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A bridge to Quantum Computing and why we need one

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Why Quantum Computing

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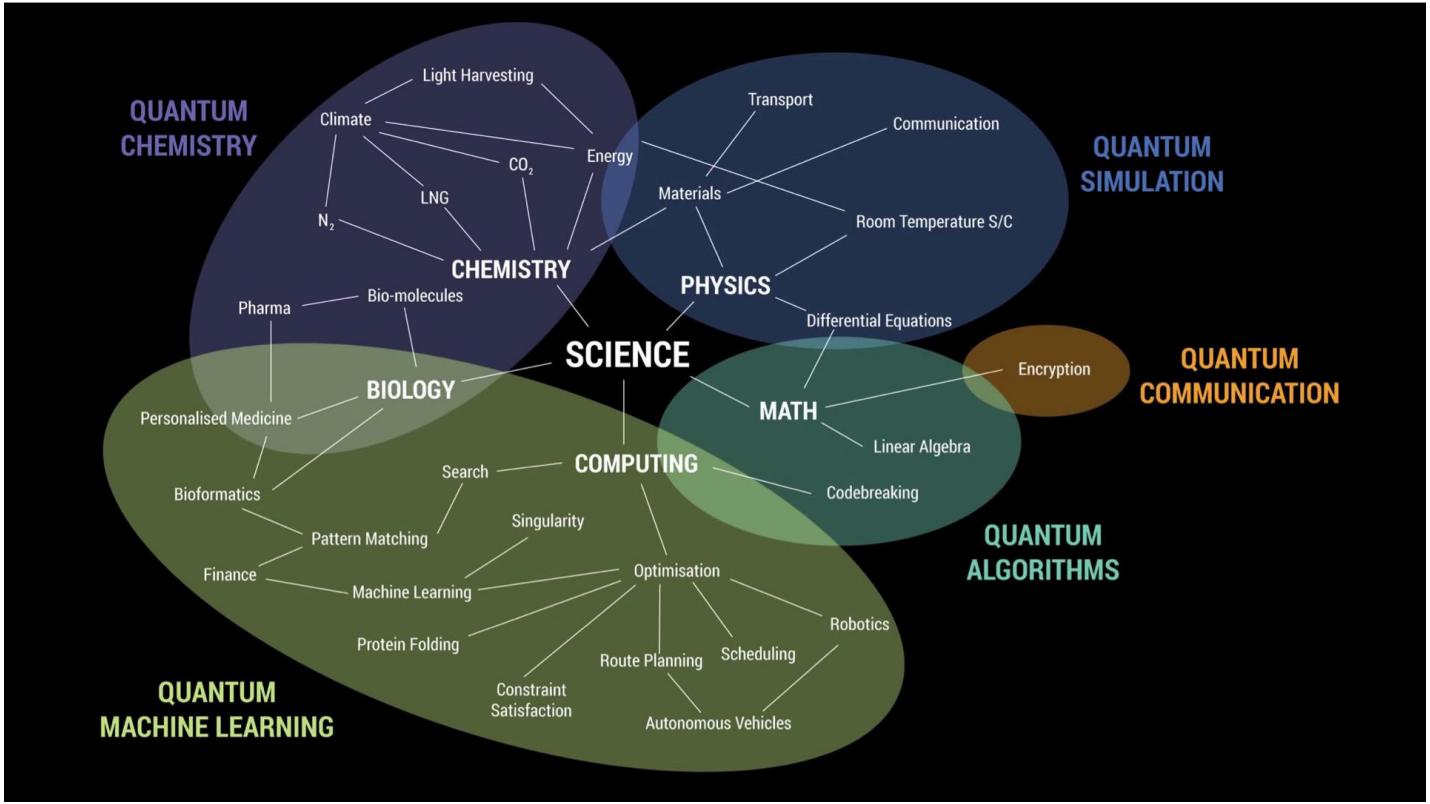

Source: Provided by Quantum Computing Industry Network based on WEF Davos

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Why does Quantum Computing work?

