Quantum Computing

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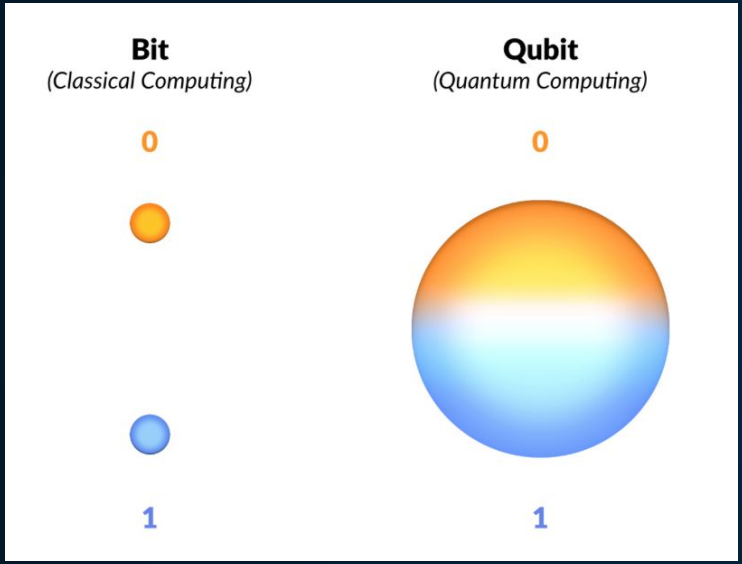
For: YWCC307-114

What is it?

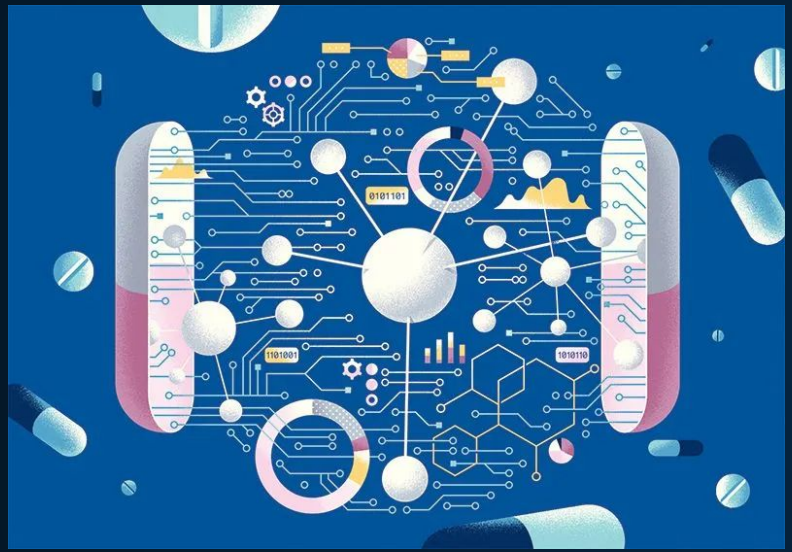


- Think of it like a traditional computer that has access to, and can manipulate, quantum information.
- Uses qubits instead of bits.
  - Can be a 0 or a 1 at the same time.
  - N Qubits lets us have 2^n states
  - Nowadays IBM uses less sensitive superconducting transmon qubits. (An artificial atom)
    - Made from superconducting materials.
- Superposition allows a qubit to be in multiple states at the same time until it is measured.
  - Allows use of quantum interference to greatly enrich the kinds of information that can be represented.
- Entanglement, or “spooky action at a distance”, can be used to establish links between distant qubits for the purpose of applying two-qubit gates.
  - No matter the distance between them, when observed, they collapse and will have a correlated result.
  - Correlation happens at a minimum 10,000,000x faster than the speed of light.

How can it help us?

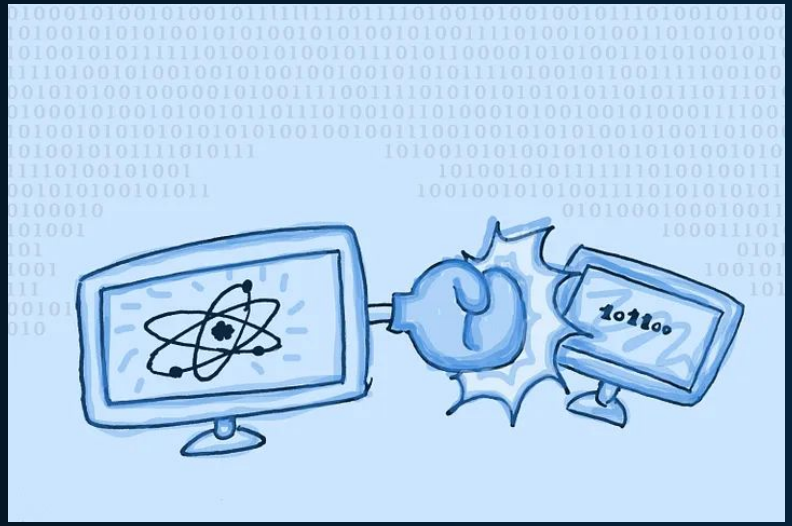
- Has the potential to to radically change the world around us.
- Can help in a variety of different industries:
  - Pharmaceutical
  - Finance
  - AI
- Able to decrypt the most secure data (e.g., bank records, government secrets, and Internet/email passwords).
- Can increase speed of integer factorization exponentially, helping to decrypt RSA, a public key that is the product of two large prime numbers that are kept secret.
- In the future can predict stock market trends with a huge amount of accuracy.
- Have tremendous potential for handling very large sets of data, often used in AI experiments.

