

Time travel to
2043:

A quantum-
inspired journey
to discover new
insights

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Human Centric Innovation

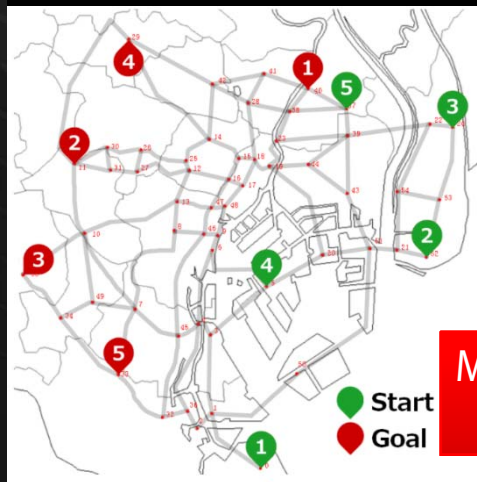
Driving a Trusted Future

Our need to discover new insights



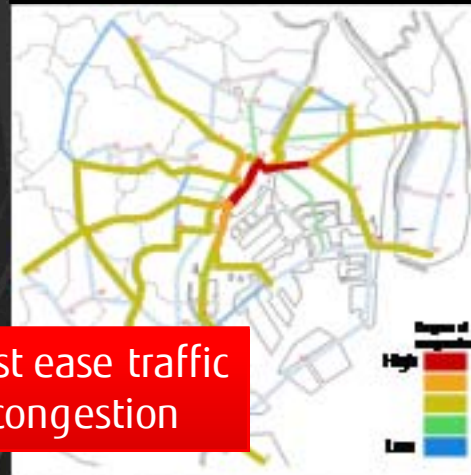
There are a lot of problems that do not bend easily to the modern computing. The potential is huge, the question is when.

Departure/Destination

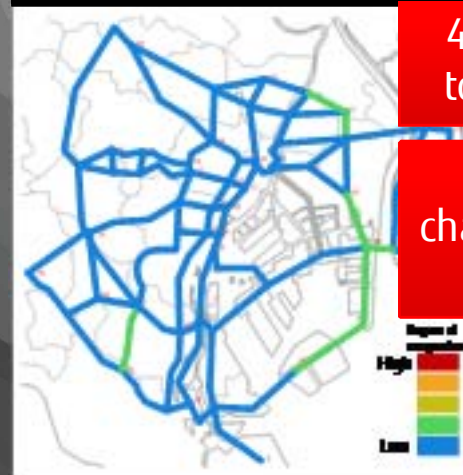


Must ease traffic congestion

SatNav navigation



Traffic route optimization



40% reduction in total traffic time?

Recalculating changing conditions every second?

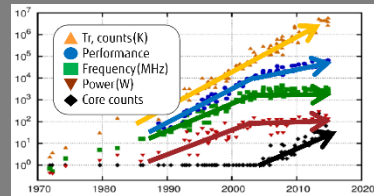
The area we are discussing today is called combinatorial optimization. These problems exist in every company.

Creating knowledge and intelligence from data



Digital era requires that we solve exponentially massive challenges

General-purpose Computers



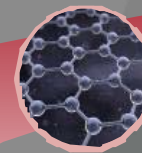
Approaching the limit of Moore's law

To solve even bigger numeric problems, just wait a few years for more powerful computers

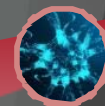


Digital Annealer

Domain specific architectures for major application functions of the domain: deep learning, media search, combinatorial optimization,...



Quantum Computing



Neural Computing

What is combinatorial optimization?

Choosing and packing a bag with 40
most valuable items out of a total of 100



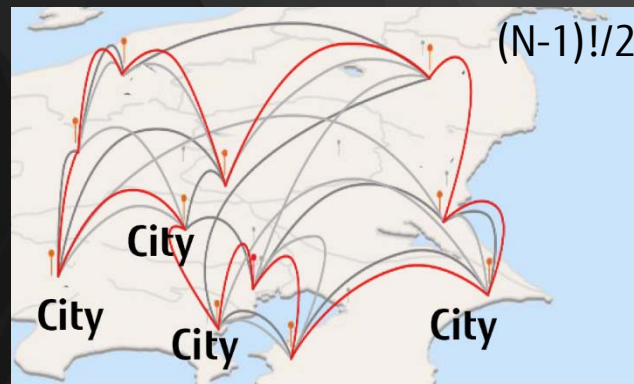
... we are dealing with 1.34×10^{28} possibilities

[One million times the number of stars in the universe]

Number of combinations increases exponentially



Finding the shortest route that visits each city exactly once and returns to the origin city



With 5 cities there are 12 possible routes but with 32 cities
... we are dealing with 4.1×10^{33} possible routes

[Takes 13 billion years even with world's fastest supercomputer]

Learning something new and fundamental in...

