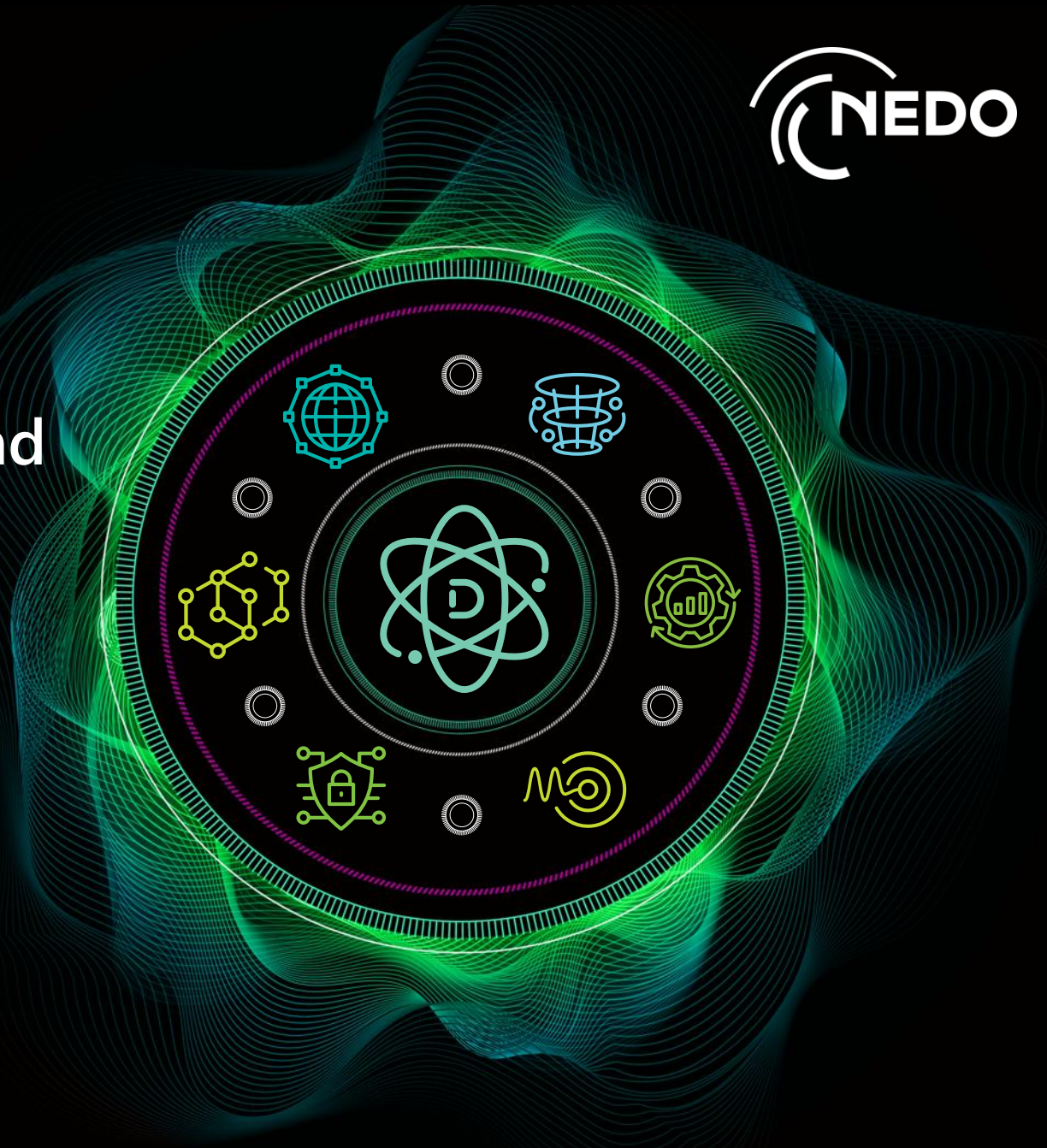
Quantum Computing Use Cases

Optimization of Picking Routes and Shelf Arrangements in Factories and Warehouse

TOPPAN Digital



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

- Optimizing factory warehouse management is one of the most complex and important challenges.
  - ✓ Optimization helps increase productivity and reduce costs
  - ✓ On the other hand, **poor optimization can lead to increased worker burden, safety issues, and reduced production efficiency.**
- Based on years of experience, the TOPPAN Group has been optimizing picking routes using simulation tools developed in-house
- However, **it was difficult and time-consuming to do the best work in a field that relied on the experience of the workers.**

