QPIAI-INDUS: INDIA'S ADVANCED QUANTUM COMPUTING SYSTEM

NEWS: **QpiAI,** (Bengaluru based startups) announced the launch of one of India's most powerful quantum computers '**QpiAI-Indus**' on the occasion of **World Quantum Day** on **14th April 2025**.

- QpiAI, one of the 8 startups selected under the **National Quantum Mission,** coordinated by the Department of Science and Technology (DST).

WHAT'S IN THE NEWS?

- **Full-Stack Quantum Platform**:
    - QpiAI-Indus is a comprehensive quantum computing system that integrates **quantum hardware, control infrastructure, and specialized software**, making it a **full-stack solution** for quantum applications.
- **Quantum Hardware Capabilities**:
    - It includes a powerful **25-qubit superconducting quantum processor**, making it suitable for solving complex problems using quantum principles.
- **Advanced Software Integration**:
    - The system uses **next-generation Quantum-High Performance Computing (Quantum-HPC)** software to allow efficient simulation and execution of quantum algorithms.
- **AI-Augmented Hybrid Quantum Solutions**:
    - QpiAI-Indus leverages **Artificial Intelligence (AI)** to enhance quantum problem-solving, enabling **hybrid classical-quantum computing** for more optimized performance.
- **Application Domains**:
    - The platform is designed to enable **innovation and real-world solutions** across diverse sectors, including:
        - **Life sciences** and **drug discovery**
        - **Materials science** and **superconductors**
        - **Mobility** and **logistics optimization**
        - **Sustainability** and **climate action planning**

India's National Quantum Mission (NQM)

- **Approval and Duration**:
    - The **Union Cabinet approved** the mission on **19th April 2023**.

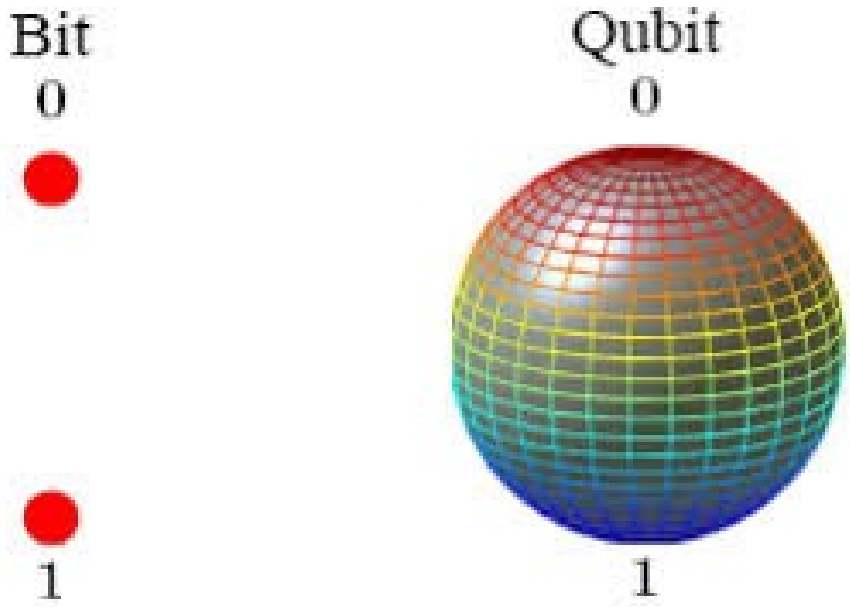
- The total **budget allocation is Rs. 6003.65 crore**, spanning **2023-24 to 2030-31**.

Mission Goals and Vision

- **Core Aim**:
    - To **seed, nurture, and scale up** both **scientific and industrial R&D** in quantum technologies.
    - The goal is to establish a **vibrant innovation ecosystem** and **position India as a global quantum technology leader**.

What is Quantum Technology?

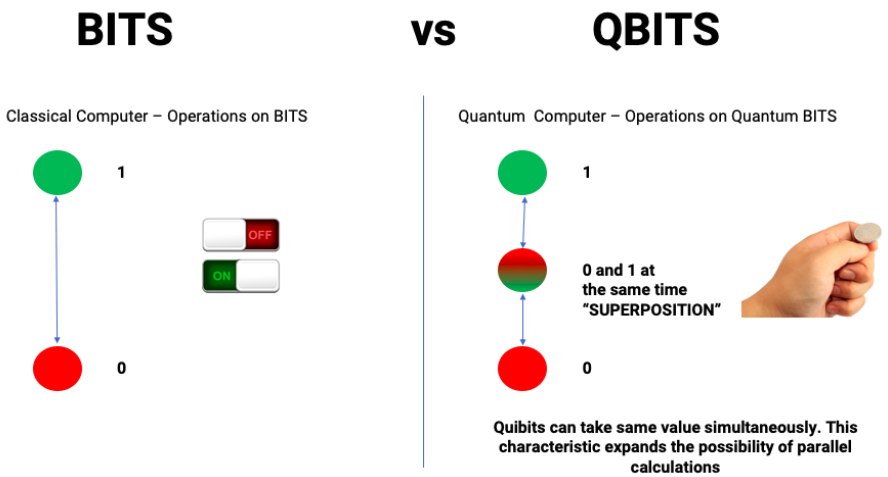
- **About:**
    - **Quantum computing/technology** refers to a **class of technologies** that **leverage** the **principles of quantum mechanics** to **perform computations** and achieve capabilities not possible with traditional technology.
- **Conventional Vs Quantum Computing:**
    - **Conventional Computing:**
        - **Conventional computing** processes information in **"bits,"** which represent **either a 1 or a 0** at any given time, operating under the **principles of classical physics.**



- **Quantum Computing:**

- Quantum computers **operate using "qubits" (quantum bits)**, which determine the behavior of matter at the atomic scale.
- These exhibit **probabilistic behavior,** enabling them to **achieve tasks beyond the scope of traditional technologies,** while **classical systems follow deterministic laws**.