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Quantum Computing uses quantum-mechanical phenomena

Quantum Superposition

In the quantum space you can be in all possible states at the same time. You can be both ‘0’ and ‘1’ at the same time.

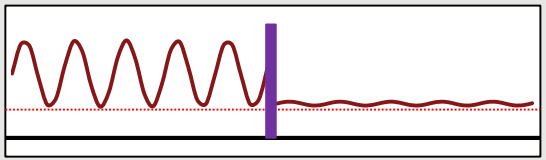
n qubits ~ 2^n bits (classic)

“0” or “1”
DIGITAL STATE

“0” and “1”
QUANTUM STATE

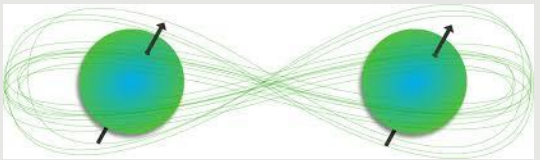
Quantum Tunneling

A process in which a particle passes through a barrier that it classically cannot surmount.



Quantum Entanglement

Is a state in which 2 particles are connected and tied together irrespective of the distance between them.



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Types of Quantum Computing

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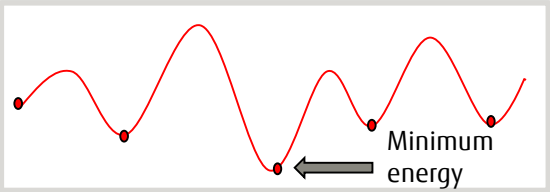
Quantum Computing Technology

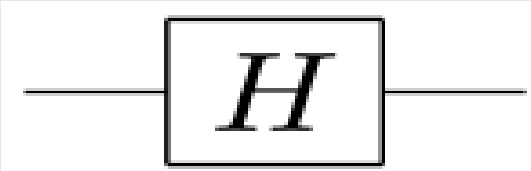
Quantum Annealing

- Using quantum physics to identify minimum energy points thru math. algorithms
- Targeted to solve Combinatorial Optimization Problems



Quantum Gate System

- Perform calculations by manipulating quantum evolution via application of gates
- Targeted to solve problems incl. cryptography and search



Challenges

Stability

Complex infrastructure and cost

Accuracy

Readiness

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Combinatorial Optimization

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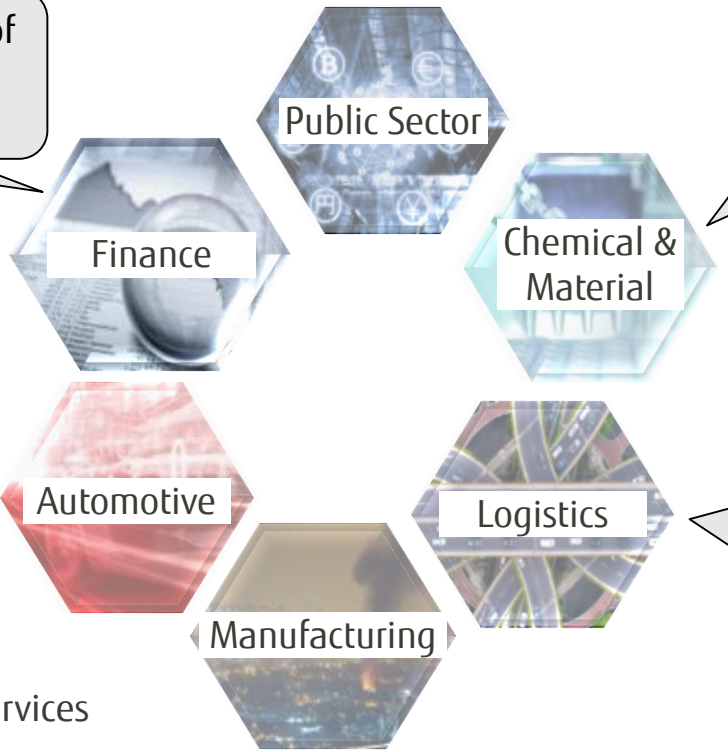
Investment portfolio analysis of 500 stocks: 1.6×10^{150} combinations