Issues and motivation to be solved

- The company had been trying to optimize the picking route using in-house developed tools, but it was difficult to optimize the work in the field depending on the experience of experienced workers. Therefore, the company **examined the applicability of quantum technology to the picking optimization**
- **In 2022, Toshiba Digital Solutions launched an initiative to apply quantum-inspired technology to optimize factory and warehouse management** with the aim of enabling efficient operations without depending on the know-how of workers.
- This joint research also tackled **shelf placement optimization in pursuit of picking route optimization**

Expected business benefits

- In addition to optimizing the picking route, the shelf layout was also optimized, resulting in **an average 15% reduction in picking time compared to simulation (classic) with current tools.**
- Expanding the scope of optimization beyond factory and warehouse management to improve BPO and manufacturing processes using quantum technology

Reference: TOPPAN Holdings Co., Ltd. "TOPPAN Digital and Toshiba Digital Solutions demonstrate the optimization of picking routes and shelf placement in factories and warehouses using SQBM+TM, a quantum-inspired optimization solution." (https://www.holdings.toppan.com/ja/news/2024/04/newsrelease240424_1.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.

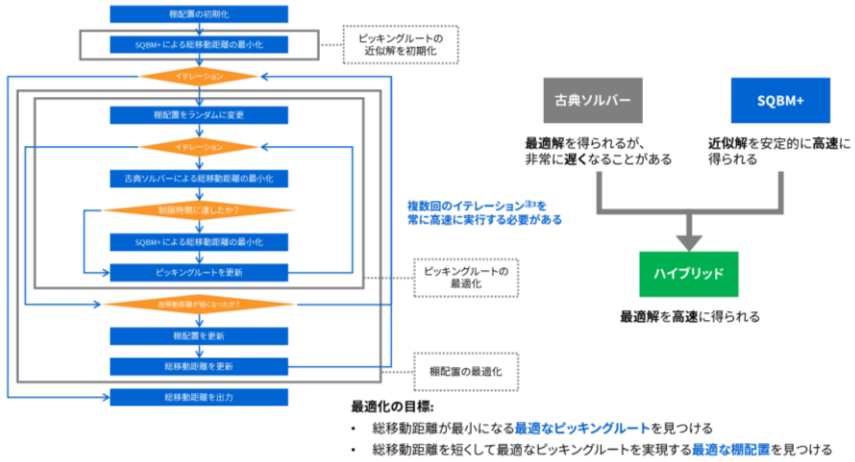
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Problem setting as a quantum computer

- Based on the actual data of the TOPPAN Group's factories, an **optimization problem with approximately 9,000 variables** was solved, which was modeled considering items, personnel, areas, and layout elements.
- The objective function is **picking route optimization and shelf placement optimization.**
- The machine uses **SQBM +, a quantum inspired optimization solution from Toshiba Digital Solutions**.
- In order to simultaneously find the optimal picking route and the optimal shelf placement, **a hybrid method that narrows the search range and shortens the search time of the classical solver by using the approximate solution obtained by SQBM+,** utilizing the respective features of SQBM+ and the classical solver.
  - ✓ Features of SQBM +: It can stably generate fast and accurate approximate solutions.
  - ✓ Characteristic of the classical solver: the larger the area searched, the longer the search time and the slower the computation, but the shortest path can be searched



Hybrid solution optimizes picking route and shelf placement

- **目的関数1：ピッキングルートの最適化**

$$F_s(\mathrm{ItemToTask}) = \underset{X,Y}{\mathrm{minimize}} \sum_{w=0}^{\mathrm{NumWorkers}-1} \mathrm{Time}_{s,w}^{Goal}$$

- **目的関数2：棚配置の最適化**

$$G = \underset{\mathrm{ItemToTask}}{\mathrm{minimize}} \sum_{s=0}^{\mathrm{NumSenarios}} F_s(\mathrm{ItemToTask})$$

Modeling

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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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