Drug Discovery

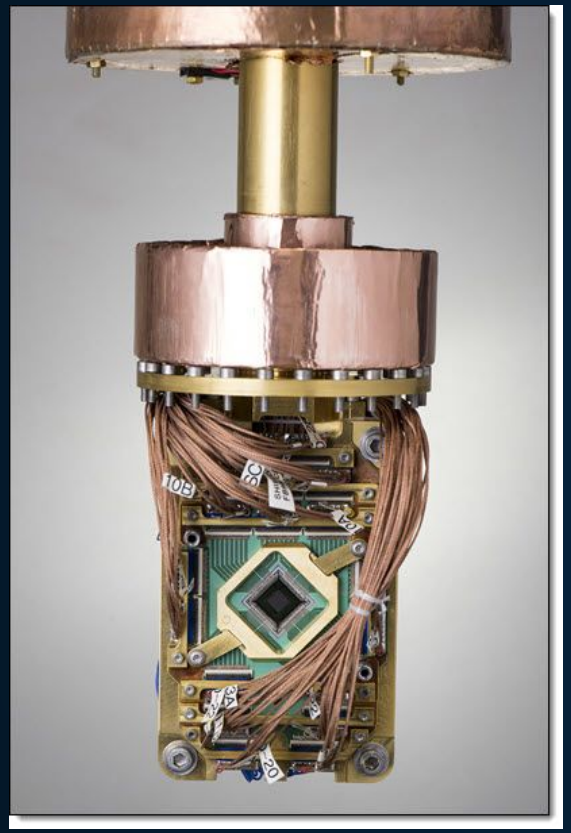


- Only 4 out of the largest 21 pharmaceutical companies have not expressed interest in quantum computing.
- These companies specifically looked at:
  - Compound Screening: the identification of compounds that could be promising candidates for drug development.
  - Lead Optimization: the process by which a drug candidate is designed after an initial lead compound is identified.
- Theoretically, quantum computers have the capacity to simulate the complete problem, including interactions on the atomic level.
- Molecules, as they scale up, increase electron to electron repulsion and electron attraction to the nuclei, exponentially.

Will it replace classical computers?

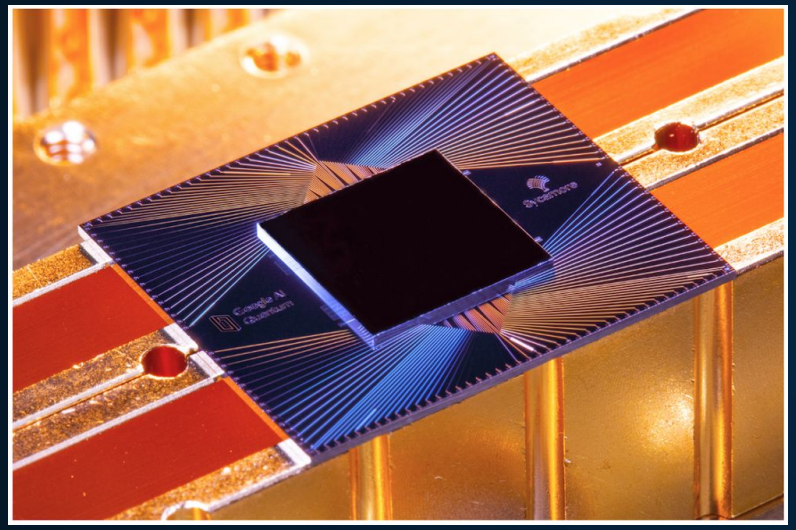


- No, they will not.
- They do more operations, not speed things up
- Qubits are incredible sensitive to the environment around them.
- Storage only lasts a few hundred microseconds at most in a quantum computer.
- Quantum computers need to kept at temperatures close to absolute zero.
- Quantum computers take a range of different inputs and return a range of possibilities. From there you can estimate how probable each answer is.
- Quantum Algorithm Steps:
  1. Create an equal superposition of all 2^n states.
  2. Encode the problem into the phases and amplitudes of all 2^n states
  3. Come to solution by using interference to magnify the amplitude of the correct answer and shrink the wrong answers. (Similar to how noise cancelling headphones work)



Cloud Access

- While it won't be convenient to have a quantum computer at home, one can access it through the cloud.
- Although it is in its early stages, providers like Amazon Web Services and Microsoft Azure, already offer cloud access to their quantum computers.
- Amazon predicts that most organizations will never own a quantum computer, but they will have cloud-based on-demand access to them.
- In the best case scenario we are able to access real quantum processors, however there are simpler options such as emulators and simulators.
- In early 2017, researchers from Rigetti Computing demonstrated the first programmable cloud access using the pyQuil Python library.



In Conclusion

- Qubits use superposition and entanglement to store quantum information.
- Can be scaled exponentially by increasing more qubits.
- Will have a large impact in the pharmaceutical, financial, AI and other industries.
- Will eventually be able to solve many intractable problems.
- Will revolutionize drug discovery by simulating molecules at the atomic level.
- Won't be widely available because of the systems sensitivity, but there are cloud-based services that allow access to emulations and even real processors of quantum computers.

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