Quantum Random Access Memory (qRAM) Analysis

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**Main Results:**

This work presents a new architecture for quantum random access memory (qRAM) called "bucket-brigade." This architecture uses a design that drastically reduces the number of switches required in each memory call to lower the complexity and energy requirements associated with accessing quantum memory. The reduction in the number of switches required from O(N^1/d) in classical RAM to O(logN) in qRAM represents the efficiency improvement of the architecture.

**Significance:**

The bucket-brigade architecture improves the noise resilience and decoherence resistance of qRAM by introducing an exponential reduction in complexity for memory calls in quantum computing. Through the simplification of the qRAM implementation, it provides access to scalable and useful quantum computing architectures. The development of quantum computers, which can do complicated computations more quickly than classical computers, may be sped up because of this breakthrough.

**High-Level Overview of Techniques Used:**

The design makes use of a bifurcation graph in which a three-level quantum system (qutrit) is present in every node. The state of qutrits, which function as switches that route the qubits, determines the direction that incoming quantum bits (qubits) direct subsequent qubits along. Like the "bucket-brigade" approach, photon-based information transfer effectively routes data over several paths while drastically lowering the number of active resources needed at any given time. This architecture offers a highly effective and noise-resistant way to access quantum memory by reducing the number of active quantum gates required in each memory call to O(logN).

**Conclusion:**

The "bucket-brigade" architecture provides an effective, scalable, and noise-resistant method of quantum memory access, marking a substantial improvement in qRAM design. The design makes the implementation of qRAM easier and could spur further developments in the field of quantum computing, which could advance the development of large-scale, useful quantum computers.