Problem Set 3

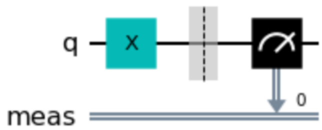
Tyler King

July 12, 2022

1 Problem 1

Throughout several trials between the HZH gate and the X-gate, the probabilities were surprisingly similar. I personally expected that the odds would favor the X-gate as there is only one instance where error could occur, while with the HZH gate there are 3 distinct instances where errors can occur. However, this was not what was observed.

In the X-gate case,



the correct result was predicted roughly .952 of the time.

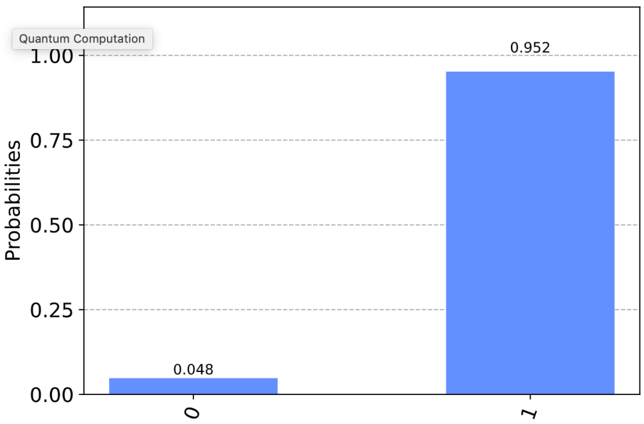
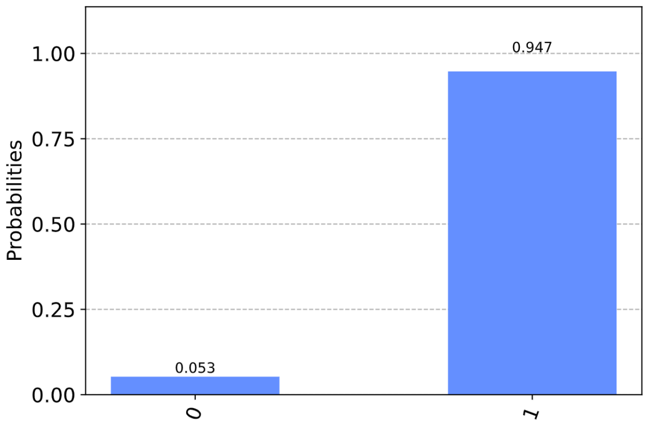


Figure 1: Sequence of gates HZH

However, with the HZH gate,

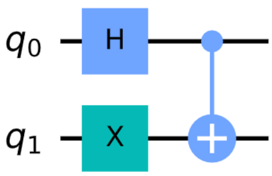
the correct result was predicted roughly .947 of the time.



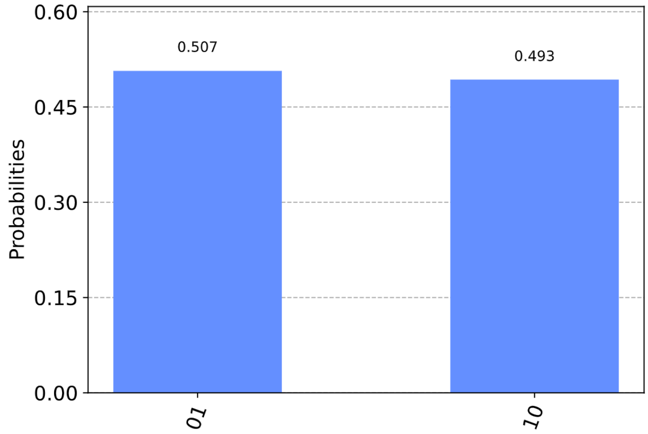
Although these are only two instances of tests being run, the pattern tended to be around .95 success rates for both the HZH gates and the X-gate.

2 Problem 2

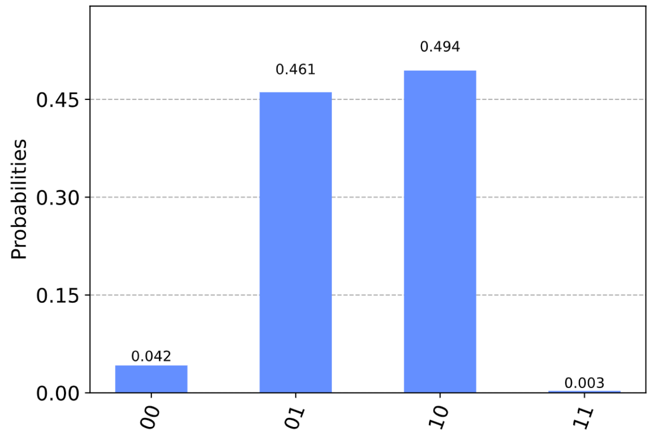
Recall that the circuit is:



When the Aer simulation is applied, we obtain the results:



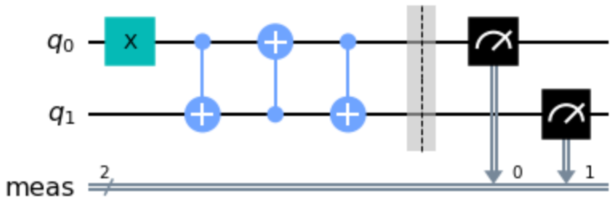
When we run the circuit on Quantum Hardware, we instead observe:



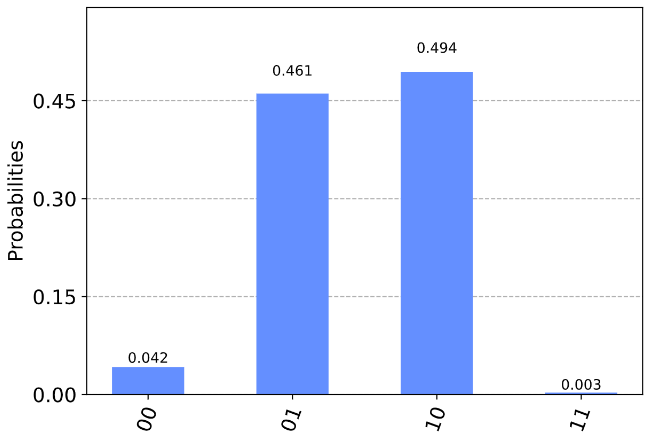
Since both histograms are based on "real" data (i.e. data that is subject to randomness), there will almost always be small deviations from a standard .5/.5 split. In the simulation, note that 00 and 11 are not possible outcomes because the simulation selects from the 2 possible qubits (01 and 10), while with hardware, any error may result in an incorrect possibility, which includes qubit states of 00 and 11.

3 Problem 3

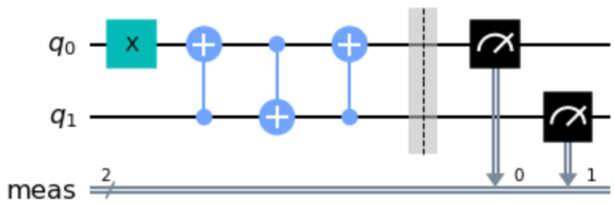
When applying the circuit



we obtain the probability distribution of

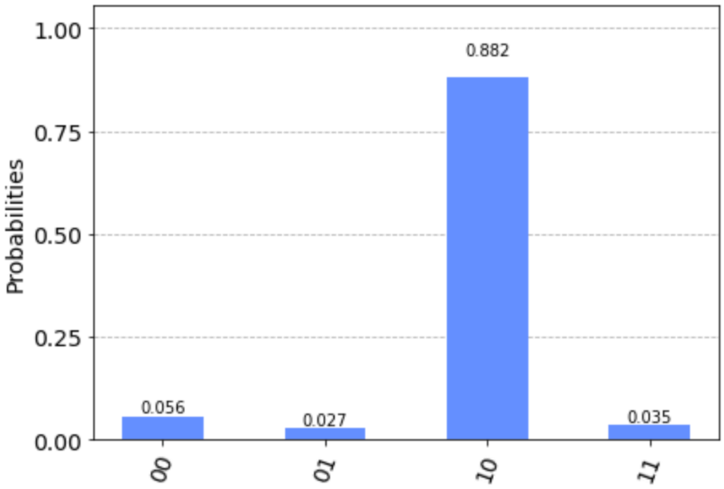


Comparatively, when we apply the circuit



we obtain the probability distribution of

which yields an accurate result a significantly higher percent of the time. This indicates that the second SWAP gate is more effective (and thus has a lower error potential since the simulations were showing the same results). I believe this is because the qubit that is more frequently controlled during the CNOT gates is the one that experiences the initial NOT gate, which means that



it experiences changes less frequently and is thus less likely to be subjugated to errors.

4 Problem 4

My first idea was implementing Quantum Walks into Quantum Circuits and testing them on IBM's hardware to quantify the error of certain walks. Relevant readings can be found here and here. My second idea had to deal with applying several phase gates consecutively and noting the error when you stack multiple phase gates, and then establish a relationship (linear or quadratic or something else) between multiple single-qubit phase gates and the probability of getting the wrong qubit. My last idea was attempting to connect quantum circuits to pathfinding algorithms, although I have no idea how to go about doing this and as such, it seems to likely be unfeasible.