Breakthrough architecture for quantum computers

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A team of researchers at the University of Waterloo's Institute for Quantum Computing has proposed a new computational model that may become the architecture for a scalable quantum computer.

In a paper to be published in the journal Science this week, the research team of IQC Associate Professor Andrew Childs, post-doctoral fellow David Gosset and PhD student Zak Webb proposes using multi-particle quantum walks for universal computation. In a multi-particle quantum walk, particles live on the vertices of a graph and can move between vertices joined by an edge. Furthermore, nearby particles can interact with each other.

Traditionally, a quantum algorithm is implemented on a register of qubits by actively manipulating the qubits according to a set of desired operations. In this new model, a desired quantum algorithm can be implemented by letting the qubits "quantum walk" on an appropriately chosen graph, without having to control the qubits. The process is analogous to a billiard-ball computer where classical logic gates are performed using collisions.

Many previous quantum-walk experiments have not been scalable. But this new model proposed by Childs and his team identifies the requirements to implement quantum walks so they have the potential for significant quantum speedup, paving the way for scalable future experiments. The model could be naturally realized in a variety of systems, including photons with interactions mediated by superconducting circuits.

Quantum walk-based computing is particularly promising because of its universality. "In principle we can cast any quantum algorithm into this model," says Childs. In future work, Childs and his team are interested in applying the model to develop new quantum algorithms and to study problems in quantum computational complexity.

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