QUANTUM COMPUTER

Gritsay I.P.
Yakovleva M.V.
Don State Technical University, Rostov-on-Don.

Quantum computer is a part of computer science and quantum physics, one of the most difficult parts of theoretical physics. Once an outstanding physicist Richard Feynman said: “If you think you understand quantum physics, it means you don’t understand it.”

Today’s computers work on the same principle as quantum Turing machines. They have a memory made up of bits, where each bit is represented by either a one or a zero. Whereas a quantum computer maintains a sequence of qubits. A single qubit can represent a one, a zero, or any quantum superposition of those two qubit states. Due to superposition of qubits quantum computers can fulfill parallel calculations. This parallelism helps quantum computers carry out a great number of calculations simultaneously. In language of quantum mechanics the condition of quantum bit is described by wave function ψ:

ψ = α | 0> + β | 1>, where α and β - coefficients which are squared, give probability at measurement to find the qubit which has condition | 0 > or | 1 >. Generally α and β are the complex numbers connected by a normalization condition, that is the rule that the total probability to find qubit is equal in this or that state to 1.

«A quantum computer operates by setting the qubits in a controlled initial state that represents the problem at hand and by manipulating those qubits with a fixed sequence of quantum logic gates. »[3.31]

The condition of quantum bit can be visually imagined as the position of a vector ψ single length on the plane where to axis X there corresponds value, and axes Y - value | 0 >. Then management of qubit by means of the quantum gate can be assimilated to rotation of a single vector ψ around the beginning of coordinates on various corners and/or to his reflection concerning a bisector of the right angle formed by axes of coordinates.

We will consider the quantum NOT gate (NOT) which is carrying out logical operation of inversion (denial) over qubit for an example: working on | 0 >, it gives

| 1 >, and acting on | 1 > - | 0 >. Coefficients α and β at the same time don't change (owing to linearity of the gate). Thus, NOT $\psi = \alpha | 1 > + \beta | 0 >$.

It is easy to notice that the quantum operation NOT is similar to reflection of a single vector ψ on the plane concerning a bisector of the right angle formed by axes of coordinates.

Owing to the quantum bit can be in a condition of superposition | 0 > and | 1 >, besides usual logical operations such as Not (NOT), and (AND), or (OR) controlled by not (NOT), etc. can be defined also new, not having classical analogs operations, for example to set the operation $\sqrt{}$NOT so that $\sqrt{}$NOT $\sqrt{}$NOT = NOT.

Because quantum computers exist only in the theory, scientists can only assume, how exactly they will work. For example, it is considered that in quantum computers will also be applied a quantum complexity. It is a phenomenon which Albert Einstein called "terrible" (he was against of the quantum theory because it isn't combined with his theory of relativity).

«The bit is the fundamental concept of classical computation and classical information. Quantum computation and quantum information are built upon an analogous concept, the quantum bit, or qubit for short. In this section we introduce the properties of single and multiple qubits, comparing and contrasting their properties to those of classical bits. » [4.13]

The sense of the phenomenon on the one hand is that two particles in the Universe can be interconnected, and on the other hand if the spirality of the first particle is positive, then the spirality of the second is always negative and vice versa. This phenomenon is called "Terrible" for two reasons: first, this bond works instantly, quicker than velocity of light; secondly, the confused particles can be at any distance from each other: for example, on the different ends of the Milky Way.

In quantum physics if we apply external force to two atoms, they can be "confused" together in such a way that one of the atoms will possess properties of another. It, in its turn, will lead to the fact that, for example, measuring the spin of one atom, its "confused" twin will accept the opposite spin.

Such property of quantum particles allows physics to learn the value of qubit, without measuring it directly.

One day quantum computers can replace silicon chips. However modern technologies aren’t able to create large-scale quantum computers. Large-scale quantum computers would be able to solve certain problems much more quickly than any classical computers.

Let’s imagine: you are going to shoot a bow in a target and you need to calculate, how highly to aim to hit. For example, it is necessary to count height from 0 to 100 cm. The ordinary computer will calculate each trajectory in turn: at first 0 cm, then 1 cm, then 2 cm and so on. The quantum computer will count all options simultaneously and give you the right answer which will allow you to score a hit. Thus it is possible to optimize many processes: from medicine (to diagnose cancer) to aircraft (to do more difficult autopilots).

Both practical and theoretical research continues, and many national governments and military agencies are funding quantum computing research in an effort to develop quantum computers for civilian, business, trade, environmental and national security purposes. Quantum computers may be able to efficiently solve problems that no classical computer would be able to solve within a reasonable amount of time. The invention of quantum computers will probably lead to emergence of artificial intelligence.

References

1. Kilin S.Ya. Quanta and information / Kilin S.Ya. – 2001 – p.1–90
2. T.D. Ladd Quantum Computing / T.D. Ladd, F. Jelezko. – 2010 – p.45–53
3. Валиев К.А Квантовые компьютеры и квантовые вычисления / Валиев К.А. – 2005 – с.3 – 39
4. Nilsen M. Quantum computing and quantum information / Nilsen M., Chuang I. 2006 – p.1–58
5. Валиев К.А. Квантовые компьютеры: надежды и реальность / Валиев К.А., Кокин А.А. – 2004