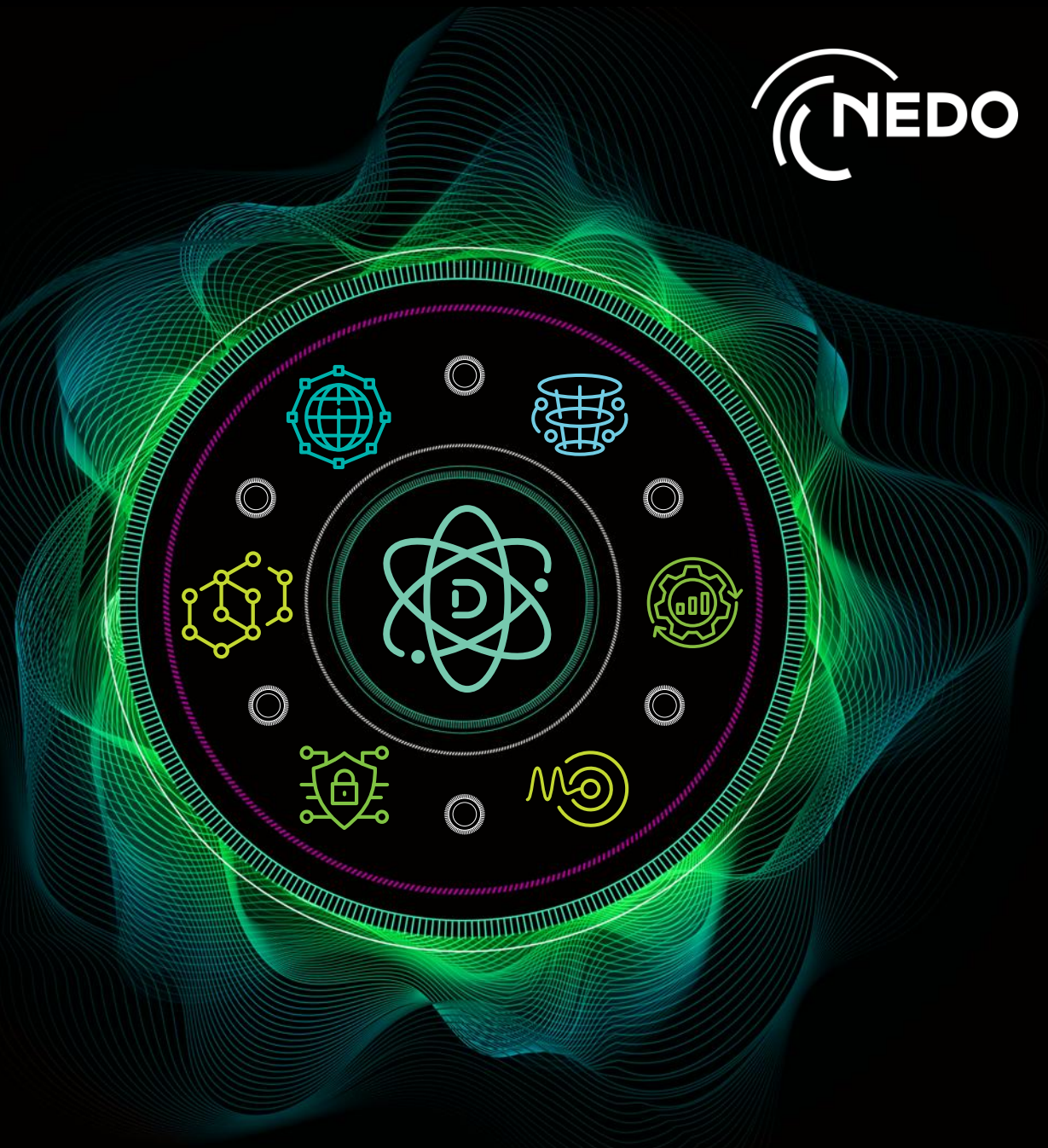
Quantum Computing Use Cases

Optimizing the Storage and Arrangement of Vehicle Supply Parts at the Parts Center

TOYOTA



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Discrete Manufacturing
Process	process design
Method	combinatorial optimization
Category	Ising*

