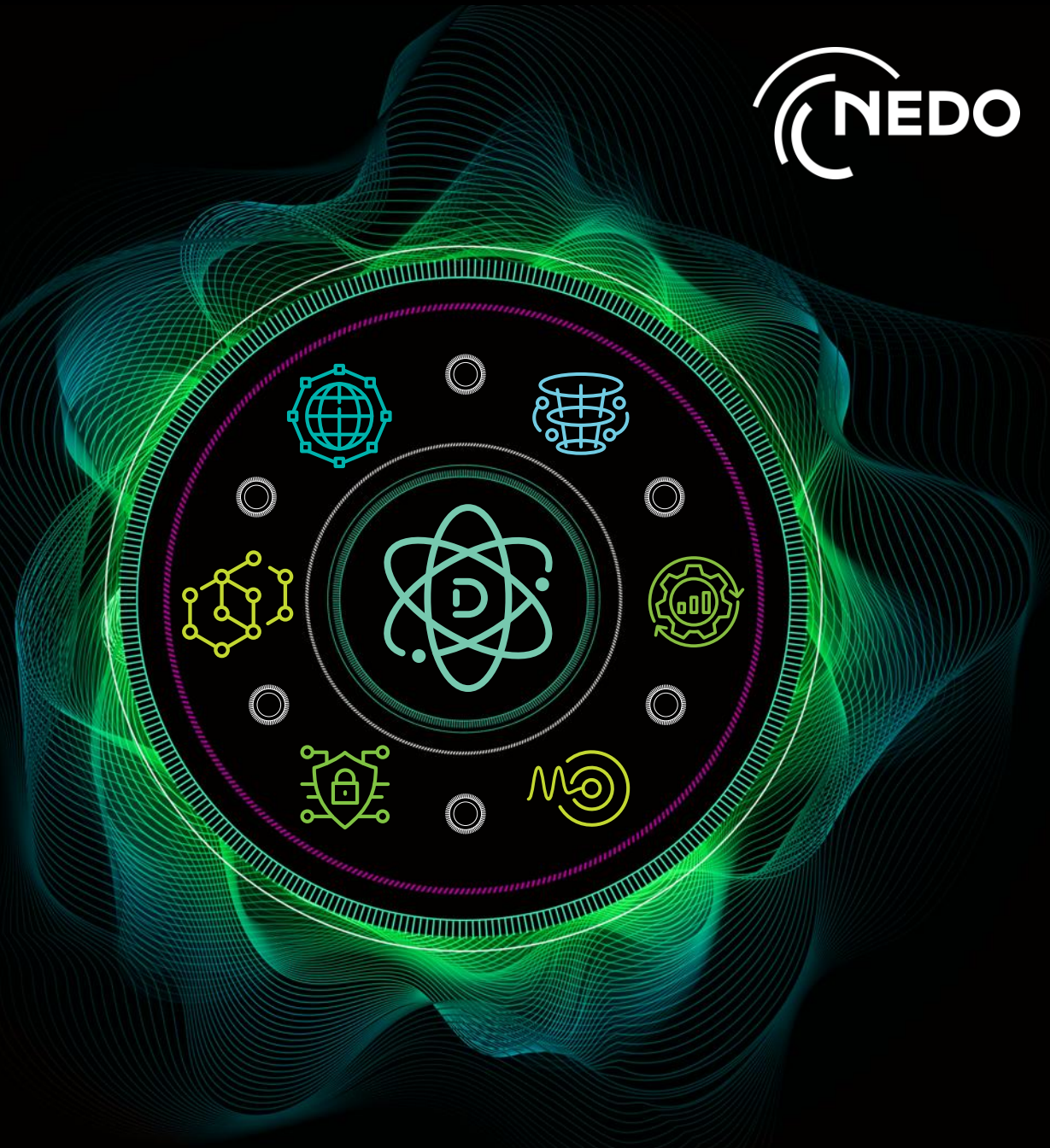
Quantum Computing Use Cases

Complex Production Planning Automation

NEC Platforms



New Energy and Industrial Technology Development Organization (NEDO)

NEC Platforms: Complex Production Planning Automation [2023/03] 1/3

Operational Use

Industry	Discrete Manufacturing
Process	Production
Method	combinatorial optimization
Category	Ising*

Background

- Due to factors such as high-mix, low-volume production, shortened product life cycles, fluctuating production volumes, and tight supply and demand for semiconductor components, **demand for rapid production of multiple products in response to daily changing demand has become apparent.**
- On the other hand, **To improve productivity, it is essential to improve the efficiency of 'setup' that changes hundreds of types of parts and equipment settings every time a product type is changed. However, since setup itself has no added value, it is necessary to determine whether the complicated setup planning process can be executed in a short time.**
  - ✓ Because the production process time varies greatly depending on the combination of "when" and "in which order" to produce the variety required for that day, which is determined by "arrangement."
- In the past, **skilled workers familiar with the production process devise production plans to minimize setup in response to fluctuations**

Issues and motivation to be solved

- **Due to the increasing complexity of production plans, even skilled workers are currently finding it difficult to make efficient plans** due to high-mix, low-volume production, etc.
  - ✓ In the surface mounting (SMT) process for manufacturing printed circuit boards, mixed production is carried out, in which multiple different types are produced on a single line. However, since "setup" for changing parts and settings is performed by stopping the line, an increase in setup leads to a decrease in productivity.
- **Production planning work was concentrated on skilled workers, but the shortage of skilled workers who are familiar with setup adjustment became apparent due to the decrease in the working population. In addition, existing mechanisms including AI are difficult to automate, and passing on skills is also an issue.**
- In light of the above, NEC Platforms planned to automate production planning by utilizing quantum computer technology capable of high-speed calculations in order to make it possible to revise production plans instantly in the event of sudden configuration changes.

