Quantum Computing Use Cases

Application “NAYUTA”

Quanmatic



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Discrete Manufacturing
Process	Production
Method	combinatorial optimization
Category	Ising*

Background

- **Production planning optimization, a key issue for improving productivity and reducing costs in semiconductor manufacturing, is a large-scale problem with vast and complex constraints and objectives. It is extremely difficult to solve because rapid replanning within a short time is required**
- To address this, the project aims to develop an application using hybrid quantum-classical technology to **optimize production planning in the front-end processes of semiconductor manufacturing**, thereby contributing to the maintenance and enhancement of industrial competitiveness, as well as to more sophisticated energy supply-demand management through improved productivity in semiconductor manufacturing
- Specifically, **the characteristics of optimization problems in semiconductor manufacturing will be analyzed, and based on that, an algorithm will be developed to construct as compact a QUBO as possible while still representing the combinatorial optimization problem**
- **The resulting QUBO minimization algorithm will be implemented, together with large-scale data quality analysis and automatic correction AI technology, as the quantum-classical application for manufacturing called NAYUTA.** The application will then be applied to and evaluated on real manufacturing problems

Issues and motivation to be solved

- **Confirm that optimal solutions can be obtained for optimization problems in semiconductor manufacturing using sample manufacturing data as test cases**
- Confirm that the large-scale data quality analysis and automatic correction AI improves correction accuracy compared with rule-based methods
- **For the manufacturing application, the targets are a 5% improvement in the number of process assignments in production plans calculated over a 12-hour time span compared with manual planning, and production planning real-time performance (time required for planning) of one-fifth or less of the manual approach**

Reference: AI and Robot Department, New Energy and Industrial Technology Development Organization (NEDO), “Cyber-Physical Development Project for Quantum-Classical Hybrid Technologies” (https://www.nedo.go.jp/content/800030349.pdf)
*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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Validation

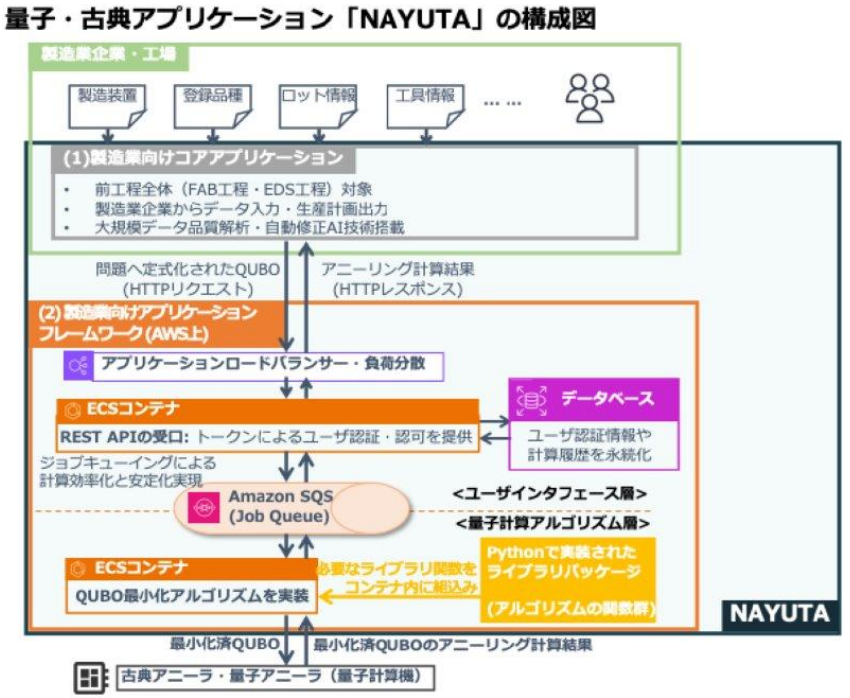
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Problem formulation for quantum computer

- In semiconductor manufacturing production planning, the number of possible patterns increases exponentially with the number of machines, product types, and production lots, **making it difficult for simulated annealing (SA) and other classical optimization methods to handle effectively**
- When the QUBO (quadratic unconstrained binary optimization) formulation is complex, construction time and communication time become dominant
- To address this, **the project enables efficient computation with quantum annealing and, through hybridization with AI, develops a practical application for manufacturing sites equipped with large-scale data quality analysis and automatic correction AI technology**
- Waseda University is responsible for both the theoretical background of algorithm development and experimental verification

Expected business benefits

- Quanmatic plans to position this application, NAYUTA, as a product and service that **can be broadly applied to complex processes across manufacturing, addressing issues such as workflow optimization, machine assignment, and workforce allocation,** and commercialize it



Reference: AI and Robot Department, New Energy and Industrial Technology Development Organization (NEDO), “Cyber-Physical Development Project for Quantum-Classical Hybrid Technologies” (https://www.nedo.go.jp/content/800030349.pdf); Configuration diagram of the quantum-classical application “NAYUTA”: from the Interop ‘26 Tokyo presentation (Thu, June 11, 17:00–17:40), “Introduction to NEDO’s Initiatives on Next-Generation Computing” (https://forest.f2ff.jp/introduction/12445?project_id=20260601&_gl=1*ylm8bh*_gcl_au*MTU2MzQwMTg2LjE3ODUxMzI0NjQ.&_ga=2.244153093.1234904232.1785132465-899828611.1775626541)

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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”.