2024

Resource analysis for quantum-aided Byzantine agreement. — In distributed computing, a Byzantine fault is a condition where a component behaves inconsistently, showing different symptoms to different components of the system. Consensus among the correct components can be reached by appropriately crafted communication protocols even in the presence of byzantine faults. Quantum-aided protocols built upon distributed entangled quantum states are worth considering, as they are more resilient than traditional ones. Based on earlier ideas, we established a parameter-dependent family of quantum-aided weak broadcast protocols. We computed upper bounds on the failure probability of the protocol, and defined and illustrated a procedure that minimizes the quantum resource requirements (Fig. 1). Following earlier work demonstrating the suitability of noisy intermediate scale quantum (NISQ) devices for the study of quantum networks, we experimentally created our resource quantum state on publicly available quantum computers. Our work highlights important engineering aspects of the future deployment of quantum communication protocols with multi-qubit entangled states [1].

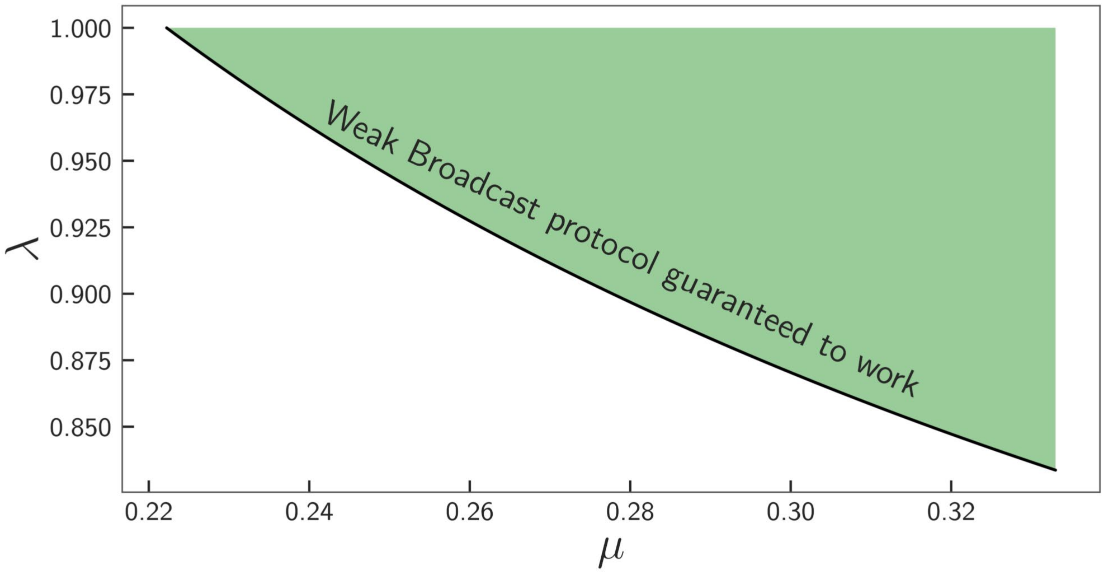
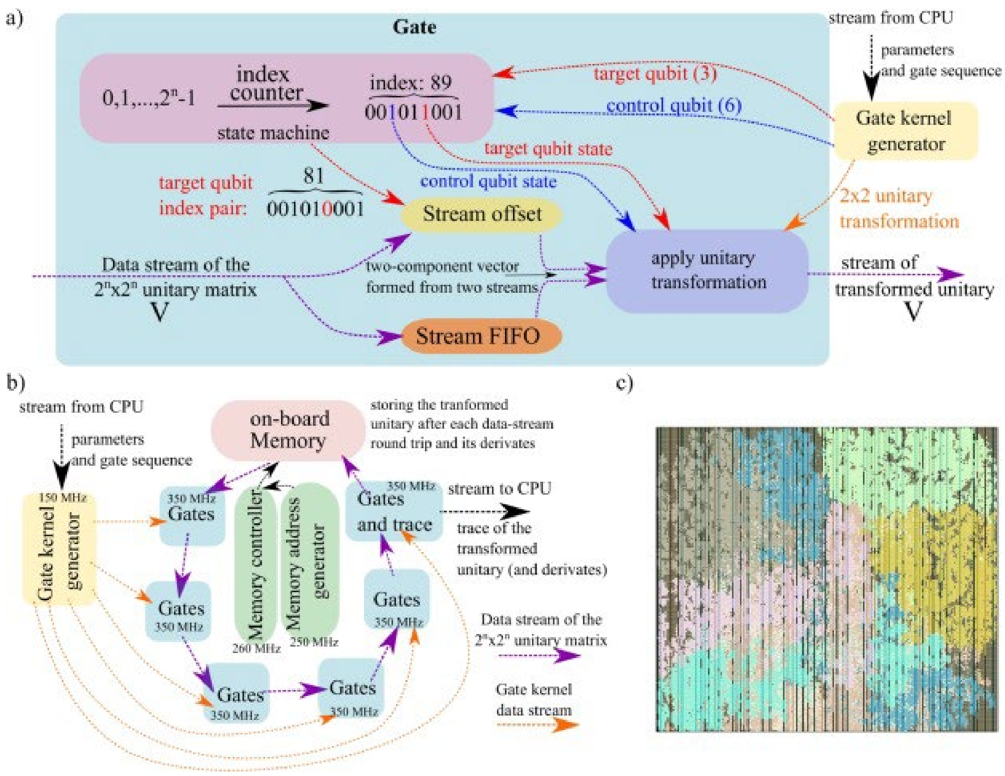


Figure 1. Green region shows the parameter regime where the consensus protocol we studied is guaranteed to work. That is, in the green region, the failure probability of the protocol can be upper-bounded by an exponentially decaying function of the number of resource states used for the protocol.

Applications of data-flow engines for circuit optimization. — The formulation of quantum programs in terms of the fewest number of gate operations is crucial to retrieve meaningful results from the noisy quantum processors accessible these days. In our work we demonstrated a use-case for Field Programmable Gate Array (FPGA) based data-flow engines (DFEs) to scale up variational quantum compilers to synthesize circuits up to 9-qubit programs. This gate decomposer utilizes a newly developed DFE quantum computer simulator that is designed to simulate arbitrary quantum circuits consisting of single qubit rotations and controlled two-qubit gates on FPGA chips. In our benchmark with the QISKIT package, the depth of the circuits produced by the SQUANDER package (with the DFE accelerator support) were less by 97% on average, while the fidelity of the circuits was still close to unity up to an error of $\sim 10^{-4}$ [2].

Figure 2. a) The design of a Gate block performing universal single qubit rotations and controlled two-qubit operations. The data stream V is split and offset to combine the elements in the columns of the unitary according to the current gate transformation. b) The implementations of the Gate blocks are chained up into a data-flow cycle, each gate performing a single gate operation on the data stream V. The transformed unitary is streamed into the on-board memory unit. During the very last gate operation the trace of the unitary is calculated and streamed back to the host CPU. c) The data-flow implementation of the design on one of the SLR blocks, indicating the different implementation blocks with coloring..



References:

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