Implementing Quantum Dot Qubits in Optimized Linear Quantum Computing Architectures through Evolutionary Computational Modeling

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Segmented linear quantum computing architectures provide high error tolerance while maintaining a simple, one-dimensional layout. However, current research on implementing currently-achievable qubits in segmented architectures is limited. The performance of segmented architectures in full-scale processors has also not been evaluated. This research analyzed the usability of current quantum dot, ion trap, and transmon qubits in segmented architectures. The theoretical performance of quantum dot qubits was evaluated in megaqubit-scale processors. Models based on current research were used to analyze large numbers of segmented designs. Architecture parameters and physical error rates were used to approximate qubit speeds, sizes, and logical error rates. An evolutionary algorithm generated optimally-compact arrays of logical qubits to evaluate full-scale processors. Segment specifications were then incorporated to determine processor speed and size. Quantum dots produced low-error qubits with fast speeds and small sizes (0.9mm^2, 186.7 gates per second). Ion traps achieved low error rates but had large sizes and slow speeds (15.7mm^2, 0.184gps). Transmon qubits were fast (59.15gps) but too large to be practical (over 1m^2). Analysis of ten qubit array sizes showed that optimal arrays mimic box fractals. Quantum dots in 10-by-10 arrays were estimated to produce 18.30cm^2 processors capable of 18429gps. The results indicate that quantum dots are strong candidates for efficient processors using segmented architectures. The qubit arrays suggest that fractaline structures allow for optimally compact qubit arrangement. These results can guide future research in scalable quantum computing and suggest that megaqubit-scale quantum dot processors are currently viable.

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