Comparison of molecules with 50 atoms: 10^{48} combinations

10 jobs, 7 machines: 300s (standard server) Requirement: Real time

Minimize congestion: 5 pairs of start/destination points deals with 10^{100} possibilities

Job shop scheduling
Workforce optimization
Part placement
Design optimization
Battery optimization
Ride hailing / mobility services

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Real World Example:
Robot Positioning Optimization

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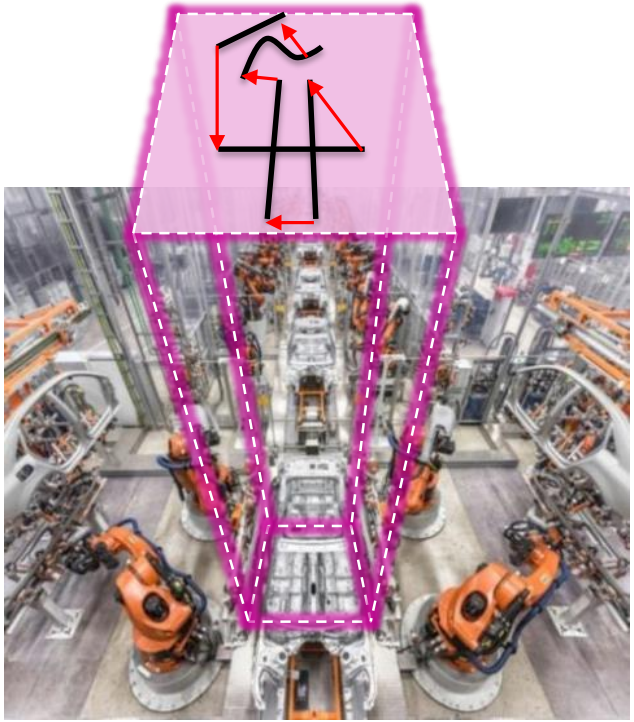
Which roundtrip / welding direction to choose ?

- Robots “visit” seam location & seam can be drawn in 2 directions

$2^{n-1}(n-1)!$ possibilities (n = number of seams)

n	2	7	10	22	64
$\mathbf{2^{n-1}(n-1)!}$	2	46,080	1.86×10^{8}	1.07×10^{26}	$1{,}83 \times 10^{106}$



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A Bridge to Quantum Computing

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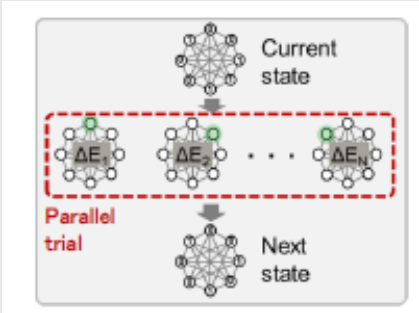
Built on digital circuit based architecture, inspired by quantum computing

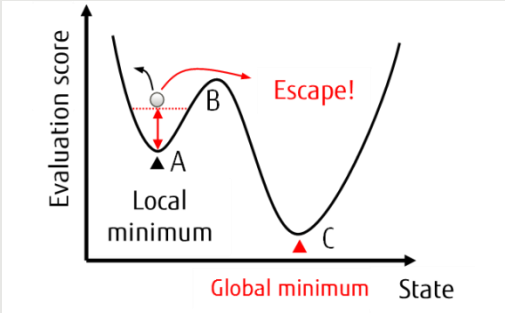
Inspired by Superposition



Parallel Speed up

Scale of 8,192 bits, parallel processing

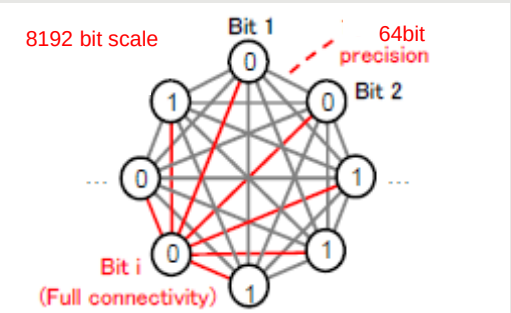
Inspired by Quantum Tunneling



Annealing Process

Increased probability to escape local minima

Inspired by Entanglement



Easy Problem Mapping

Full connectivity through the 8,192 bit scale with 64-bit precision

Robot Positioning Optimization

n	2	7	10	22	64
$2^{n-1}(n-1)!$	2	46080	1.86×10^{8}	1.07×10^{26}	$1,83 \times 10^{106}$

