the ground state during a later stage of the computation. The robustness of finding the ground state of the Hamiltonian for solving the problem is improved.

According to an aspect, there is provided an apparatus comprising: a first pair of logical superconducting units for use in computation, each logical superconducting unit being configured to have quantum states that can be spanned over Pauli operator σ_{sj}^{i}, where $i = x, y,$ or z; a first pair of control superconducting units for use in assisting the computation without being a computational unit, each control superconducting unit being configured to have quantum states that can be spanned over Pauli operator σ_{ck}^{i}, where $i = x, y,$ or z; a first coupler between a first logical superconducting unit and a second logical superconducting unit, wherein when a magnetic field is applied along a z direction, the first coupler couples a quantum operator σ_{s1}^{z} of the first logical superconducting unit with a quantum operator σ_{s2}^{z} of the second logical superconducting unit in a first coupling represented by $\sigma_{s1}^{z}\sigma_{s2}^{z}$; a second coupler between a first control logical superconducting unit and a control second superconducting unit, wherein when a magnetic field is applied along a z direction, the second coupler couples a quantum operator σ_{c1}^{z} of the first control superconducting unit with a quantum operator σ_{c2}^{z} of the second control superconducting unit in a second coupling represented by $\sigma_{c1}^{z}\sigma_{c2}^{z}$; a third coupler between the first logical superconducting unit and the second control superconducting unit, wherein when the magnetic field along the z direction is applied, the third coupler couples a quantum operator σ_{s1}^{z} of the first superconducting unit with a quantum operator σ_{c2}^{z} of the second superconducting unit in a third coupling represented by $\sigma_{s1}^{x}\sigma_{c2}^{z}$; and a fourth coupler between the second logical superconducting unit and the first control superconducting unit, wherein when the magnetic field along the z direction is applied, the fourth coupler couples a quantum operator σ_{s2}^{z} of the first superconducting unit with a quantum operator σ_{c1}^{z} of the second superconducting unit in a fourth coupling represented by $\sigma_{s2}^{x}\sigma_{c1}^{z}$.

The details of one or more embodiments of the subject matter of this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages of the subject matter will be apparent from the description, the drawings, and the claims.

DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic perspective view of interacting qubits in a quantum processor.

FIG. 2 is a schematic diagram showing the structures and interactions of two qubits in a quantum processor.

FIG. 3 is a schematic diagram showing the effect of a quantum governor on a quantum annealing process.

FIG. 4 is a schematic diagram showing the interplay of an initial Hamiltonian, a problem Hamiltonian, and a Hamiltonian of a quantum governor chosen for the problem Hamiltonian during a quantum annealing process.

FIG. 5 is a flow diagram of an example process for determining a quantum governor distribution.

FIG. 6 is a flow diagram of an example process for performing an artificial intelligence task.

DETAILED DESCRIPTION

Overview

Solutions to hard combinatorial problems, e.g., NP-hard problems and machine learning problems, can be encoded in the ground state of a many-body quantum Hamiltonian system, which is also called a quantum annealer or "QA." A QA of a system can sometimes be obtained through adiabatic quantum computation, in which the QA is initialized to a ground state of an initial Hamiltonian H_i that is known and easy to prepare. Over time, the QA is adiabatically guided to a problem Hamiltonian H_p that encodes the problem. In theory, during the adiabatic quantum computation, the QA can remain in the instantaneous ground state of a Hamiltonian H_{total} evolving from H_i to H_p, where H_{total} can be expressed as: