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QUANTUM COMPUTER

- A new era of future computing

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Generations of computer

- First generation computers (1940-1956)
  - vacuum tubes
- Second generation computers (1956-1963)
  - Transistors
- Third generation computers (1964-1971)
  - Integrated Circuits

Generations of computer

- Fourth generation computers (1971-present)
  - Micro-processors
- Fifth generation computers (present-beyond)
  - Artificial Intelligence (AI)
- Sixth generation computers (future)
  - Quantum computers

Introduction of quantum technology

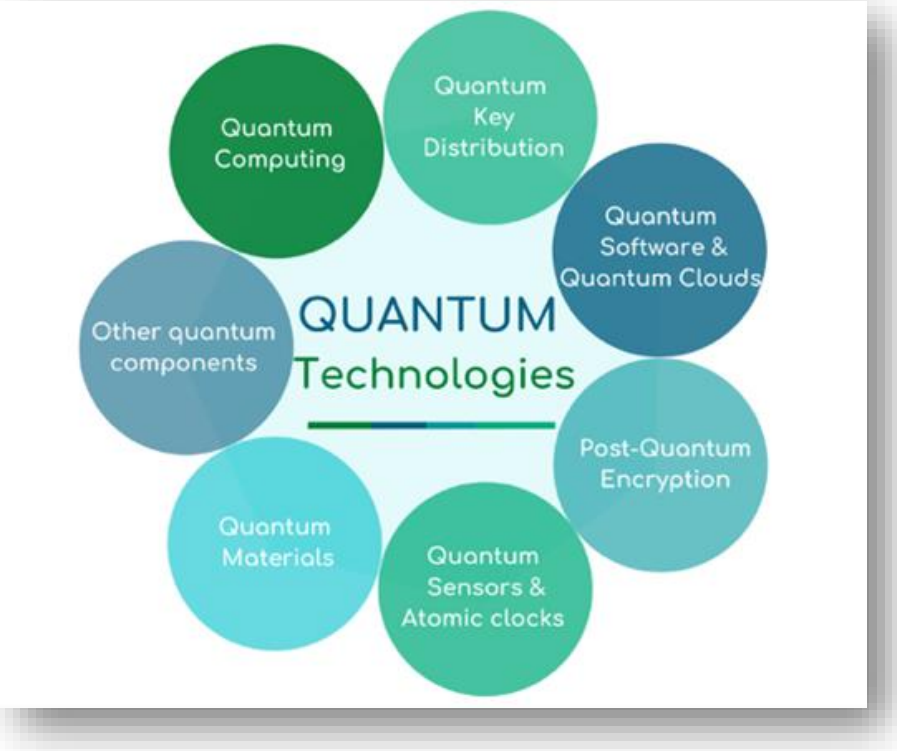
- **Quantum technology** is a technology that works by using the principles of quantum mechanics.

- The two principles of quantum mechanics that quantum technology primarily relies on are quantum superposition and quantum entanglement.
  - Quantum superposition: is a physics theory that subatomic particles can exist in multiple states at once.
  - Quantum entanglement: occurs when two atoms joined or fixed together despite being separated by space.

- The field of quantum technology was **first outlined in a 1997** book by **Gerard J. Milburn**, which was then followed by a 2003 article by Jonathan P. Dowling.

Applications of quantum technology

- Quantum computing
- Quantum sensors
- Quantum communication
- Quantum simulation
- Quantum cryptography



Quantum computer ??

A quantum computer is a computation device that makes direct use of quantum-mechanical phenomena, such as superposition and entanglement, to perform operations on data.

What is quantum computing ?

- Quantum computing is the **computer technology** based on the principles of quantum theory, which explains the nature and behavior of energy and matter on the quantum(atomic or subatomic) level.

- A quantum computer is a computation device that makes **direct use of quantum-mechanical** phenomena, such as superposition and entanglement, to perform operations on data.

- Quantum computing is essentially harnessing and exploiting the amazing laws of quantum mechanics to process information.

Why quantum computer ?

- Quantum AI systems will be able to **process large amounts of information quickly and accurately.**
- Because quantum computers can **perform several tasks at the same time**, which allows for significantly faster results.
- For some problems, supercomputers aren’t that super.
- To **solve complex problems**, that supercomputer can’t able to solve.

