intel Back in 1994, Peter Shor, an applied mathematician at MIT, introduced the world to a groundbreaking concept: using quantum computers to hack the internet by efficiently finding prime number factors of large numbers, which serve as the bedrock of online encryption. Shor's algorithm has since remained an emblem of quantum computing's potential, despite quantum computers not yet reaching the scale or reliability required for practical implementation with large numbers. However, a breakthrough may be on the horizon.

Oded Regev, a computer scientist from New York University, has unveiled a new quantum algorithm that could outperform Shor's. Presented in a preprint on the arXiv server on August 12, Regev's scheme aims to significantly reduce the number of logical steps needed to factor enormous numbers. This advancement could empower smaller quantum computers to identify secret encryption keys more efficiently or expedite decryption on larger machines, potentially revolutionizing internet security.

Vinod Vaikuntanathan of MIT finds Regev's work fascinating, with the potential for groundbreaking ideas in quantum computing. Kenneth Brown of Duke University emphasizes the surprising and exciting nature of Regev's findings. Shor's algorithm, like all quantum algorithms, relies on quantum bits (qubits) with superposition properties. For current internet encryption standards with at least 2048-bit numbers, Shor's algorithm requires millions of gates, which is beyond the capacity of current quantum technology.

Regev's innovation lies in the multidimensional approach, requiring significantly fewer gates for the same result, marking the first substantial improvement on Shor's algorithm in three decades. Despite some drawbacks, Regev's novel approach is a promising step forward in the field of quantum cryptography.

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