Quantum circuit simulation benchmark with half precision floats in ARM64 architecture

- Quantum circuit simulation with Schrodinger's formulation is memory bound
- Memory, communication bandwidth and compute time doubles with each additional qubit.
- Quantum Fourier Transform is one of the most difficult circuits to simulate
- Simulation capability essential for quantum circuit design

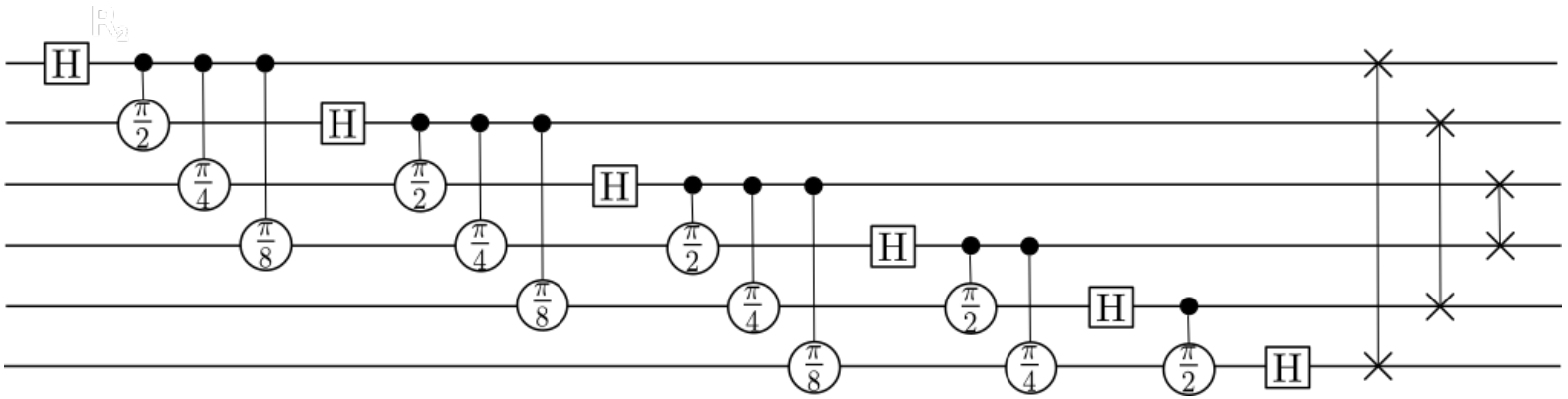

Figure: The quantum benchmark computes the Approximate Quantum Fourier Transform, using input data from Shor's factorization algorithm. Unlike the QFT, the AQFT only performs $2 + \log_2 Q$ phase gates.

Some details

- Built complex16 type with 2 Float16 and/or fp16 (1 bit sign, 5 exponent bits and 10 bits of mantissa)
- Converts the sign bit of the exponent into an additional significant bit
- Developed mathematical model than ensures that accuracy is not lost for any foreseeable simulation
- Saves half of total memory.
- fp16/Float16 available in 64-bit ARM architecture. Here we used as storage type, but in other systems it is also available as native arithmetic.
- Implemented an ARM version of Shor's quantum factorization algorithm benchmark.
- See details at github.com/datavortex/QuanSimBench/
- 32 nodes at Leicester Catalyst HPE Apollo 70 system, University of Leicester and DiRAC HPC Facility

