Different Quantum Computing Architectures Affect Resulting Probabilistic Outputs

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Introduction

- The goal of this research is to show the affect on resulting probability when superdense coding algorithm runs on different quantum computing architects.
- For this paper, we are going to run the circuit on IBM 5 qubit London and IBM 5 qubit Rome processor and will be connecting different qubits to see if the result differs.

Superdense Coding

- Superdense coding, is a quantum information process that allows one person to send two classical bits to another person using only a single qubit of a pair of entangled qubits.
- This protocol was first proposed by Bennett and Wiesner in 1992 and experimentally actualized in 1996 by Mattle, Weinfurter, Kwiat, and Zeilinger using entangled photon pairs
- It is one of the underlying principle of secure quantum secret coding. The necessity of having both qubits to decode the information being sent eliminates the risk of eavesdroppers intercepting messages.

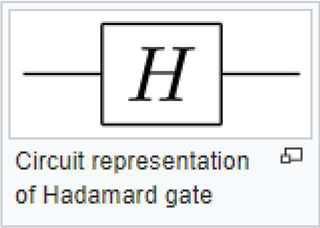
Quantum Logic Gates

- Commonly used gates
  - Hadamard gate
  - Pauli-X gate
  - Pauli-Y gate
  - Pauli-Z gate
  - Phase shift gates
  - Swap gate
  - **Controlled gates**

Hadamard Gates

- Simplest gate involves one qubit and is called a Hadamard gate (also known as a square root of NOT gate). Used to put qubits into superposition

$$H = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}.$$

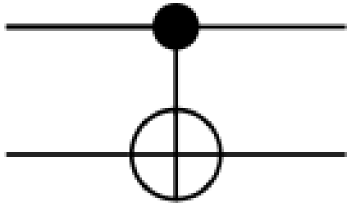


Circuit representation of controlled Hadamard gate

Controlled Gates

- Controlled gates act on 2 or more qubits. For example, the controlled NOT gate (or CNOT) acts on 2 qubits, and performs the NOT operation on the second qubits only when the first qubit is **|1>** , and otherwise leaves it unchanged. It is represented by the matrix-