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Manufacturing

Parts placement

Shelf layout

Work route

Material blending

Staff scheduling

Production planning

Acoustic design

Fluid simulations

Crash simulation

[Car chassis seam sealing for 64 seams deals with 10^{106} combinations]

Learning something new and fundamental in...

FUJITSU

Financial services

Portfolio risk optimization

Credit risk scoring

Trading

Fund/derivative management

Financial instruments modeling

Asset valuation

Loan design

Quality risk assessment

[Investment portfolio analysis of 500 stocks deals with 10^{150} combinations]

Learning something new and fundamental in...

FUJITSU

Pharmaceuticals

Drug discovery

Molecular similarity

Protein folding

Chemical & Material Science

New material discovery

Compound design

[Comparison of molecules with 50 atoms for molecular similarity deals with 10^{48} combinations]

Learning something new and fundamental in...

FUJITSU

Healthcare

Cancer radiation therapy

Bed allocation

Patient's meal preparation

Shift schedule management

Surgery scheduling

[Cancer radiation therapy with beams from only one direction deals with 10^{150} combinations]



Learning something new and fundamental in...

FUJITSU

Logistics / Transportation

Warehouse routing

Parallel fleet routing

Milk run logistics

Picking and loading

Delivery routing

Traffic infrastructure construction

Waste management

[Six trucks and 43 delivery locations must find its greenest solution from 10^{50} combinations]



Learning something new and fundamental in...

FUJITSU

Utility & Energy

Power transmission routing

Plant shutdown planning

Transmission scheduling

Power flow optimization

Telecom network configuration

Station allocation

Learning something new and fundamental in...

FUJITSU

Retail

Joint replenishment

Assortment rationalization

Price optimization

Loading & packing

Social network analysis

Workforce rosters

Across all industries, business and functions

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Manufacturing
Banking
Insurance
Pharmaceuticals
Healthcare
Logistics
Retail
Transportation
Utility & Energy
Materials

Solving these problems in
real time?

Would be game changing.

Logistics
Production
Quality control
Marketing
Strategy and planning
Procurement
Sales
R&D
Services
Infrastructure

What is annealing?

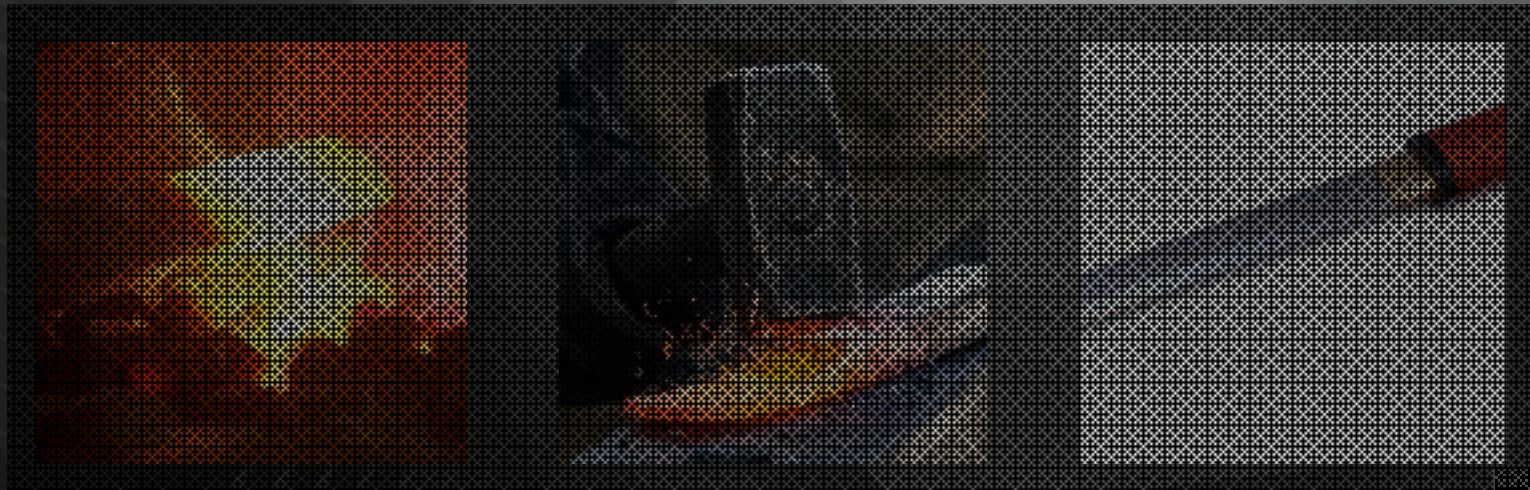


Metal is heated to a high temperature.
The structure stabilizes as it is slowly cooled (=low energy).
The most stable state has minimum energy.

