A Test Suite for Quantum Network Applications

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1. Background

- Quantum computig is a promising realm of Computer Science
- Quantum links and Quantum nodes lay the foundations of a Quantum internet [1]
- A Benchmark is needed to quantify performance of Quantum Networks
- The workings of existing applications and protocols can be able to asses performance
- This research evaluates the distributed CNOT gate application as a benchmark

2. Research Question

How informative is a distributed CNOT gate application as a benchmark for properties of the total quantum network system?

3. Method

- Qubits states can be represented as points of a Bloch Sphere (fig. 1)
- Quantum gates are used to transfer a Qubit state to another
- The distributed CNOT gate has two qubit inputs: c and t (fig. 2)
- c inputs in the z-basis have an effect on the output of t
- t inputs in the x-basis have an effect on the output of c

- The error rate of all inputs sets in the z and x-basis are measured by repeating the application 250 times
- The error rate is plotted against multiple hardware parameters of the Quantum link and Quantum nodes
- The trend is modelled between the parameter and error rate (fig. 3)
- The maximum slope of this trend is the sensitivity (tab. 1, 2 & 3)

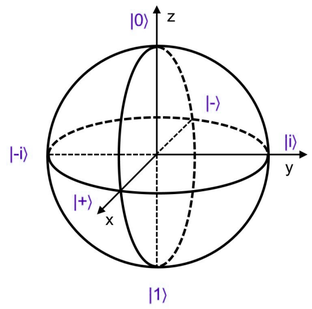

Figure 1: The Bloch Sphere [2] is used to represent Qubit states. States in the z-basis are |0> and |1>. States in the x-basis are |+> and |->.

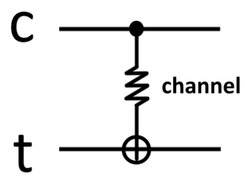

Figure 2: The distributed CNOT gate are two Quantum nodes connected via a Quantum link. It performs the CNOT gate on the c and t qubits.

5. Conclusion

- The distributed CNOT gate is sensitive to errors in the Quantum link and both Quantum nodes.
- Inputs in the x-basis are sensitive to all parameters the application is sensitive to.
- For some parameters inputs in the z-basis are more sensitive than inputs in the x-basis.
- Inputs |00> and |01> are significantly less sensitive to some parameters.

- Any input in the x-basis could function as a sufficient benchmark
- For more sensitivity different inputs could be combined.
- For optimal sensisitivity an input of the x-basis is combined with the input |10> or |11>.

6. Future work

- The results of different Quantum network applications can be used to compose a benchmark suite.
- This suite can be optimized by being sensitive to as many different parameters as possible.
- The distributed CNOT gate application can be included if it is sensitive to parameters all other application are not sensitive to.

7. References

[1] S. Wehner, D. Elkouss, and R. Hanson, "Quantum internet: A vision for the road ahead," *Science*, vol. 362, no. 6412, pp. 1–9, Oct 2018.

[2] . Nielsen and I. Chuang, *Quantum Computation and Quantum Information*, 10th ed. Cambrigde UK: Cambridge University Press, 2010.

4. Results

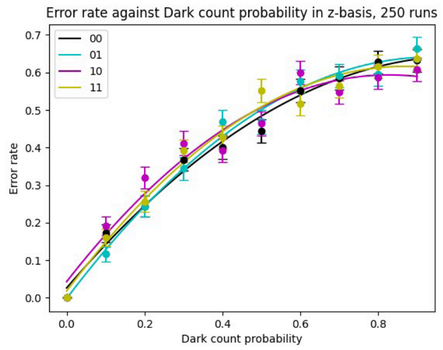

Figure 3: The error rate plotted against the dark count probability for inputs |00>, |01>, |10> and |11>.

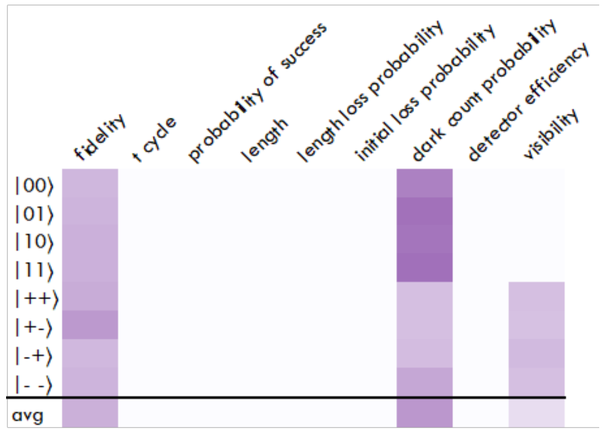

Table 1: The sensitivity of input sets in the z and x-basis against the hardware parameters of different Quantum link types.

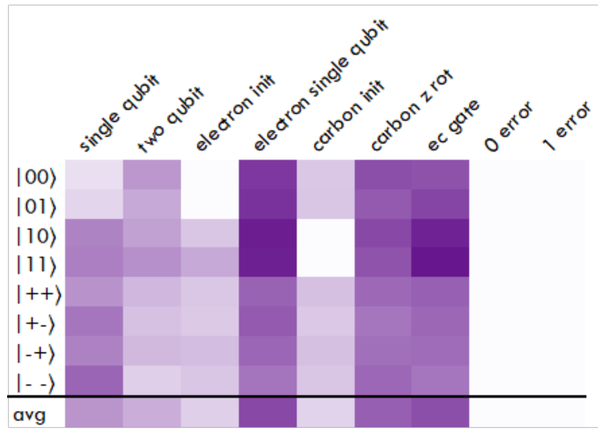

Table 2: The sensitivity of input sets in the z and x-basis against the hardware parameters of in the distributed CNOT c node.

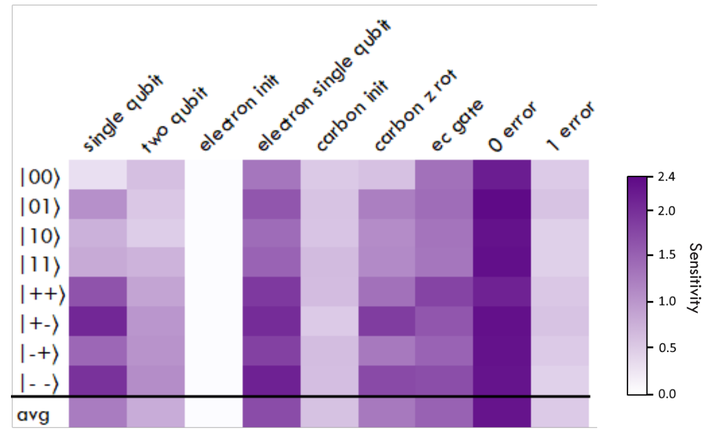

Table 3: The sensitivity of input sets in the z and x-basis against the hardware parameters of in the distributed CNOT t node.