$$\mathrm{CNOT} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

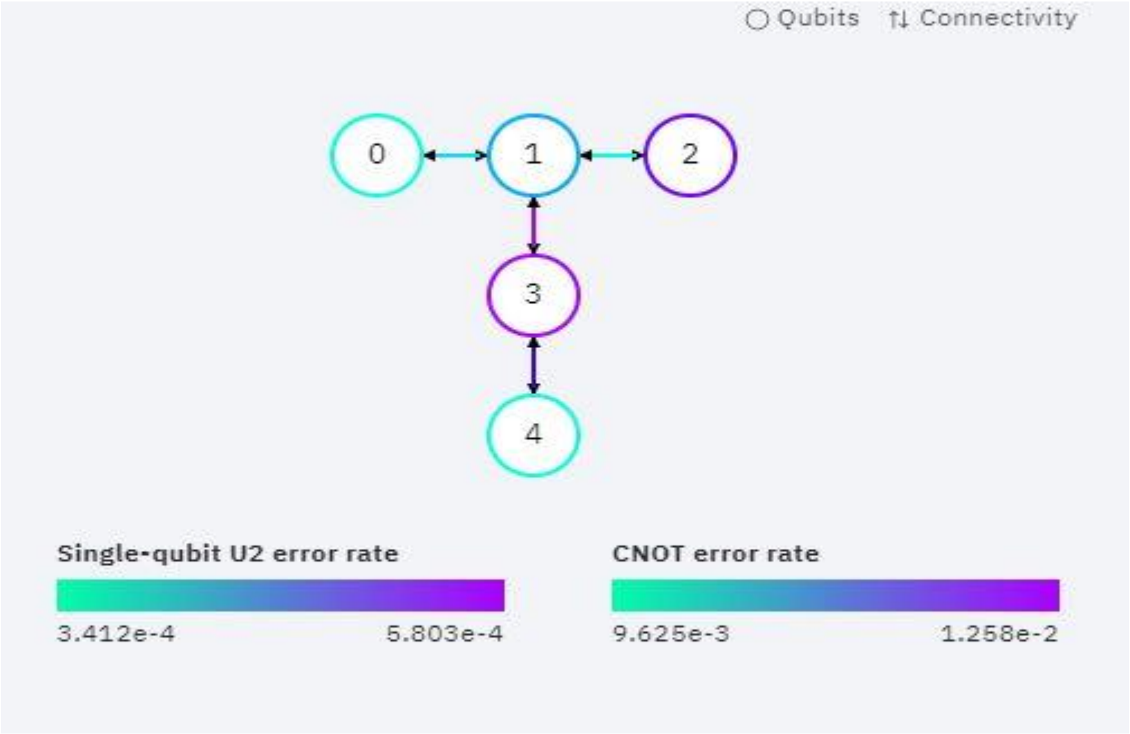


Circuit representation of controlled NOT gate

Software

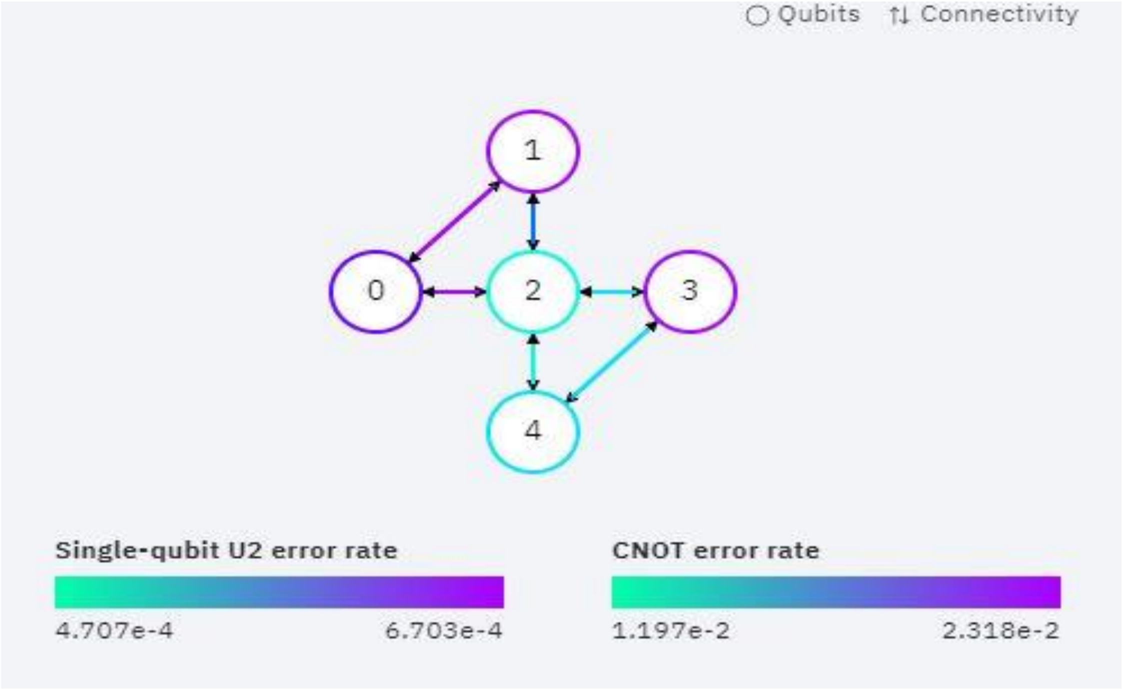
- Anaconda environment
- Jupyter Notebook containing QISKit
- IBM Q experience

