

Application of Quantum Computers

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What

How

Where

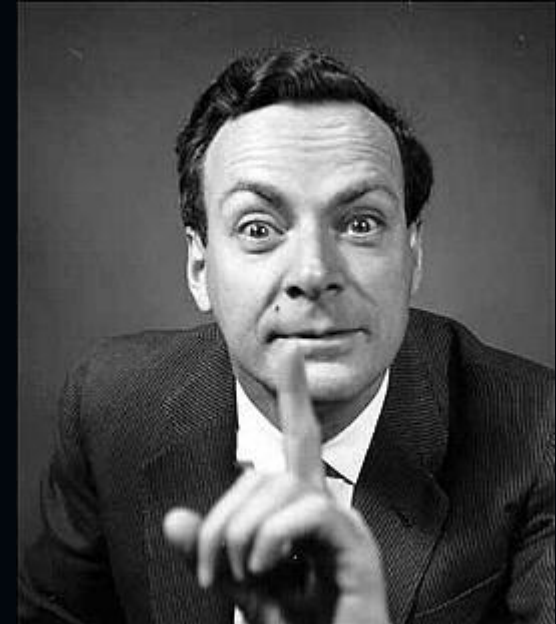
Why



What

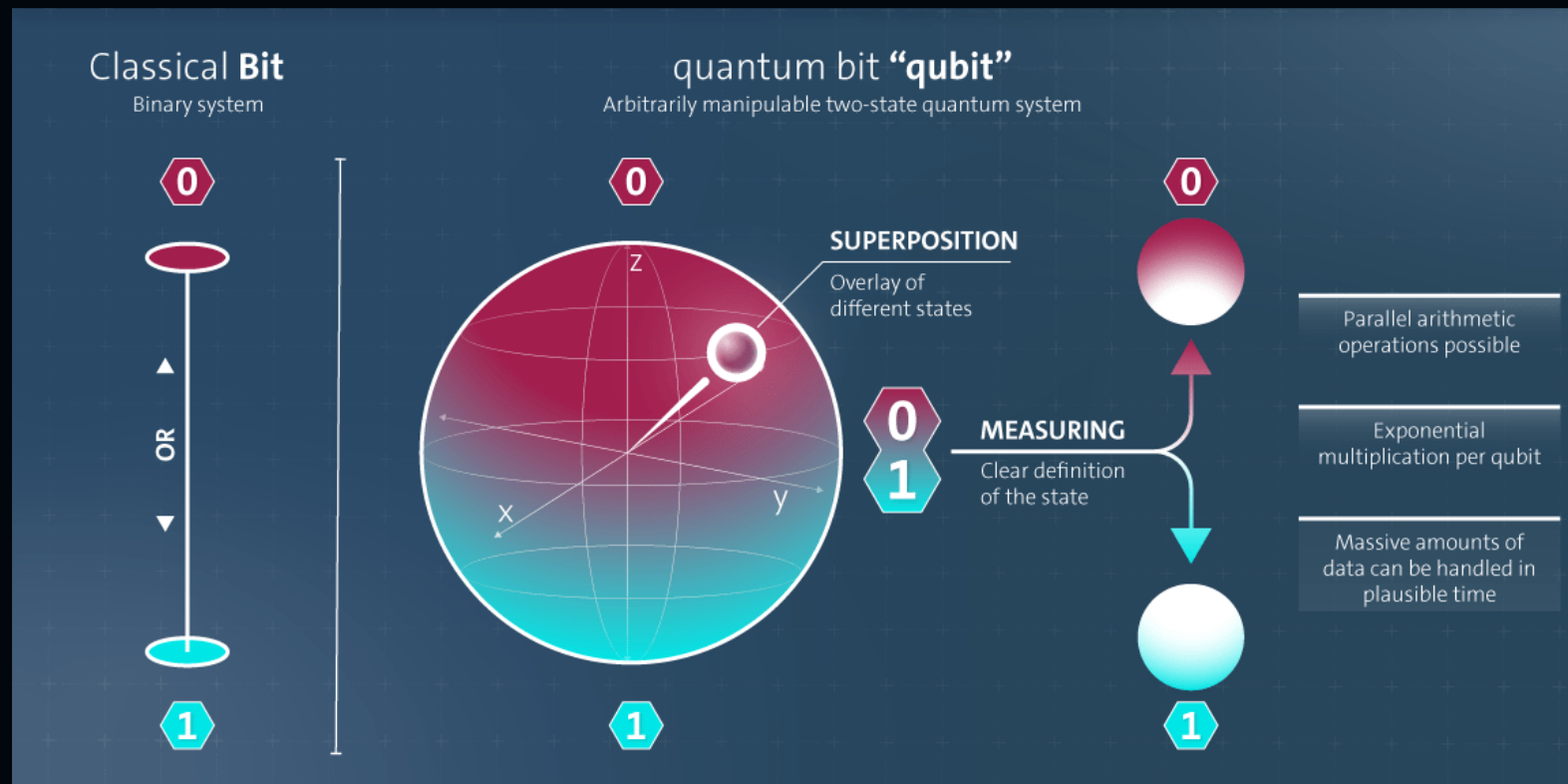
- Paul Benioff proposed ‘Quantum Turing Machine’ in 1980
- “Nature is not classical, dammit, and if you want to make a simulation of Nature, you’d better make it quantum mechanical, and by golly, it’s a wonderful problem because it doesn’t look so easy” –Ricard Feynman
May 1981 at the conference on ‘Simulating Physics with Computer’
- Shor’s algorithm by Peter Shor in 1994