} The
minimum
value

What is annealing?

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$$\sum \min$$

Simulated annealing



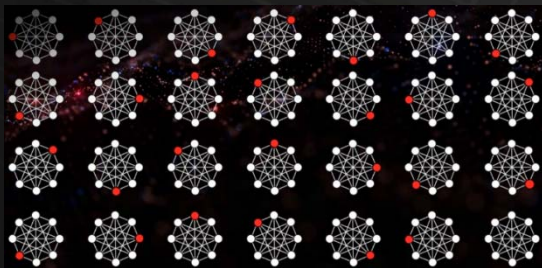
Annealing is a technique to gradually cool after heating the metal and reducing crystal defects

Digital annealing



Stochastic parallelism

Evaluates all subsequent candidate states, arising from all possible bit flips (energy states), in parallel



Inspired by quantum parallelism (superposition)

Annealing process

Simultaneously evaluates multiple energy potentials, avoiding local minimum traps

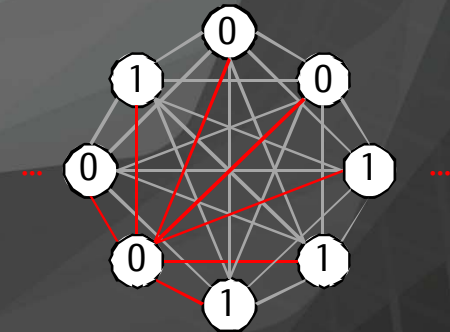
Finding the optimal solution



Inspired by quantum tunnelling

Easy Problem Mapping

Full-connectivity across all bits facilitates instant interaction across the whole system

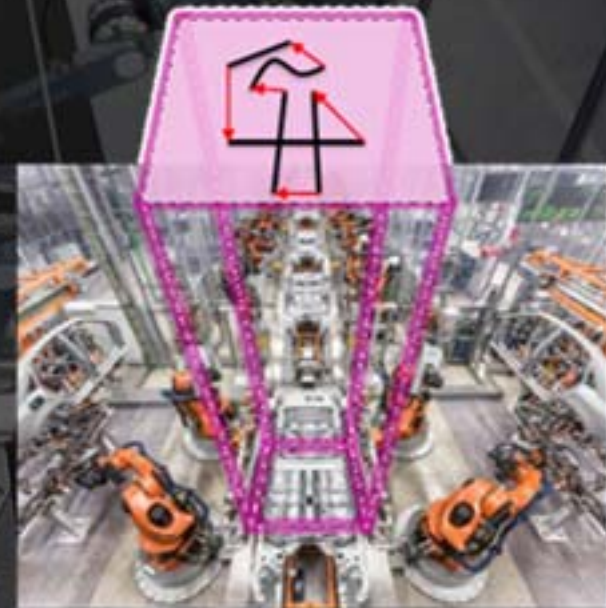


Inspired by quantum entanglement

Case study | Welding robot automatization

Digital Annealer optimizes the routing of seaming process reducing time and cost

- Welding robots visit seam locations
- Seam can be welded in 2 directions
- Find best welding directions and optimal roundtrip between endpoints = minimum time
- Deals with countless of possibilities:
 $2^{n-1}(n-1)!$ where n = number of seams



[Chassis seam sealing for 64 seams deals with 10^{106} combinations]

Digital Annealer | Current state and roadmap



Cloud

1st Generation (2018)

1,024 bits

Full interconnection

16-bit precision

65,536 gradations

2nd Generation (2019)

Up to 8,192 bits

Full interconnection

Up to 64-bit precision

18.45 quintillion gradations



Digital Annealer Unit



On-Premises

Cloud

Next Generation

Large-scale
parallel
processing

1 million
bit scale

[12 Moore's generations ahead today = Year 2043]

Call to action

1. Identify the business problem
2. Map the problem to Ising or QUBO
3. Proof-of-technology and proof-of-value
4. Run it on Digital Annealer in the cloud or on-premises

[A quantum-inspired journey to discover new insights]

Thank you | Speakers | Contact



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