Comparison between fp16 versus fp32: speed

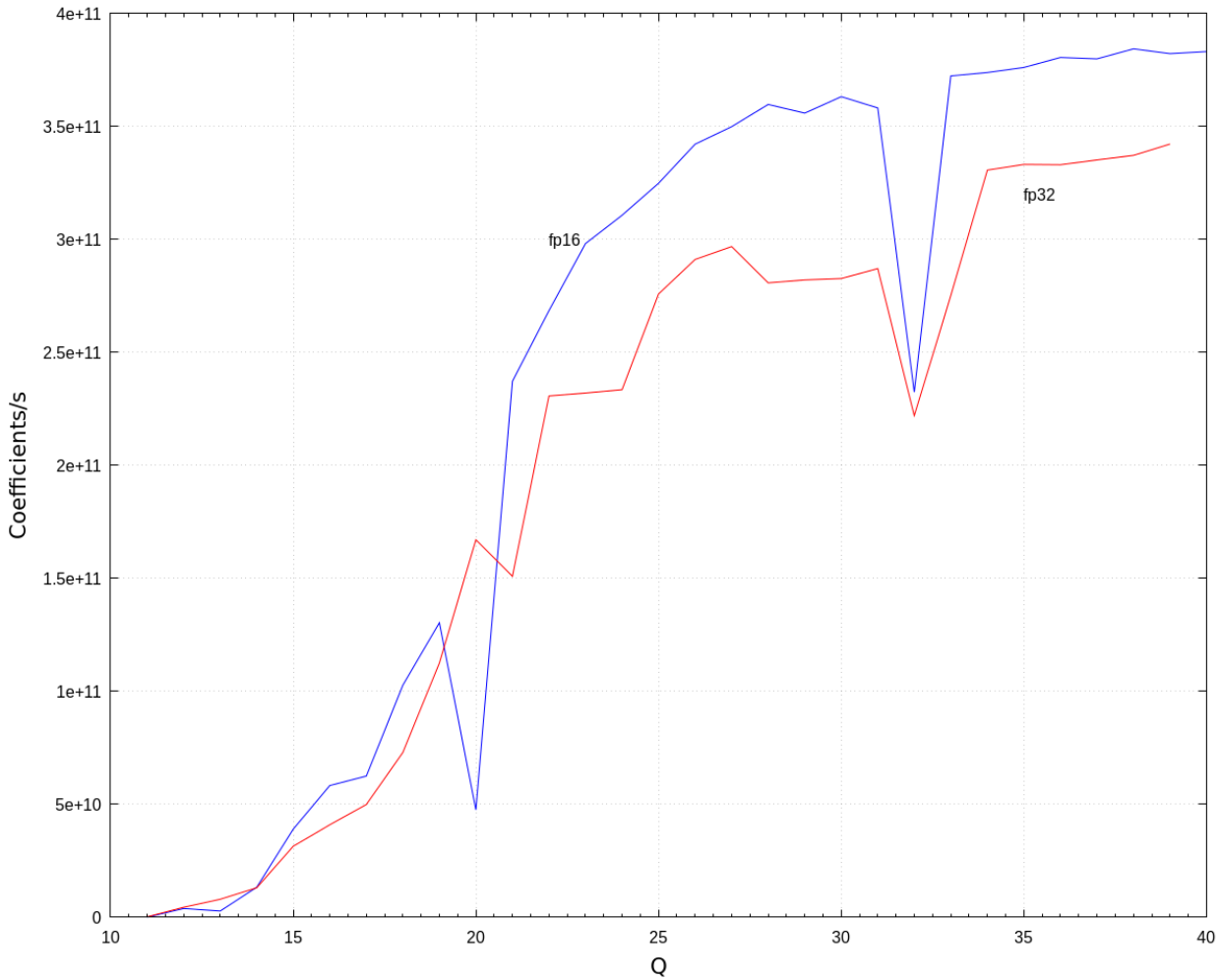

Figure: Coefficients processed per second as a function of number of qubits. fp16 is faster than the fp32 version because it has to communicate half the data between nodes, and it also can compute one more qubit.

Comparison fp16 versus fp32: probability of success

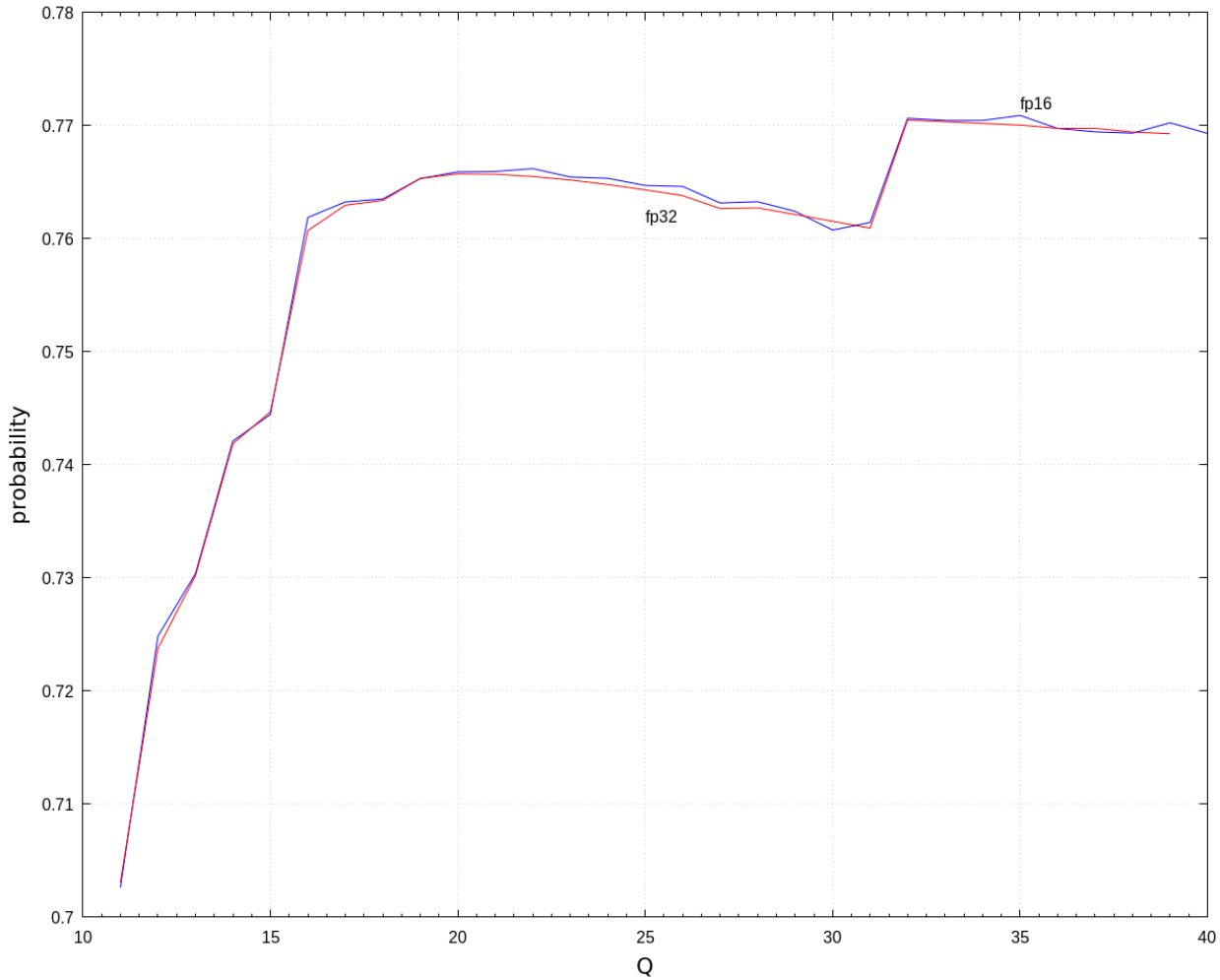

Figure: The probability of success of Shor's algorithm is the same with fp16 or fp32, but fp16 uses half the memory.

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