A quantum computer is a computational device that uses the principle of quantum mechanics to perform computation

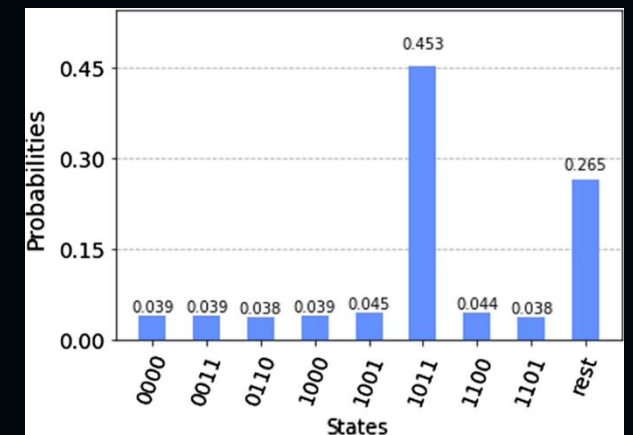
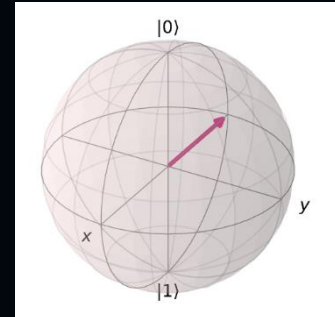
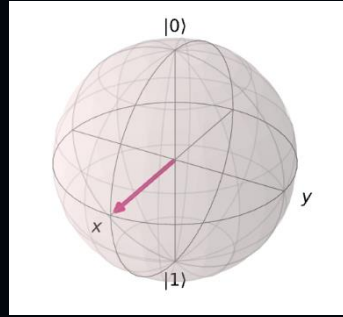
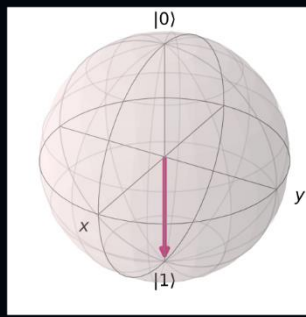
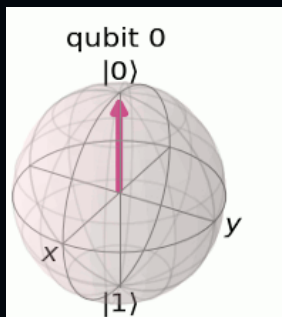
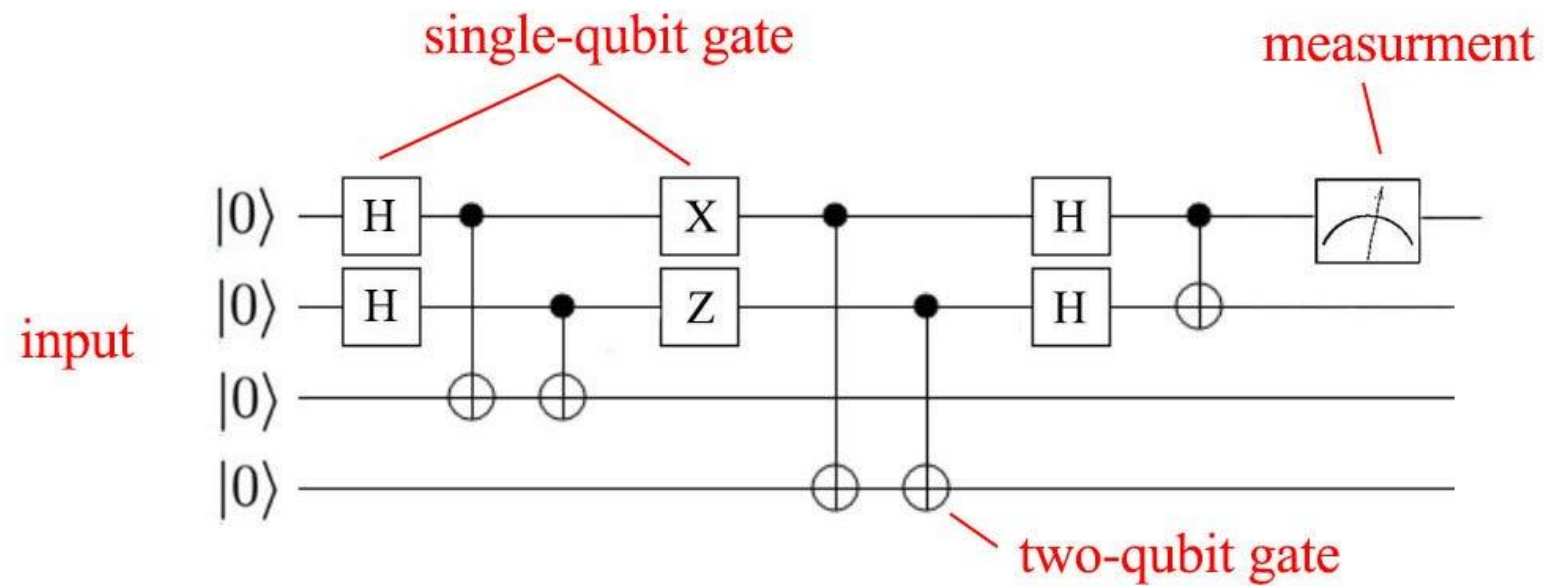


How

- QUBITS instead of BITS



How



Hopping Gate :- $\exp(-i\frac{\theta}{2}(X_i X_j + Y_i Y_j)) \rightarrow$

