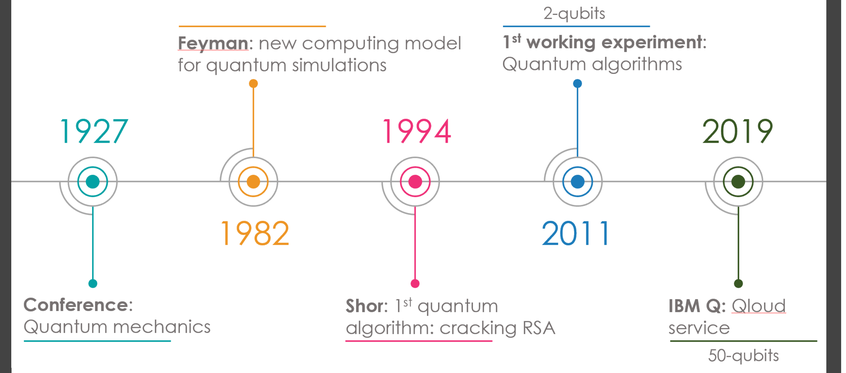
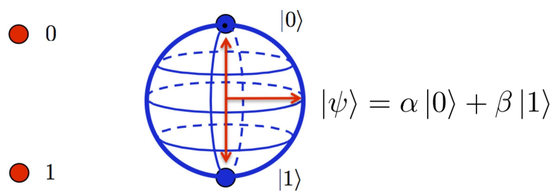
Quantum Computing

Sokratis Papadopoulos, Ioannis Prapas (eBISS 2019)

Brief History



The Qubit



Zahid Hussain and Asma Talib. "Strengths and Weaknesses of Quantum Computing"

$\begin{pmatrix} \alpha \\ \beta \end{pmatrix}$ α and β are complex numbers representing the state probabilities of 0 and 1

Superposition

A qubit is both 0 and 1, until it collapses into one value when measured.

Entanglement

Spooky action at a distance.

Teleportation

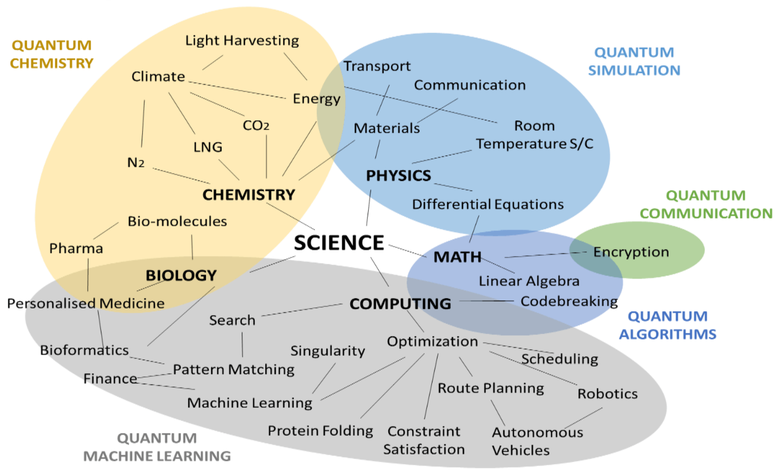
The process of transferring the state (e.g. spin) of a qubit from one location to another without physically moving the involved particle.

Quantum Gates

Gate	Notation	Matrix
NOT (Pauli-X)		$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$
Pauli-Z		$\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$
Hadamard		$\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$
CNOT (Controlled NOT)		$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$

Yan, F., Iliyasu, A., & Jiang, Z. (2014). Quantum computation-based image representation, processing operations and their applications

Algorithms



Quantum Computing Will Transform Almost Every Aspect of our Technology, Science, Economy & Life, (Source – World Economic Forum, HSRC)

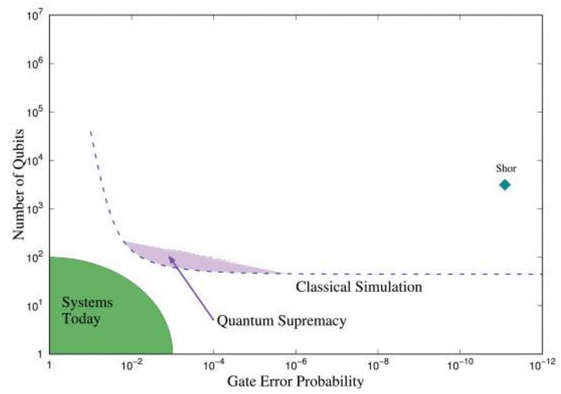
Quantum ML

Q-SVM	Q-Deep Learning
Q-RBM	Q-Gradient Descent
Q-Pattern matching	Q-PCA
Community detection	Quantum Annealing

Fault tolerance

- Quantum "Decoherence" or simply noise
- Noise propagates
+ Error correction techniques (encoding more)
+ 1% error rate per gate is tolerated

Quantum Supremacy



D. Maslov, Y. Nam, and J. Kim. "An Outlook for Quantum Computing [Point of View]"

Conclusion

- QC is not a replacement for classical computing
- Quantum Supremacy – possible?
- PoC implementations– useful?
- Big room for creative ideas