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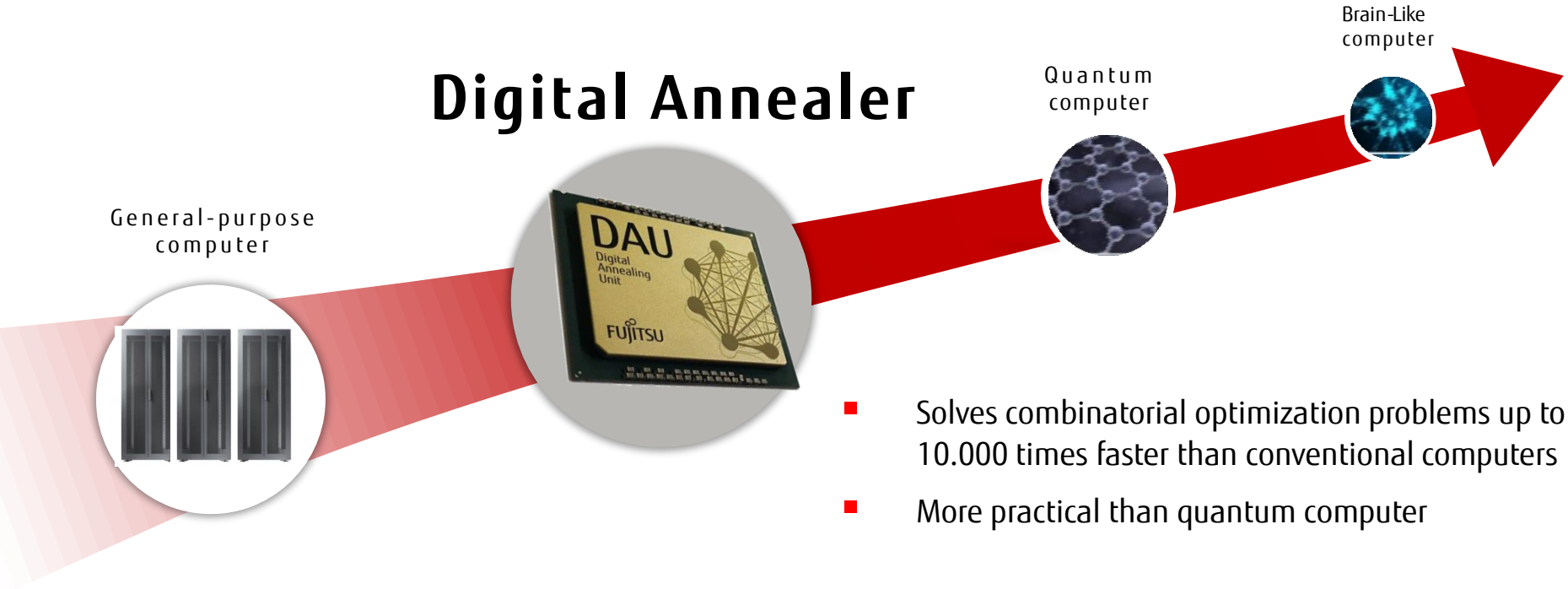
New digital circuit architecture inspired by quantum phenomena



- Solves combinatorial optimization problems up to 10.000 times faster than conventional computers
- More practical than quantum computer

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Eco-systems / Skills required

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Engagements

- Process improvement: Can I solve my problem faster / more often / accurately… ?
- Disruption: How will my business change through continuous / real time optimization ?