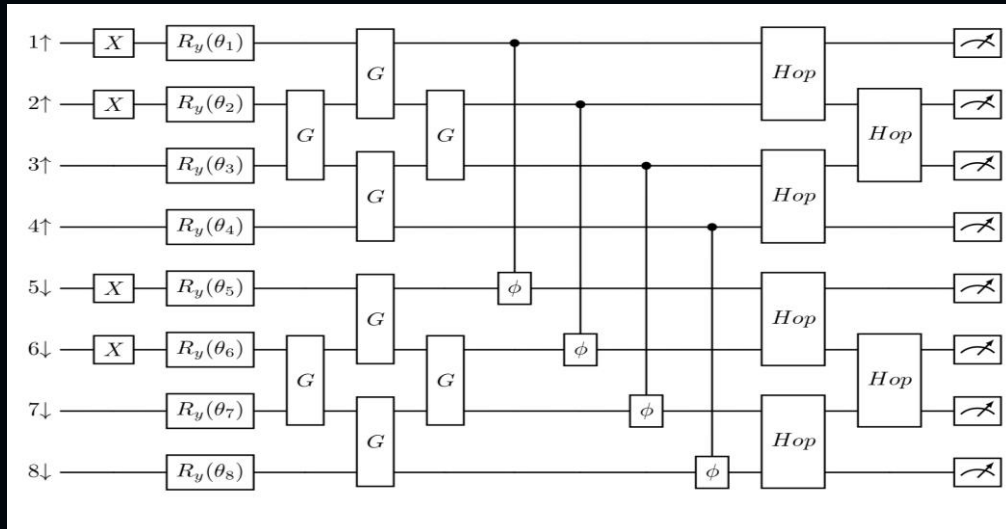
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \frac{\theta}{2} & -i \sin \frac{\theta}{2} & 0 \\ 0 & -i \sin \frac{\theta}{2} & \cos \frac{\theta}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Onsite Interaction Gate :- $\exp(-i\frac{\phi}{2}(|11\rangle\langle 11|)) \rightarrow$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & e^{i\phi} \end{bmatrix}$$