Reference: NEC platforms "Complex Production Planning with Quantum Computing Technology" (https://jpn.nec.com/quantum_annealing/case/necplatforms/index.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.

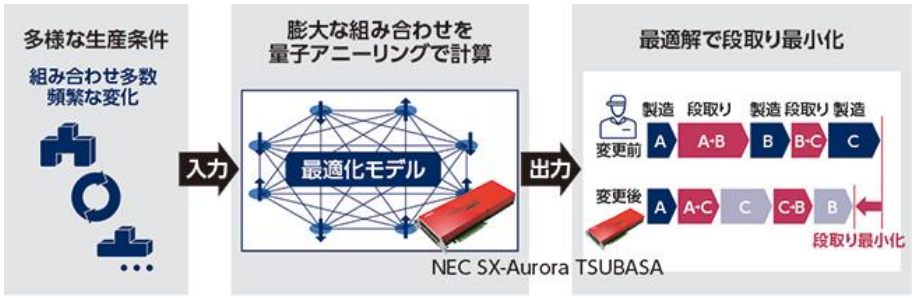
NEC Platforms: Complex Production Planning Automation [2023/03] 2/3

Operational Use

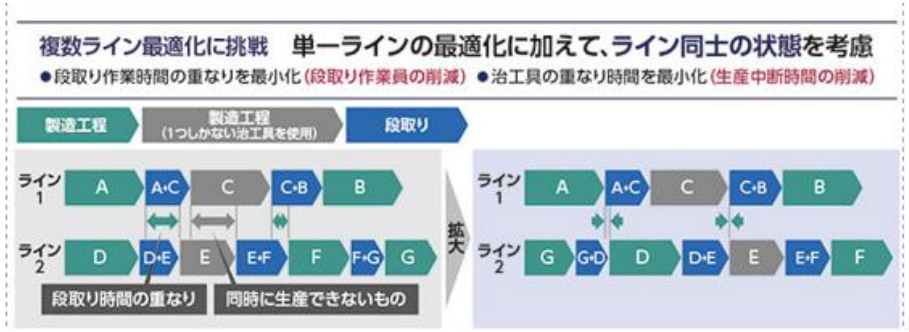
Industry	Discrete Manufacturing
Process	Production
Method	combinatorial optimization
Category	Ising*

Problem setting as a quantum computer

- Through quantum computer technology, **Automation of production planning to minimize setup and mixed production on multiple lines, *1, Demonstration of high-efficiency production planning in**
  - ✓ **Multi-line x mixed production takes into account resources such as workers and jigs and tools between lines, so it is difficult for a classical computer to process a huge combination of parameters. Therefore, the advantage of a quantum computer capable of simultaneous high-speed processing is utilized.**
- As the objective function, **reduction of setup workers and reduction of production interruption time** is assumed.
  - ✓ Ultra-high-speed processing of large-scale combinatorial optimization problems, such as formulation of delivery plans that minimize delivery distance, time, and cost, and formulation of work shift plans that satisfy job titles and skills, etc.
- Utilization of **NEC Vector Annealing Service** for ultra-high-speed processing of vast combinatorial problems using quantum computing technology
  - ✓ Application of quantum annealing technology to NEC's SX-Aurora TSUBASA vector supercomputer **utilizing quasi-quantum annealing platform**



Optimization of production scheduling of a manufacturing line that leverages the high-speed processing of pseudo-quantum annealing technology



Optimization of mixed production with multiple production lines, which is difficult even for skilled workers

Reference: NEC Platforms "Complex production planning automated with quantum computing technology" (https://jpn.nec.com/quantum_annealing/case/necplatforms/index.html),
NEC"NEC Vector Annealing service for solving diversifying business problems as combinatorial optimization problems" (https://jpn.nec.com/nec-vector-annealing-service/index.html)
*1: Mixed production is a system in which multiple varieties are produced on the same line.
*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.

NEC Platforms: Complex Production Planning Automation [2023/03] 3/3

Operational Use

Industry	Discrete Manufacturing
Process	Production
Method	combinatorial optimization
Category	Ising*

Expected business benefits

- Automating production planning by minimizing "setup" and realizing ultra-high-speed simultaneous optimization of multiple lines
  - ✓ **Production planning, which used to take 1~2 hours even for a skilled worker (manual), can be planned with the same accuracy in about 10 minutes.**
  - ✓ In addition, **the simultaneous optimization of multiple lines is more complex, and by shifting the setup time between lines, it is possible to create value-added plans, such as reducing the burden on workers, which was not included in the plans for skilled workers.**
- Production planning automation is expected to reduce setup man-hours by 50%, increase capacity utilization by 15%, and reduce production planning man-hours by 90%.
  - ✓ **Achieve value delivery that leads to overall cost savings with greater scope for optimization**
- **Classical computer AI needs to collect data for machine learning every time a new product is released, but it was not possible to introduce and compare it because the data mentioned on the left was not available.**

Reference: NEC Platforms "Complex production planning automated with quantum computing technology" (https://jpn.nec.com/quantum_annealing/case/necplatforms/index.html),
NEC"NEC Vector Annealing service for solving diversifying business problems as combinatorial optimization problems" (https://jpn.nec.com/nec-vector-annealing-service/index.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.

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)
AI and Robotics Department (e-mail: quantum_ai@ml.nedo.go.jp)

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".