D-WAVE

ADVANTAGE SYSTEM

The Advantage™ quantum system of D-Wave Systems Inc. ("D-Wave") comprises the following components:

- Quantum processing unit (QPU)
- QPU control system
- QPU I/O system
- Cryogenic dilution refrigerator system
- Magnetic shielding system
- Radio-frequency (RF)–shielded enclosure

The QPU (see Fig. 1) is a lattice of tiny metal loops, each of which is a qubit or a coupler. Below their critical temperature, these loops become superconductors and exhibit quantum-mechanical effects. The QPU of the Advantage system has more than 5,000 qubits and 35,000 couplers. In order to reach this scale, the chip uses over 1 million Josephson junctions.

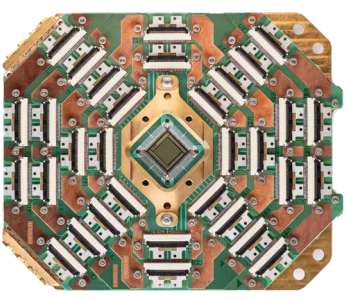

Fig.1: D-Wave Advantage QPU

The qubits of the Advantage QPU interconnect in a topology known as Pegasus, see Fig. 2. In the Pegasus graph each qubit is connected with 15 other qubits except for the qubits at the edges.

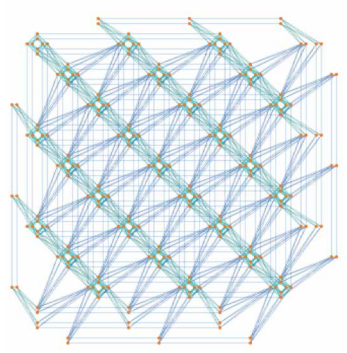

Fig.2: A Pegasus graph of size 4 (P4) with 27 unit cells and several partial cells, containing 264 qubits (orange dots).

The QPU must be kept at a temperature near absolute zero and isolated from the surrounding environment in order to behave quantum mechanically. The system meets these requirements by

- operating the QPU at temperatures below 20 mK, cryogenic temperatures achieved using a closed-loop cryogenic dilution refrigerator system;
- shielding it from electromagnetic interference, achieved using a radio frequency (RF)–shielded enclosure and a magnetic shielding subsystem.

The RF-shielded enclosure (an electromagnetic-tight box) houses the cryostat, the QPU, the I/O system, the rest of the QPU control system, and most of the magnetic shielding system.

The cryogenic dilution refrigerator system includes a cryostat (see Fig. 3), a nitrogen cold trap, and equipment racks. The cryostat, which is surrounded by a magnetic shielding system, is mounted within the RF-shielded enclosure; the cold trap and equipment racks sit outside it. Communication between the equipment racks and the cryostat occurs through flexible hoses and cabling.

Fig.3: Cryostat

The dilution refrigerator has an internal fluid path through which helium flows in a closed cycle. The cycle includes the cold-trap dewar, where impurities that might cause blockages in the circulation path are removed. The cold-trap dewar is maintained at a cryogenic temperature by immersion in a liquid nitrogen dewar. The refrigeration system's nitrogen cold trap sits outside the RF-shielded enclosure and has flexible connections to the pumping control rack.

The server rack contains the data processing, system control, monitoring, network, and backup power resources for the system.

The data processing resources provide the web user interface, web services, and the underlying communications infrastructure for users to interact with the D-Wave system.

Control and monitoring servers run applications that control the system and provide remote monitoring capability. The monitoring server tracks diagnostic information from the various subsystems and alerts D-Wave support personnel if it detects abnormal events.

The contents of the server rack connect flexibly to the refrigerator's instrumentation rack and to feed-through connections in the RF-shielded enclosure wall.

The gas handling control rack contains gas manifolds and pumps that circulate the helium and also contains pumps and specialized equipment used only during system service.

The pumping control rack houses the compressor for the cooling, additional pumps that circulate the helium and a control cabinet that houses the electrical and pneumatic control subsystems.

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