CPHASE

Custom Multi Qubit gates



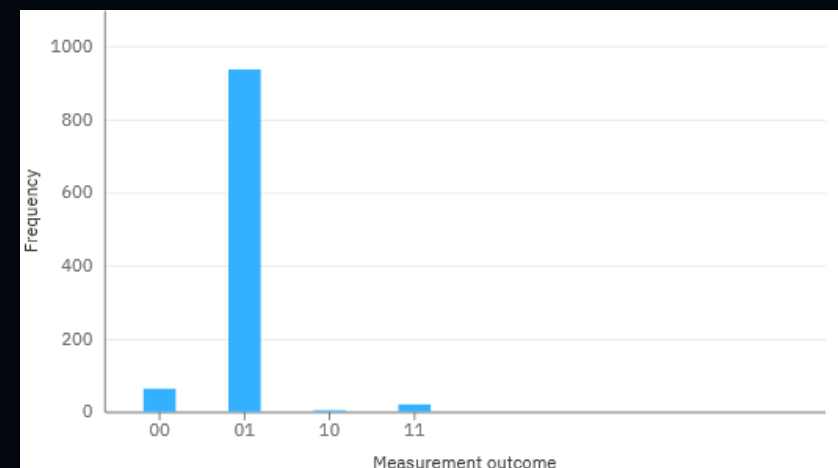
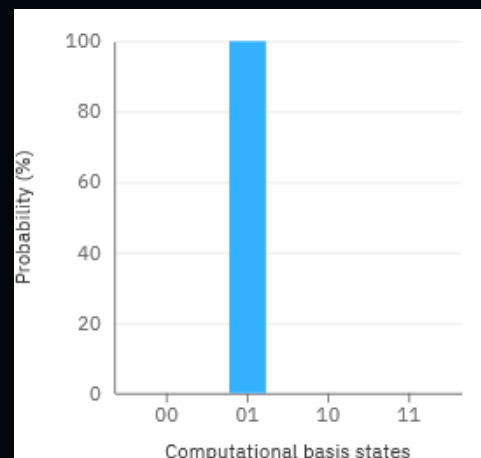
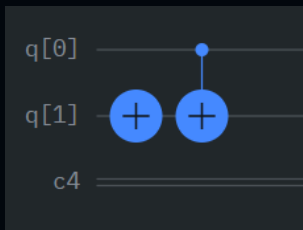
Parameterized circuit

Why

- Cryptography
- Power to simulate nature
- Application Quantum Chemistry and medicine discovery
- New materials discovery
- Financial modeling
- Quantum Machine learning and AI
- Efficient – space, time and query
- Energy efficient