IBM 5 Qubit London Architecture

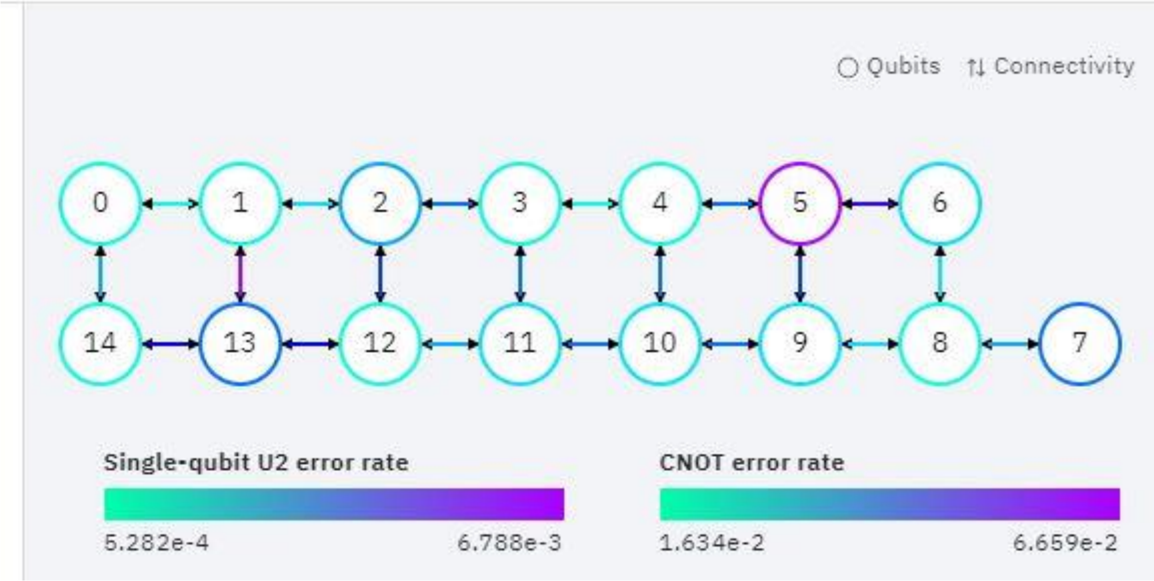


IBM 5 Qubit Rome Architecture

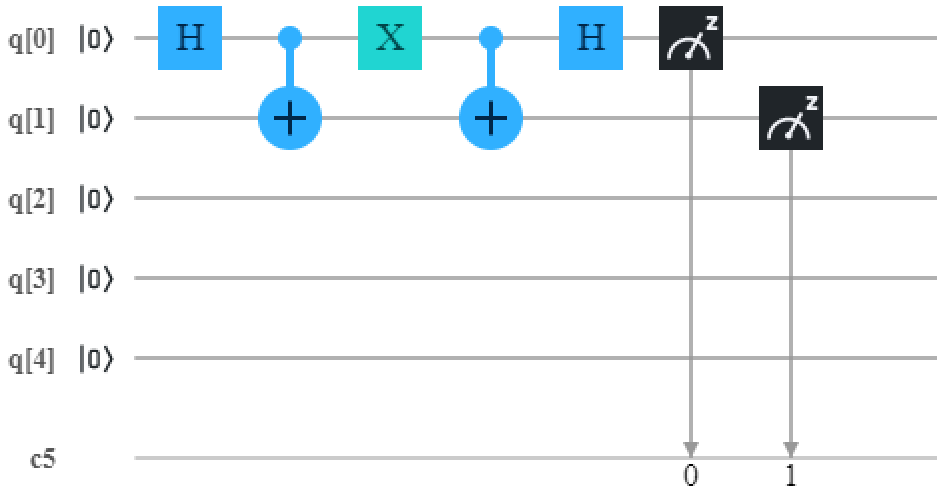
IBM 5 Qubit Yorktown Architecture



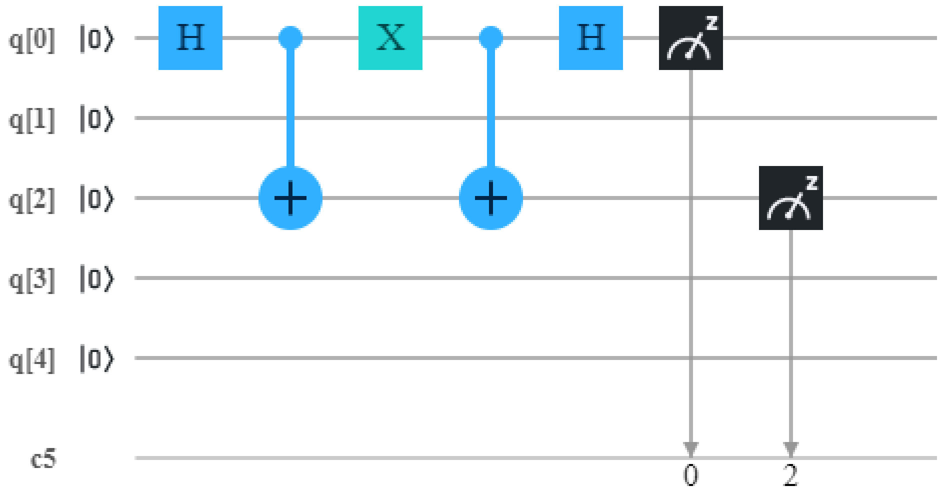
IBM 16 Qubit Melbourne Architecture