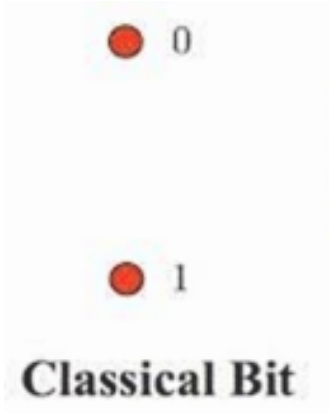
History:

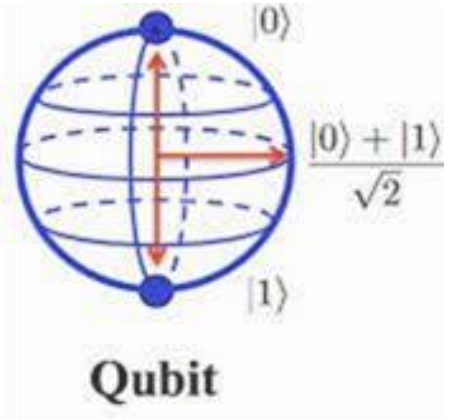
Year	scientist	Research
1982	Richard Feynman	Idea of creating machines based on the laws of quantum mechanics.
1985	David Deutsch	Developed the quantum turning machine, showing that quantum circuits are universal.
1994	Peter Shor	A quantum algorithm to factor very large numbers in polynomial time(n^2).
1997	Lov Grover	Develops a quantum search algorithm with 0 complexity. The first tiny quantum computer was built.
2000	Emanuel Knill, Raymond Laflamme, and Rudy Martinez	Successfully built both a 4-qubit and a 7-qubit quantum computer

What is qubits ?

- In quantum computing, a qubit is a **unit of quantum** information.
- It represents the smallest possible unit of computation in quantum computing.
- It **exists in both** of its possible states at once, a condition known as a superposition.
- Qubit is known as **quantum bit** and the **heart of quantum computer**.
- It is **made up of photons**, atoms, electrons, molecules or something else.

Bit	Qubit
• It's a single unit of information that has a value of either 0 or 1	• It can hold a one, a zero or a combination of these.
• Bits are used in classical computers.	• Qubits(Quantum bits) are use in quantum computer
• Bits are slow.	• Qubits are faster.
• Information is stored in bits, which take the discrete values 0 and 1.	• A qubit can be in states labelled (0 and 1), but it can also be in a superposition of these states, a|0} + b|1}, where a and b are complex numbers.





How quantum computer works?

- A quantum computer **uses qubits** to run multidimensional quantum algorithms.
- Our quantum processors **need to be very cold** – about a hundredth of a degree above absolute zero. To achieve this, we use super-cooled **superfluid to create superconductors.**
- When **electrons pass through superconductors** they match up, forming "Cooper pairs." These pairs can **carry a charge across insulators**, through a process known as **quantum tunneling.**
- Two superconductors placed on either side of an insulator form a Josephson junction

- Superposition is the ability of a quantum system **to be in multiple states** at the same time.

- Superposition allows quantum objects to simultaneously(occurring at the same time) exist in more than one state or location.

- Entanglement is when **two particles link together** in a certain way no matter how far apart they are in space. Their state remains the same.

- If the qubit is in a superposition of the 1 state and the 0 state, and it performed an **calculation with another qubit** in the same superposition, then one calculation actually **obtains 4 results**: 1/1, 1/0, 0/1 and 0/0.

- The ability of a quantum computer to perform multiple computations simultaneously(parallel) is called **quantum parallelism**.

- If there are **n qubits** in the quantum computer, then it will have **2^n different states.**
- So experimentally, it can **hold more information** as compare to regular bits.

Benefits and limitations:

Advantages	Disadvantages
• Quantum computing required less power.	• Quantum CPU will have efficiency and heating problems of its own.
• It can execute any task very faster and very accurately compared to a classical computer.	• Current quantum computers are largely prototypes that are still bulky(large and heavy), complicated and expensive .
• Quantum computers are incredibly fast and effective.	• To developed quantum computer became so costly.
• Quantum computers are able to analyze the data to provide feedback much more efficiently than traditional computers.	• As the processing in these computers is done very deeply so it needs a temperature of negative 460 degrees F. This is the lowest temperature of the universe and it is very difficult to maintain that temperature.

Applications:

- Quantum computing with the help of machine learning can help in developing various techniques to fight against these **cybersecurity threats.**
- It can be **used to solve complex** mathematical problems.
- Modelling and indexing of very large databases.
- Quantum computer can be used in cryptography (quantum key distribution).

Contribution of Indian government

- The government in its budget 2020 has announced a **National Mission on Quantum Technologies & Applications** with a total budget outlay of **Rs 8000 Crore for a period of five years** to be implemented by the Department of Science & Technology (DST).

- Created **21 Quantum hubs** in the country.

- **4 Quantum research parks** across India.

Present status

- Nowadays many companies/countries are trying to make quantum computers.
- **IBM** hopes to have a 1,000-qubit quantum computer in place by 2023.
- **Google** has been working on building a quantum computer for years and has spent billions of dollars. It expects to have its quantum computer ready by 2029.
- Public and private investments totaled $35.5 billion by 2022 across a range of quantum technologies.’

Thank you