Abstract

Quantum computing may have a significant impact on future technology, but there are many difficulties in the realization of universal quantum computers. One of the difficulties is how to decompose or synthesize quantum gates. This problem is similar to the logic synthesis of classical computers.

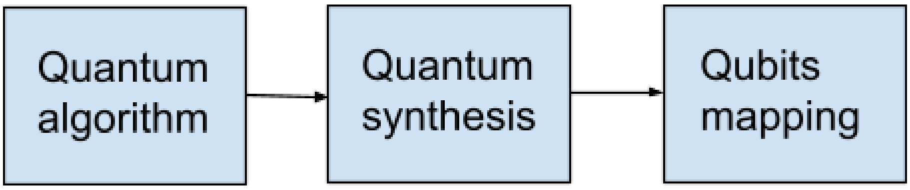

fig.1 A simple quantum circuit process flow

To evaluate the feasibility of the general-purpose quantum computer, the number of available qubits is a major consideration. Therefore, researchers are exerting all efforts on researching how to scale up the number of effective qubits of quantum computer candidates such as trapped ion or superconductor quantum computers. As the technology continues to break through and the number of available qubits continues to rise, the quantum circuit will become larger and more complex, and the importance of quantum synthesis will become increasingly important. Therefore, I think that studying quantum synthesis is also a way to evaluate whether the general-purpose quantum computer is feasible.

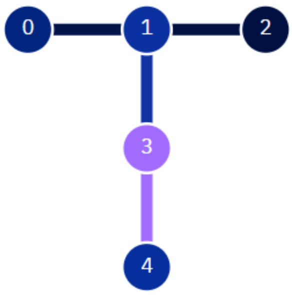

Fig.2 The connectivity graph of quantum computer ibmq_quito [1]

The existing Quantum synthesis method can be roughly categorized as follows: Decomposing the matrix by linear algebra, Selecting an instruction set and analyzing its algebraic properties to synthesize the matrix, and synthesis considering qubit connectivity. In the report, I will introduce some typical examples that have been proposed.

Another popular research topic is the impact of the actual connectivity between qubits under different architectures. Scientists use a connectivity graph to represent the connection of qubits of a quantum computer, as shown in Fig.2. When a quantum circuit has a multi-qubit gate, we must carefully consider where the qubits in the abstract circuit should be mapped to the connectivity graph, because if the qubits the multi-qubit gates act on are not physically connected, SWAP gates must be employed to put them in neighbored positions. In this report, I will implement a simple 4-qubit Deutsch–Jozsa algorithm on a real quantum computer to analyze the difference in circuit depth under different qubit layouts.

[1] IBM. (n.d.). Compute resources—System profile of ibmq_quito. Retrieved November 28, 2022, from https://quantum-computing.ibm.com/services/resources?tab=systems&search=qu&system=ibmq_quito.