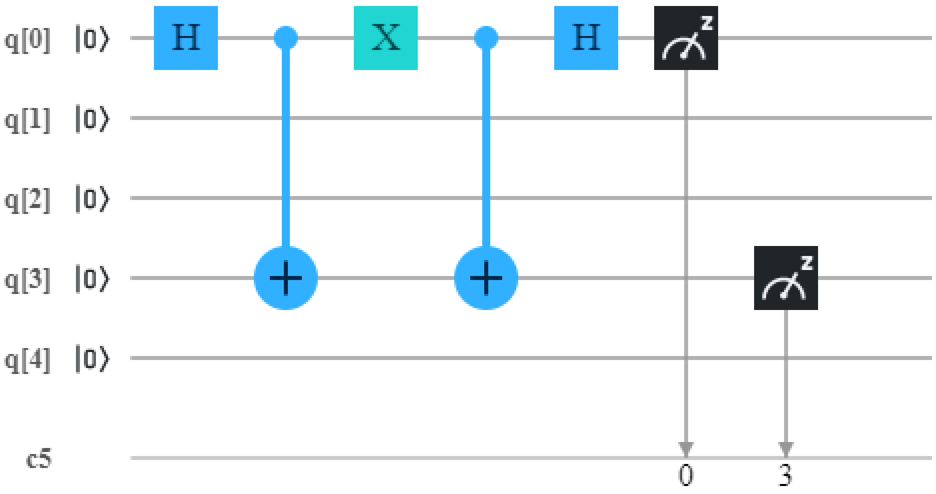
Circuit 1



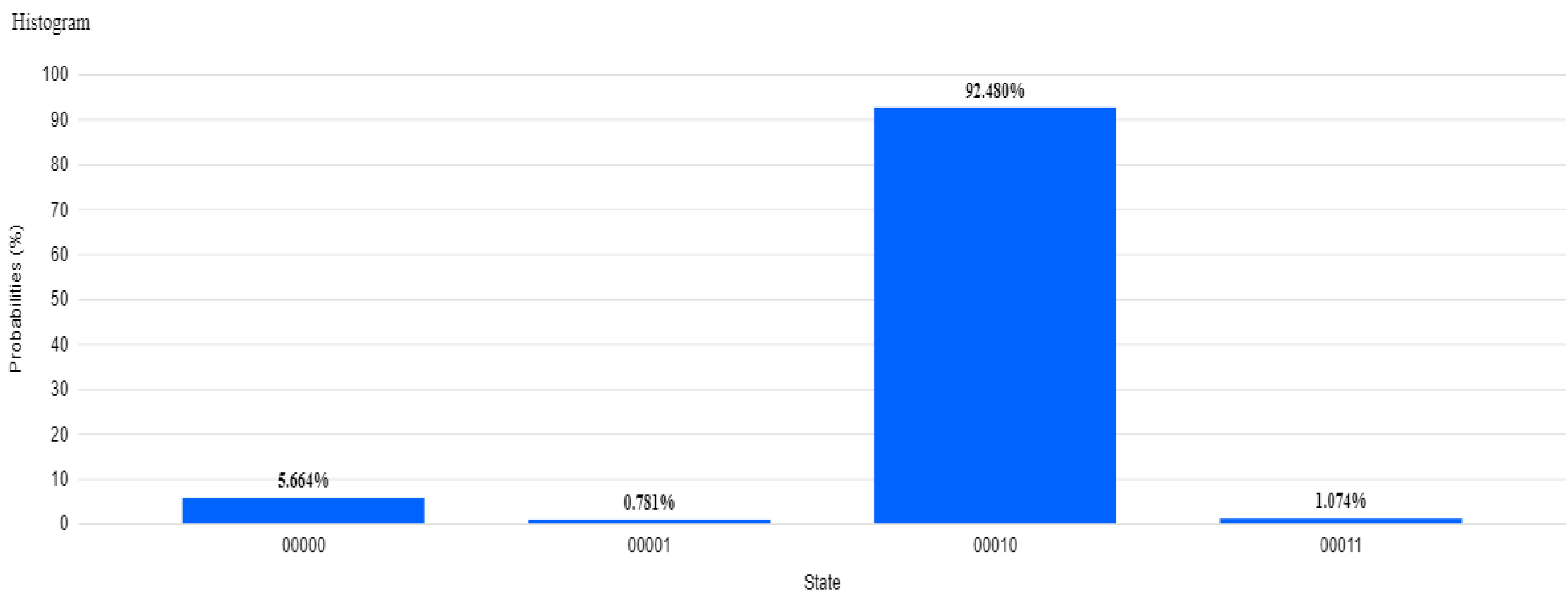
Circuit 2



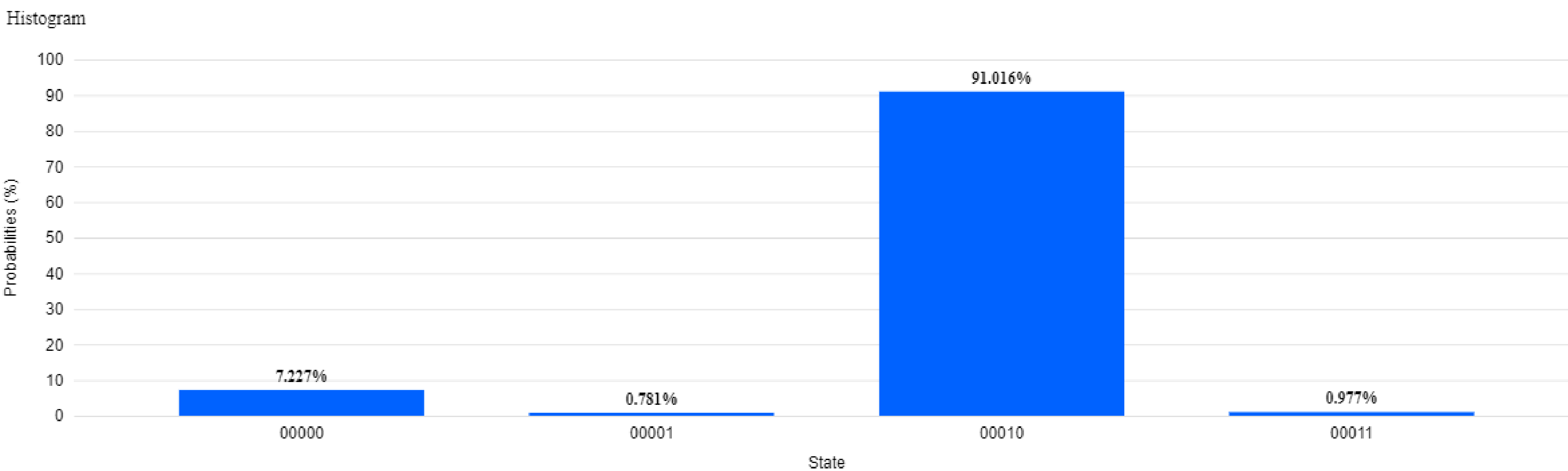
Circuit 3



Result of Circuit 1

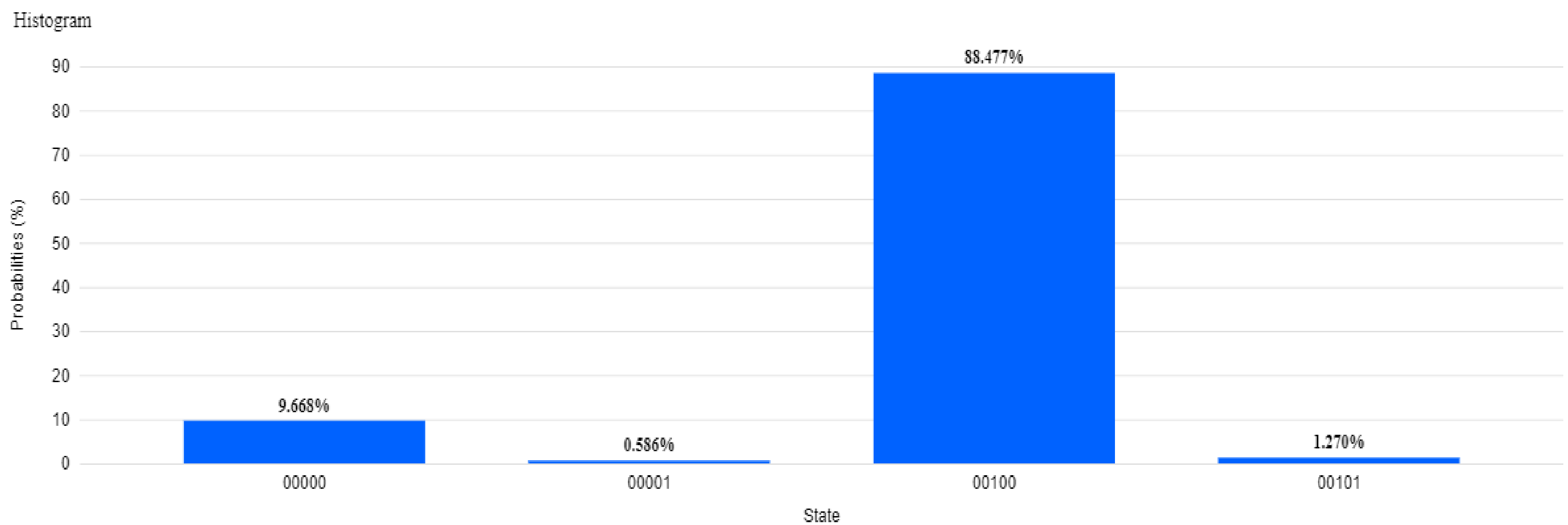


Result 1 IBM Rome

