National Mission on Quantum Technologies and Applications.

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Why in News: The Union Cabinet recently approved the National Quantum Mission (NQM), putting India among the top six leading nations involved in the research and development in quantum technologies.

About Quantum Computers

Quantum computers are not just the next generation of faster and more efficient computers. Conventional computers, when they are more powerful and have much higher capabilities, become supercomputers. But these perform their tasks in the same way as the normal home computers or mobile phones do.

Quantum computers are fundamentally different in the way they handle and process information. They are meant to be useful in some very specific situations where the traditional ways of computing are inadequate.

For more mundane uses, like playing a video or browsing the internet, quantum computers would not offer any significant advantage over conventional computers.

If conventional computing is compared to the task of climbing up the stairs of a tall building, a more powerful computer would mean getting a fitter or healthier person to climb. The fitter person can probably go faster and a few storeys higher, but would eventually get exhausted.

Using the elevator is a fundamentally different way of accomplishing the task.

There is a significant gain in speed, but the main advantage is the ability to access floors that would be out of reach, or extremely inefficient to climb, for any person.

At the same time, in certain situations, like when only the first couple of floors are to be reached, the elevator might not offer any great advantage.

Quantum Properties

Conventional computers store and process information in bits. A bit is the smallest unit of data that computers can handle. It can take just two values — 0 or 1 — but only one of these at a time.

A zero would result in a certain set of instructions to be carried out, while a one would lead to a different set of instructions. All data in computers, including text, pictures and videos, are broken down into a sequence of zeros and ones for purposes of storage and processing, and can be reconstructed from these.

A two-bit system in a conventional computer can have four states — (0,0), (0,1), (1,0) and (1,1) — but again only one at a time. To go through each of these four states, the computer has to take four steps.

A more powerful computer can speed up the process, but it would still have to go through the four steps.

This is where the quantum computer starts to do things differently. Superposition makes it possible for the quantum bit, or a qubit as it is called, to exist in both 0 and 1 state simultaneously.

Counter-intuitive as it may appear, it can be 60 per cent 0 and 40 per cent 1 at the same time, or any other combination.

Similarly, the two-qubit system can be in all four states at the same time — some part (0,0), some part (0,1), some part (1,0) and remaining (1,1). What it means is that a quantum computer can go through these four states in one step, unlike the conventional computer that requires four steps.

As more qubits are added, the processing capability of the quantum computer increases exponentially. With just a few qubits, say 50, quantum computers can outpace traditional computers that perform a couple of billion operations per second.

Tasks that conventional computers would take millions of years to finish can become a matter of seconds with a quantum computer. Such tasks are found in a variety of domains, like internet and data security, and health research. And this is where the main use cases of quantum computers lie

The mission in India

NQM, planned during 2023 – 2031, is worth Rs. 6,003.65 crore and will mainly work towards strengthening India's research and development in the quantum arena alongside indigenously building quantum-based (physical qubit) computers which are far more powerful to perform the most complex problems in highly secure manner.

DST will lead this national mission, supported by other departments. Presently, R&D works in quantum technologies are underway in the US, Canada, France, Finland, China and Austria.

NQM will entail development of satellite-based secure communications between a ground station and a receiver located with 3,000kms during the first three years.

For satellite-based communication within Indian cities, NQM will lay communication lines using Quantum Key Distribution over 2,000kms. For long distances quantum communication, especially with other countries, tests will be conducted in the coming years.

The mission will focus on developing quantum computers (qubit) with physical qubit capacities ranging between 50 – 1000 qubits developed over the next eight years. Computers up to 50 physical qubits will be developed over three years, 50 – 100 physical qubits in five years and computers up to 1000 physical qubits in eight years.

Under NQM, there will be four broad themes — Quantum Computing, Quantum Communication, Quantum Sensing and Metrology and Quantum Material and Devices. Thematic hub for each will be established at research institutes and R&D centres who are already working in this field of research.