Mathematical mapping

Annealing

$$E(X) = -\sum_{\{i,j\}} W_{ij} x_i x_j - \sum_i b_i x_i$$

Identify the problem

Describe the problem

Solve it

Gate Computing

Algorithm
Error correction

Algorithm development

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A Bridge to Quantum Computing

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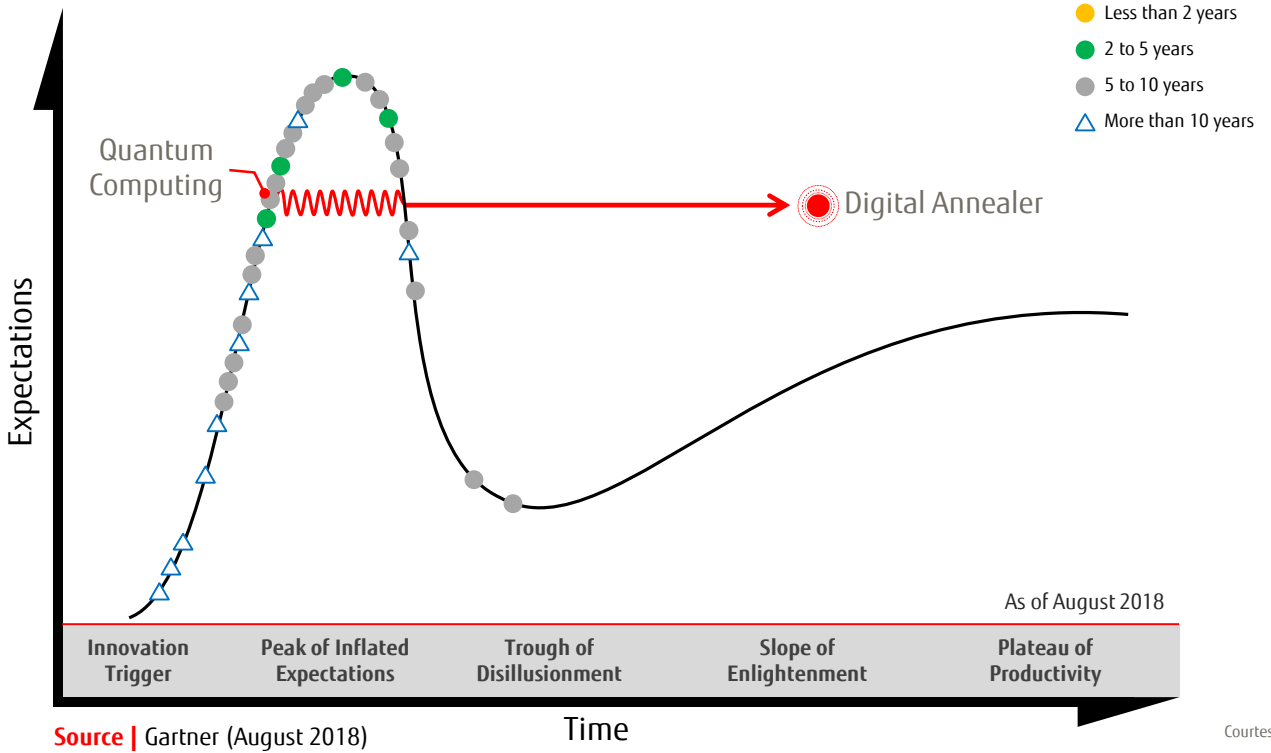
Hype Cycle
Emerging Technologies, 2018



Source | Gartner (August 2018)

Courtesy: D. Snelling

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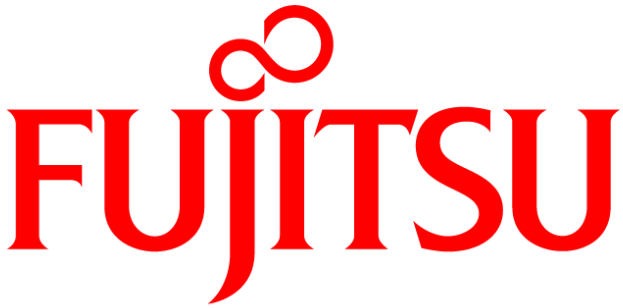

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