AQUA and the FIRST Project

Rodney Van Meter and the AQUA Team
http://aqua.sfc.wide.ad.jp/

We have a good grasp on how to build a Shor Factoring Machine: we know it’s big (maybe six billion physical qubits) and that will take a long time (days to months) and a lot of error correction to work properly. What applications will be achievable and production-ready sooner? What is the smallest useful quantum computer?

Quantum simulations were the first-proposed application of quantum computers, but detailed estimates machine type and size and error correction for executing them are still limited.

We are looking at:
- Phase Estimation Algorithm on the surface code

We are focusing on device architectures for surface code error correction. Critical questions:
- How can we handle hard faults (physical defects) in the lattice?
- Can we shorten lattice refresh cycle, and raise error threshold to 3-5%?

We are interested in collaborations to bridge the gap between small and large devices, and test our ideas!

Architecture for large systems involves much more than just scaling up devices of a few qubits. We adopt a layered architectural approach and use classical principles to handle:
- Physical heterogeneity in technologies
- Asynchrony in operations
- Hard and soft faults

In quantum networks, many of the key issues remain open:
- Debate on long-distance purification v. hop-by-hop teleportation current hot topic
- When to use purification, how to use error correction
- Routing (quantum Dijkstra’s algorithm)
- Multiplexing/resource sharing
- Detailed protocol designs emphasizing robustness, minimizing round-trip delays
- Distributed quantum state creation protocols (quantum recursive network architecture, QRNA)
- Management of federated, untrusted networks
- Truly scalable architectures

References and Acknowledgements

FIRST quantum information Processing project (JSPS)