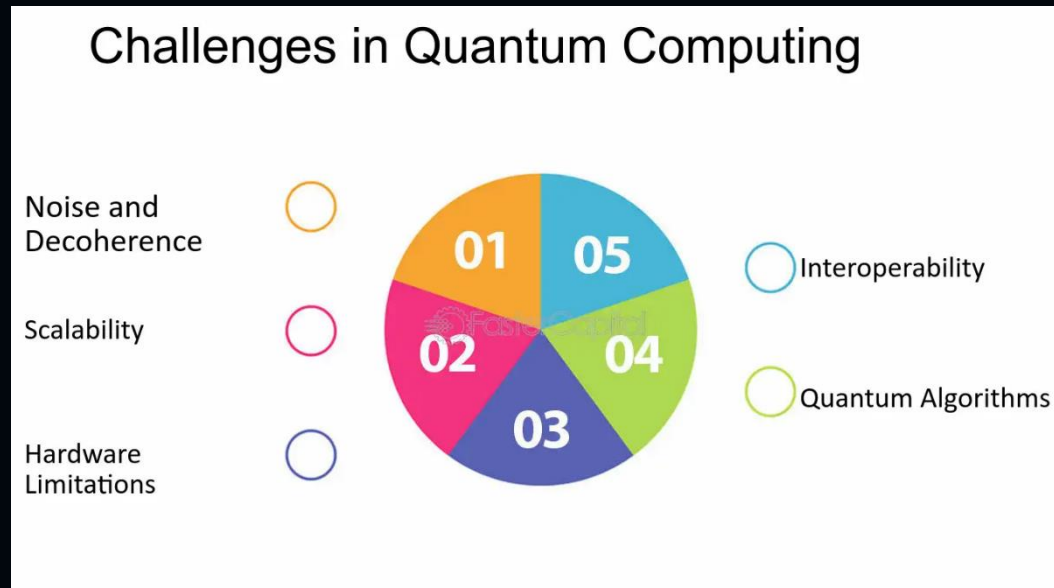
Where

NISQ era (Noisy Intermediate Scale Quantum era)



Challenges

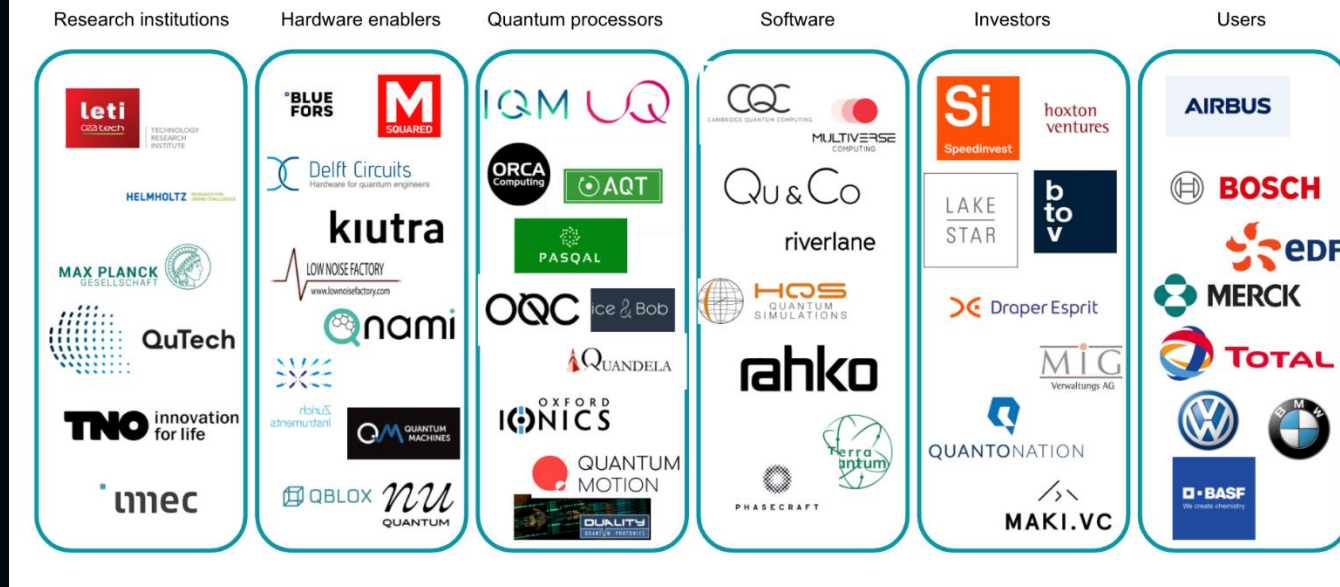
- Hardware – Bad qubits and quantum computers
- Algorithms – Lack of quantum algorithms
- Very expensive



Opportunities



European quantum computing stack





Thank You