Background

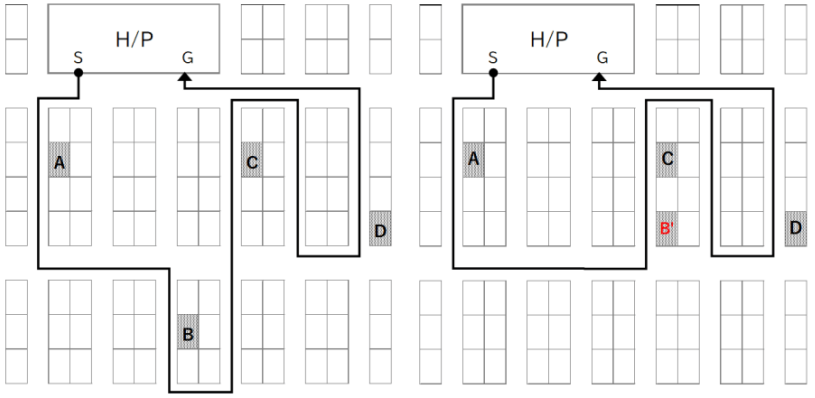
- Toyota has **a wide variety of problems and data on them in various domains (Design, manufacturing, logistics, human resources, etc.)**
- By considering the use of quantum computers for a wide variety of problems, we identify the characteristics of problems that we are good at and bad at.
- By widely sharing the knowledge obtained from the examination results, Toyota hopes to **contribute to the development of quantum technology and solutions to social issues.**

Issues and motivation to be solved

- Combination optimization has been an issue in various areas within Toyota, but **optimization of storage and arrangement of spare parts (parts) for vehicles in parts centers, which is a difficult problem to optimize due to the enormous number of combinations (several billion types)** was selected as a verification issue
- In **picking work** where a worker walks to a storage shelf when an order is received, picks up parts, and returns them, the purpose of this verification is to **reduce the travel distance by changing the storage arrangement of parts.**

Problem setting as a quantum computer

- **The movement distance of the worker was expressed in the form of binary optimization without quadratic constraint which can be handled by the quantum annealer, and the minimization problem of the scale of several tens of thousands variables was solved using this as an objective variable.**
- Tens of thousands of variables are **much smaller than the actual problem,** but **two devices were made to reflect the characteristics of the actual problem as much as possible.**
  - ① Excerpt from the actual shelf layout of the Parts Center
  - ② To generate pseudo order data in which the number of kinds of parts ordered at one time and the distribution of order frequency of each part coincide with actual order data and the number of kinds of all parts is arbitrarily selected.
- The machine uses **D-Wave Systems' Quantum Classical Hybrid Solver Service.**



Reduction of workers' travel distance by changing storage arrangement

Reference: Toyota Motor Corporation "Quantum computer research at the Mirai Creation Center" (https://global.toyota/jp/mobility/frontier-research/40116331.html)
*Ising: A computing approach, mainly associated with quantum annealers and simulators specialized for the Ising model, in which a problem is first formulated as an Ising model and then solved computationally. It is particularly well suited to problems that involve finding the optimal combination from a vast number of possibilities.

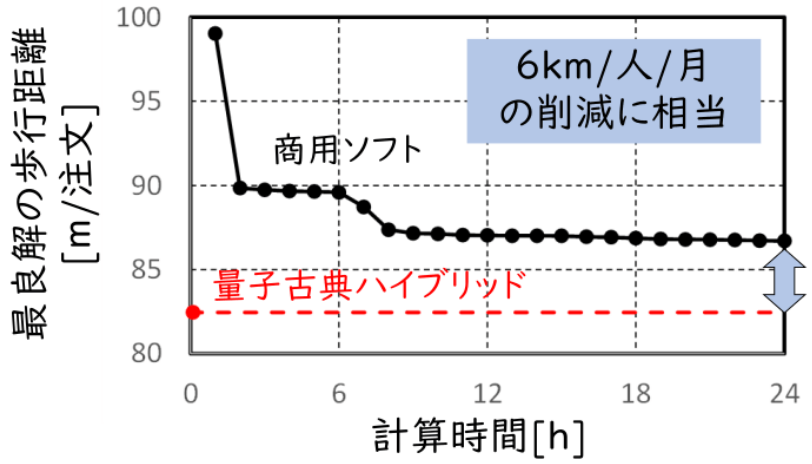
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Expected business benefits

- Comparison is made between the calculation using commercial optimization software on a classical computer and the quantum classical hybrid calculation.
  - ✓ As a result, **Classical only: 24 hours, quantum classical hybrid: 6 minutes.**
  - ✓ In addition, we were able to calculate **the optimal solution that the quantum-classical hybrid can shorten the walking distance by about 3m**.
- A difference of 3 m can be expected to **reduce the travel distance of 6 km/person per month** if, for example, 1 worker performs picking work 100 times a day and works 20 days per month.



Calculation time and average travel distance

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More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

New Energy and Industrial Technology Development Organization (NEDO)
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This collection of use cases was obtained as a result of the work commissioned by the New Energy and Industrial Technology Development Organization (NEDO) "Cyber-Physical Development Business of Quantum/Classical Hybrid Technology/Study of Use Case of Quantum Technology" and the "Post-5G Information and Communications System Infrastructure Reinforcement R & D Project (Quantum Industrialization)/Comprehensive Study for Promoting the Industrialization of Quantum Computers".