National Quantum Mission (NQM)

The National Quantum Mission (NQM) was approved by the Indian government on 19th April 2023 with a total budget of ₹6,003.65 crore. It will run from 2023-24 to 2030-31 and aims to make India a leader in Quantum Technologies and Applications (QTA) by creating a strong scientific and industrial research ecosystem.

Goals of the Mission

1. Quantum Computers:
    - Develop quantum computers with 50–1,000 qubits (units of quantum information) over the next 8 years using technologies like superconducting and photonic platforms.
2. Secure Quantum Communication:
    - Enable satellite-based secure quantum communication across 2,000 km within India.
    - Facilitate secure long-distance quantum communication with other countries.
    - Build inter-city quantum networks and multi-node quantum key distribution systems.
3. Advanced Quantum Technologies:
    - Develop atomic magnetometers (devices for measuring magnetic fields) and atomic clocks for ultra precise timing, communication, and navigation.
    - Create advanced quantum materials like superconductors and unique semiconductor structures.
    - Build devices like single-photon sources and entangled photon sources for communication and sensing.

Mission Implementation

The NQM will set up four Thematic Hubs (T Hubs) in top academic and R&D institutions, focusing on:

1. Quantum Computing: Research and development in quantum computer systems.
2. Quantum Communication: Secure data transfer and communication systems.
3. Quantum Sensing & Metrology: High precision measuring tools and sensors.
4. Quantum Materials & Devices: Development of advanced materials for quantum devices.

These hubs will promote basic and applied research and create knowledge for cutting-edge technology.

Why Is the Mission Important?

The NQM can transform key sectors such as communication, healthcare, banking, energy, and space. For example:

- Drug Design: Speed up drug discovery for new medicines.
- Secure Banking: Enable more secure financial transactions.
- National Security: Improve encryption and defense systems.

What is Quantum Computing?

Quantum computing is a new kind of computing based on quantum mechanics, the science of very tiny particles like atoms and electrons. Unlike regular computers (classical computers), quantum computers can solve certain problems much faster, which could revolutionize areas like medicine, cybersecurity, and space exploration. The idea of quantum computers was first proposed in 1982 by physicist Richard Feynman, who wanted a computer capable of simulating quantum systems. Classical computers struggle to handle such complex calculations, leading to the creation of quantum computers.

How Do Quantum Computers Work?

1. **Classical vs. Quantum Computers:**
    - Regular computers use bits (0s and 1s) to store information.
    - Quantum computers use qubits, which can represent 0, 1, or both at the same time. This ability
      is called superposition.
2. **Superposition:** Imagine flipping a coin. While it spins, it's both heads and tails at the same time. Similarly,
   a qubit can hold multiple possibilities until it is measured.
3. **Entanglement:** Another feature of qubits is entanglement, where qubits become linked. Changing one
   qubit instantly changes the other, no matter how far apart they are. This makes computations much faster.

Why Are Quantum Computers Faster?

Thanks to superposition and entanglement, quantum computers can process multiple solutions at once, unlike classical computers, which solve problems step by step. For example:

- Using a quantum computer, scientists can quickly solve problems like breaking encryption codes or finding patterns in huge amounts of data.

How Far Have We Come?

1. Shor’s Algorithm (1994): This method, invented by scientist Peter Shor, showed that quantum computers
could factor large numbers quickly. This threatens current data encryption systems.
2. IBM Q System One (2019): IBM launched the first commercial quantum computer using circuits, designed
for general-purpose tasks.
3. Google’s Sycamore Processor (2019): Google achieved quantum supremacy, solving a problem in 200
seconds that would take the best supercomputer 10,000 years.
4. Google’s Willow Chip (2024): This chip improves error correction, a major challenge in quantum
computing. Willow can perform tasks in minutes that would take classical computers 10 trillion trillion
years.

Challenges in Quantum Computing

1. Cost and Complexity:
    - Building quantum computers is very expensive.
    - They require extreme conditions, like very low temperatures, to keep qubits stable.
2. Errors and Stability:
    - Qubits are fragile and prone to errors due to interference from their surroundings (decoherence).
    - Millions of qubits are needed for solving real-world problems, which is still far from reality.

India’s Role in Quantum Computing

India launched the National Quantum Mission in 2023, with a budget of ₹6,000 crore to advance quantum technologies, including building quantum computers.

Key Takeaways

- Quantum computers rely on superposition and entanglement to process information faster than classical
computers.
- Milestones include Shor’s algorithm, IBM’s Q System One, and Google’s Sycamore and Willow chips.
- Challenges like high costs, qubit errors, and scalability remain, but countries like India are investing in their
potential.

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