Research for topics

- What is quantum computers
- How quantum computers work
- Troubles of Quantum Computers
- The history of quantum computers
- How they are being used today
- The future of quantum computers

What is a quantum computer?

- To put it simply a quantum computer is a device that uses certain properties that are found in quantum mechanics in order to improve and enhance calculations and computations
- The use of quantum mechanic properties in the computer can be so helpful that even in our most modern supercomputers, a quantum computer can outperform it
- Bits are 0s and 1s which are used in all places of modern technology, whether it by your phone, or a message you send out, bits are used everywhere
- Typically a bit being 1 represents on and 0 is an off, a bit can only be in one of these states but not both at the same time
- In quantum computers, the basic unit of memory is the qubit
- A qubit is different from a normal bit in that it works like a wave, in that the qubit can represent 0 and 1, but it can also be in both states at the same time
- This is due to superposition one of the many quantum properties that quantum computers take advantage of
- To be more specific the qubit is a subatomic particle like the spin of an electron or the orientation of a photon
- Fun fact 8 normal bits can represent single number between 0 and 255 but 8 qubits can represent all the numbers between 0 and 255 at the same time
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How quantum computers work

- Quantum computers, take advantage of quantum physics properties like superposition and quantum entanglement
- Both of these properties are extremely important to the qubit
- Superposition is the property for a system to be in multiple states at the same time
    - As mentioned this allows the qubit to be in the state of 0 and 1 at the same time
- In the computer itself, the qubit is manipulated by precision lasers or microwave beams in order to put the qubit in a state of superposition
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- Quantum entanglement is the property for two particles to be so closely linked and dependable on one another even if they may be far apart or close to each other
- In a pair of entangled particles, since they are dependable on one another if a change is made to one, then the other particle will experience the same change in a predictable manner, this allows for predictable changes

- In regular computers computing larger computations will require the use of more bits, this puts more strain on the processing power, but due to entanglement adding extra qubits for a large computation only increases the ability to compute

Troubles of Quantum Computers

- Quantum computers have already shown the potential to be more powerful than even supercomputers, but they still are not as reliable as digital computers because of decoherence
- Decoherence is when the qubit interacts with its environment which leads to the quantum behavior of the qubit disappearing, it essentially prevents the computer from finishing its given task
- Decoherence is also known as “noise”. Noise is most often seen with vibrations or changes in temperatures.
- However researchers still try their hardest to counter some of these issues, for example, many quantum computers need to be cooled and kept at steady cold temperatures, but these temperatures can often be near absolute zero
    - Many quantum computers require what is called a cryostat or a dilution refrigerator to keep these extremely cold temperatures
    - Similar to a normal computer the CPU chip is usually the hottest part, and in some cases for the quantum computer it must be cooled to a little bit above absolute zero
    - Other parts of the computer are cooled to temperatures similar to deep space
    - The challenge of preventing noise is keeping consistent temperatures even though all parts of the computer are cooled to different temperatures

History of Quantum Computers

- By 1959 the American Physicist Richard Feynman, proposed the idea that as pieces for computers continued to get as small as microscopic scales, then eventually we would start to see the effects of quantum mechanics to build even stronger computers
- By 1985, David Deutsch of the University of Oxford described the possibility of quantum logic gates that could be implemented in a universal quantum computer
- By 1992 the first quantum algorithm was formed, however, at the time it was not taken too seriously
- By 1994, Shor’s algorithm would be formed which would use a quantum computer to factor numbers
- In 1998, the first 2 qubit quantum computer was formed, it was very simplistic, but it could take an input and output a solution, and it also demonstrated many properties of quantum computation
- Just 2 years later in 2000, the 4 qubit quantum computer was formed, this model was the first to use a precise laser to entangle the particles
- Just a week later the 7 qubit quantum computer was formed

How are Quantum computers being used today?

- Currently, they are being used in industries such as AI, finance, automotive, and pharmaceuticals
- Due to their immense power and potential, these computers are used to do things like predict the weather, produce new chemicals, and analyze compounds to form new drugs.
- To go more in-depth pharmaceutical companies plan to analyze compounds that could lead to the creation of new drugs
- There are also companies with a quantum computer that allow other companies to make use of it
- In specific IBM is working with many companies to improve their products
    - For example, IBM is working with Mercedez-Benz to improve their batteries for their electric cars. Determining the chemical reactions in a battery is difficult for most computers but quantum computers can give more accurate simulations of these reactions, ultimately quantum computers will help Mercedes-Benz to reach its goal of going carbon neutral by 2039
    - Exxonmobil uses quantum computers to find the most efficient routes to ship fuel, with the power of quantum computers it can go through all of the route combinations to find the most efficient ones
    - CERN a European organization for nuclear research is using quantum computers to better analyze and find discoveries in the universe
- Researchers are using them to simulate the behavior of matter down to the molecular level

Future of the quantum computer and its implications

- The main goal for the future is to reach “quantum supremacy” or where they are used for broad tasks and are able to demonstrate their more practical use over modern computers
- However it will require more qubits to be held steady at one time, researchers are still unsure as to how many qubits would be needed to achieve this milestone
- Currently, 128 qubits are the max to be held steady at a single time
- Already Universities like MIT have built their own quantum computer and are investigating areas like quantum algorithms, information theory, and application and connections
- Harvard is focused on forming new discoveries and being the ones to usher in the next major discovery for quantum computers
- As New discoveries are made, this mean new fields in quantum computers, which allow new career and job opportunities for the future
- There are also plans on eventually being able to use quantum computers to make a truly personalized learning experience for every single student

Sites used for research

Quantum Computing: Current Progress and Future Directions | EDUCAUSE Review

Explainer: What is a quantum computer? | MIT Technology Review

Quantum Computing Is Coming. What Can It Do? (hbr.org)

Quantum computer | Description & Facts | Britannica