- **Key Features:**
  - **Superposition:** Qubits can exist in a state of quantum superposition, meaning they can **represent both 1 and 0** simultaneously.
    - This unique property allows quantum computers, in theory, to perform computations as if multiple classical computers are working in parallel.
    - For instance, a coin in mid-air represents both heads and tails simultaneously until it lands. Similarly, an electron can exist in a quantum superposition until measured.
  - **Entanglement:** Entanglement occurs when **two qubits exist in a shared quantum state,** such that a change in the state of one qubit instantaneously affects the other, regardless of the distance between them.
    - Albert Einstein referred to this phenomenon as **"spooky action at a distance."**
  - **Decoherence:** Decoherence is the process in which **quantum particles and systems can decay, collapse or change**, converting into **single states** measurable by classical physics.
  - **Interference:** Quantum interference allows particles (such as qubits) to be in multiple positions simultaneously due to superposition.
    - A single particle, like a photon, can interfere with its own trajectory, altering its path predictably.



What are the Key Applications of Quantum Technology?

- **Pharmaceuticals:**
    - Quantum computers can **simulate molecular behavior, accelerating the development of life-saving drugs** and **treatments**.
    - It aids in **studying protein folding,** with potential applications in treating diseases like **Alzheimer's** and **Parkinson's**.
- **Chemistry**:
    - Quantum particles can enhance chemical processes, such as **improving catalysts for petrochemical alternatives** and **reducing harmful emissions.**
    - These are also crucial for **developing high-temperature superconductors.**
- **Improving Advanced Technologies:**
    - Quantum materials are used in **advanced technologies** such as **energy-efficient devices, solar cells, batteries, and healthcare diagnostics**.
        - Quantum materials are substances that exhibit **unique and complex properties at the quantum level.** These materials are characterized by their behavior, which is governed by **quantum mechanics**.
    - **Example:** Fluorescent quantum dots aid in multicolour bioimaging and cellular protein labelling, **QLED (Quantum Dot Light Emitting Diode)**
- **Enhancing Machine Learning:**
    - Quantum computing can **enhance machine learning** by developing **innovative algorithms** that **analyze complex data patterns** beyond the reach of traditional methods.
    - Quantum algorithms can **optimize AI models, accelerating tasks and reducing energy consumption.**
- **Disaster Management:**
    - **Tsunamis, drought, earthquakes** and **floods** may become more predictable with quantum applications.
    - The collection of data regarding **climate change** can be streamlined in a better way through quantum technology.
- **Secure Communication:**

- China's quantum communications satellite, **Micius**, **launched in 2016**, became the world's first to demonstrate secure quantum communication links between ground stations and satellites.
- This advancement is crucial for **satellites, military, and cybersecurity,** offering the potential for **ultra-fast computing and unhackable communication**, ensuring **high levels of security** for users.

- **Quantum Cryptography:**
  - Quantum cryptography **strengthens cybersecurity** by **creating encryption that is theoretically unbreakable,** safeguarding sensitive data from the decryption capabilities of future quantum computers.

Key Components and Objectives

1. Quantum Computing Development:

- **Goal**: Build **intermediate-scale quantum computers** with capabilities ranging from **50 to 1000 qubits**.
- **Technologies Involved**: Leverage **superconducting circuits** and **photonic-based quantum systems**.
- **Timeline**: Achieve scalable computing platforms over the next **8 years**.

2. Quantum Communication:

- **Secure Satellite Communication**:
  - Establish **satellite-based quantum communication networks** over **2000 km** range within India.
- **International Collaboration**:
  - Develop infrastructure for **long-distance secure quantum communication** with other countries.
- **Quantum Key Distribution (QKD)**:
  - Deploy **inter-city QKD** networks over **2000 km** for secure data transmission.
- **Quantum Networks**:
  - Build **multi-node quantum communication networks** with embedded **quantum memory systems**.

3. Quantum Sensing and Metrology:

- **Precision Instruments**:

- Develop high-sensitivity **magnetometers** for precise measurement and **atomic clocks** for accurate **timing, navigation, and communication systems**.

4. Quantum Materials and Device Development:

- **Materials R&D**:
  - Focus on the **design and synthesis** of advanced **quantum materials** such as:
    - **Superconductors**
    - **Topological materials**
    - **Next-generation semiconductors**
- **Device Fabrication Support**:
  - These materials will be used in building **reliable quantum computing devices** and **sensing components**.

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