Performance of Surface Codes in realistic quantum hardware

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Abstract

One of the main obstacles for the construction of a many qubit quantum computer is quantum decoherence. Qubits within quantum computers tend to fail and prevent us from achieving their true potential. In order to tackle quantum decoherence, Quantum Error Correction Codes (QECC) aim to detect and correct those errors. Surface codes are a class of QECC which enjoy a great popularity in the current scientific community since they do not need a large number of qubits [1]. Most of the studies on the performance of surface codes assume all qubits experience noise following an independent and identical error probability distribution (i.i.d.). In this poster, supported by experimental evidence in which individual qubits within the code present different deocherence times, we propose the independent non-identical error probability error model (i.ni.d.) [2-4]. Based on such model, we observe the change in the performance of the planar code and we try to design an algorithm which can exploit the difference in error probability of the constituent qubits in order to enhance the aforementioned performance.

References

[1] A.G. Fowler, M. Mariantoni, J.M. Martinis y A.N. Cleland, "Surface codes: Towards practical large-scale quantum computation", *Physical Review A,* vol 86, 2012.

[2] ibmWashington IBM Quantum. https://quantum-computing.ibm.com/services, 2022.

[3] ibmqBrooklyn IBM Quantum. https://quantum-computing.ibm.com/services, 2022.

[4] Wu, Y. et al. Strong Quantum Computational Advantage Using a Superconducting Quantum Processor. *Phys. Rev. Lett.* 127, 180501 (2021).

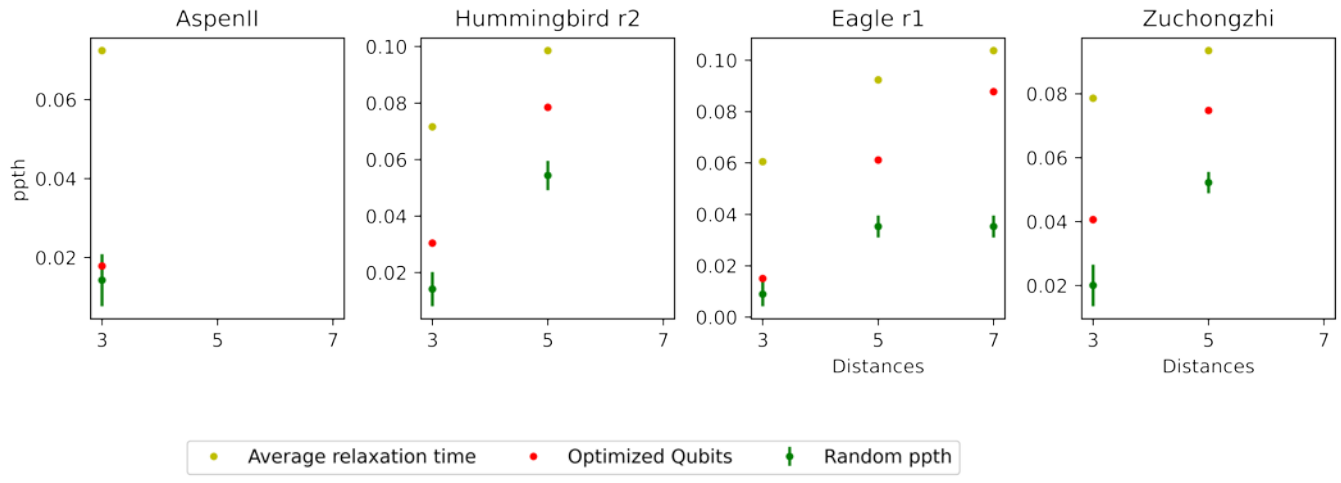

Figure 1: Pseudo-threshold for the random (i.ni.d.), optimized (i.ni.d.) and i.i.d. scenarios for 4 different quantum processors.