Quantum Computing

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Context: **A recent study by IBM highlights the increasing interest in quantum computing in India. This surge is attributed to active participation by students, developers, and academic institutions.**

About Quantum Computing

Quantum computing is a **revolutionary technology** that leverages the principles of **quantum mechanics** to tackle problems too complex for traditional computers.

Key Concepts of Quantum Mechanics

1. **Quantum Mechanics**: A branch of physics studying particles like **atoms, electrons, and photons** at the molecular and sub-molecular levels.
2. **Superposition**: Enables particles to exist in **multiple states simultaneously**, forming the basis of quantum computing.
3. **Entanglement**: A phenomenon where particles remain **interconnected**, allowing instantaneous changes in one to affect its pair, regardless of distance.

Capabilities of Quantum Computing

- Solves problems **beyond the scope of classical computers**, such as:
  - **Cryptographic algorithms**
  - **Complex simulations**
  - **Optimization challenges**

Key Features of Quantum Computing

1. **Fundamental Difference from Classical Computing**:

   - **Quantum Bits (Qubits)**: Unlike classical bits, which are either 0 or 1, qubits can represent **0, 1, or both states simultaneously** through superposition.
     - **Example**: A spinning coin represents **both heads and tails** until measured.
   - **Entanglement**: Entangled qubits work together, **enhancing speed and computational power**.

2. **Exponential Computational Power**:

   - **Superposition** allows qubits to process **multiple calculations simultaneously**, making quantum computers exponentially faster than classical systems.

Milestones in Quantum Computing

1. **Origins**:

   - **1982**: Proposed by physicist **Richard Feynman** to simulate quantum systems beyond classical computing capabilities.

2. **Breakthrough Algorithms**:

   - **Shor's Algorithm (1994)**: Revolutionized cryptography by factoring large numbers **exponentially faster than traditional methods**.

3. **Technological Advancements**:

   - **IBM Q System One (2019)**: The first commercial circuit-based quantum computer.
   - **Google Sycamore Processor (2019)**: Achieved **quantum supremacy** by completing a task in **200 seconds**, which would take classical supercomputers **10,000 years**.
   - **Google Willow Quantum Chip (2023)**: Introduced **scalable error-corrected qubits**, completing calculations in **minutes** that would otherwise take classical systems **billions of years**.

Conclusion

Quantum computing represents a monumental leap in technology, offering capabilities that can redefine fields like cryptography, artificial intelligence, and scientific research. As India actively engages with this cutting-edge technology through its students, developers, and academic institutions, it positions itself as a global player in shaping the future of quantum advancements. By fostering innovation and collaboration, India has the potential to unlock transformative solutions to some of the world's most complex problems.