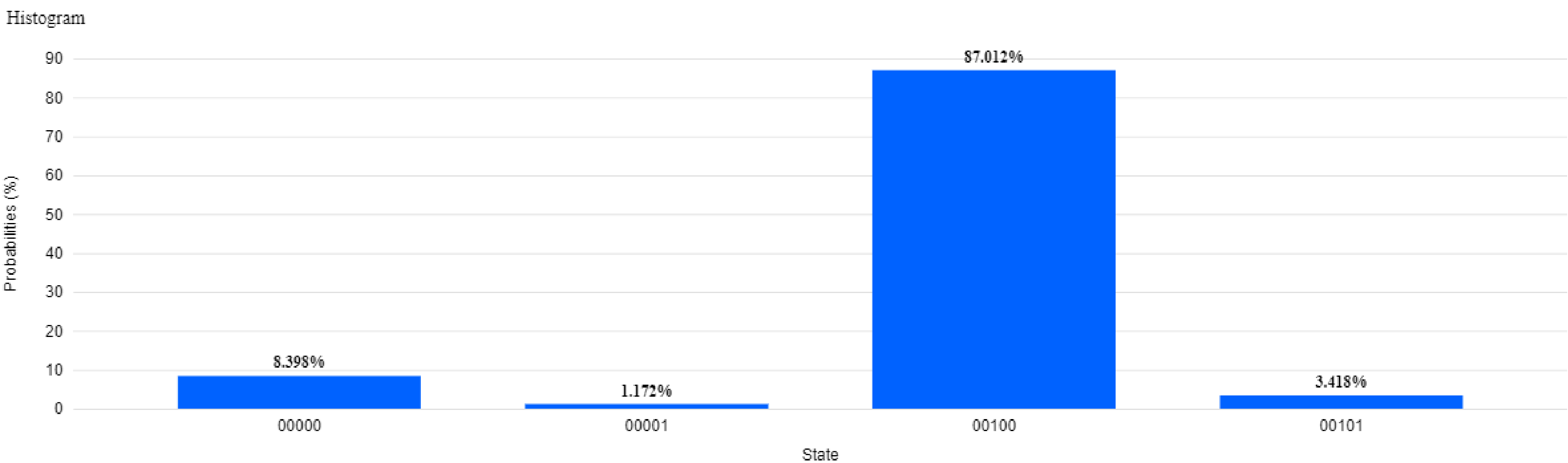


Result 1 IBM London

Result of Circuit 2

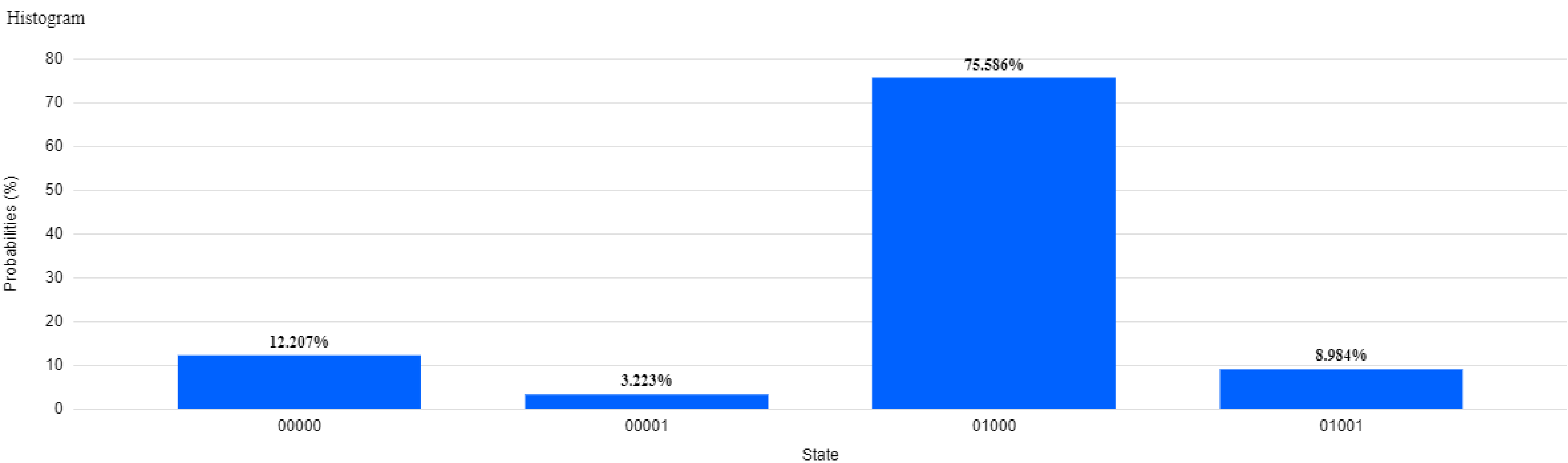


Result 2 IBM Rome

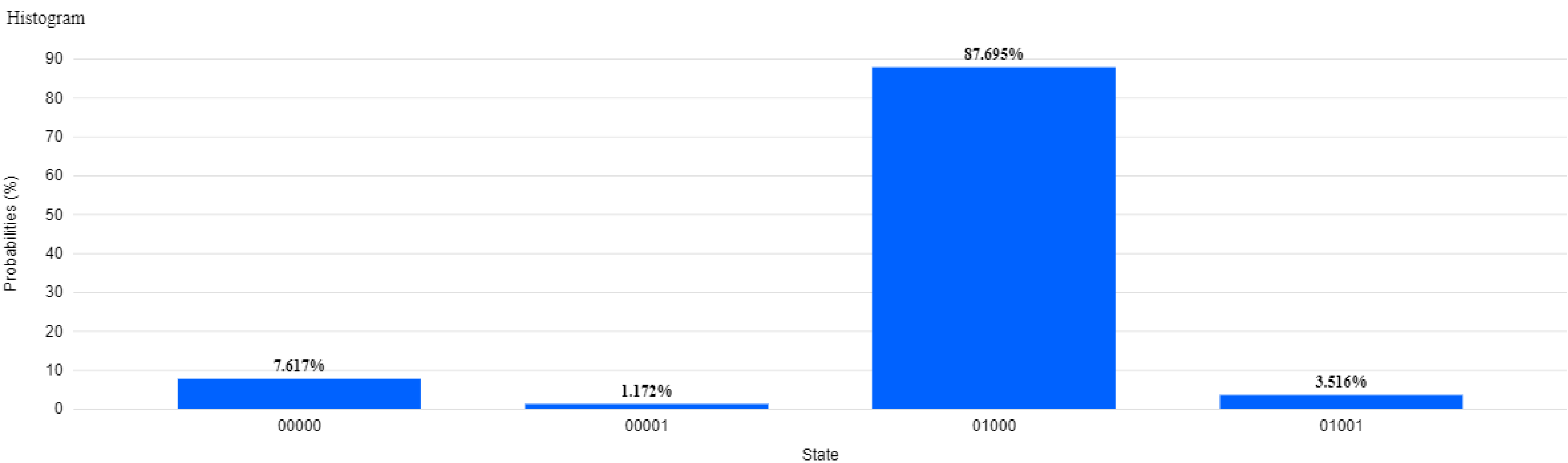


Result 2 IBM London

Result of Circuit 3



Result 3 IBM Rome



Result 3 IBM London

Probability results by computer and circuit

Circuit	Computer	00	01	10	11
Circuit 1	London	7.22	0.78	91.01	1.00
	Rome	5.66	0.78	92.48	1.07
Circuit 2	London	8.40	1.17	87.01	3.42
	Rome	9.67	0.59	88.48	1.27
Circuit 3	London	7.62	1.17	87.70	3.52
	Rome	12.20	3.22	75.59	8.98

Conclusion & Future Work

- The three circuits were constructed and run on the IBM's London and Rome quantum computers. The results show that the accuracy depends on how many qubits are between the qubits that are entangled.
- In the future, similar tests should be run on IBM's Yorktown and Melbourne computers to test these different architectures. The tests should also be extended to test the performance of using qubits 0 and 4 as this will further explore the effects of qubit separation.


Thanks!