Studying the relationship of the quantum software and the energy consumption and success ratio

Elena Desdentado[1]
Coral Calero[1,2]
Mª Ángeles Moraga[1]
Félix Óscar García[1]

[1]*Instituto de Tecnologías y Sistemas de Información, Universidad de Castilla-La Mancha*
[2]*aQuantum. Green Quantum Algorithms & Software Research*

{Elena.DFernandez,Coral.Calero,
Mariaangeles.Moraga, Felix.Garcia}@uclm.es

Quantum computing is growing a lot in recent years as it is expected to be able to solve problems for which classical computing needs too much time or is not able to solve.
However, this technology is energy-intensive, so if we want to use it to solve highly complex problems, it is essential to implement energy-efficient solutions. This preliminary study examines correlations between energy consumption and the success rate of quantum circuits with respect to some static measures of quantum code. Moreover, we have studied the correlation for 4 IBM quantum computers.
The measures used, proposed by [1] are: M2.2: Lines of Code, M3.3; Number of operations, M3.5: Percentage of operations that increase the cyclomatic complexity, HM1.1: Number of used qubits and HM6.1: Quantum cyclomatic complexity; that have been applied to five algorithms.
The energy consumption and success rate are taken from a previous study developed by the authors [2].
The results (Figures 1 and 2) indicate that there exist significant moderate to high correlations between the energy consumption and the total number of operations, the number of qubits used and the quantum cyclomatic complexity of the algorithm. We can also observe that there are negative high correlations between the success rate and the number of lines of code, operations and qubits employed. These findings underscore the importance of efficiently managing complexity and size to decrease the energy consumption of quantum circuits.

References

[1] Díaz, A., Rodríguez, M., Piattini, M.: Towards a set of metrics for hybrid (quantum/classical) systems maintainability. Journal of Universal Computer Science (J.UCS) 30(1), 25–48 (2024). https://doi.org/10.3897/jucs.99348
[2] Fernández, E.D., de la Rubia, M.M., Martín, M.S.: Studying the consumption of IBM quantum computers (08 2021), https://aisel.aisnet.org/isd2014/proceedings2021/sustainable/3
[3] Quantum-and-Classical-Computing-Study, https://github.com/elenaDesdentado/Quantum-and-Classical-Computing-Study

Figures

Energy consumption

	M2.2	M3.3	M3.5	HM1.1	HM6.1
ibmq_lima	+	+	+	+	+
ibmq_quito	+	+	+	+	+
ibmq_santiago	+	+	-		
ibmq_manila				+	+

Figure 1: Energy consumption correlations to the static measures for all quantum algorithms.

Success rate

	M2.2	M3.3	M3.5	HM1.1	HM6.1
ibmq_lima	-	-	-	-	-
ibmq_quito	-	-	-	-	-
ibmq_santiago	-	-	-	-	
ibmq_manila	-	-	-	-	

Figure 2: Success rate correlations to the static measures for all quantum algorithms.