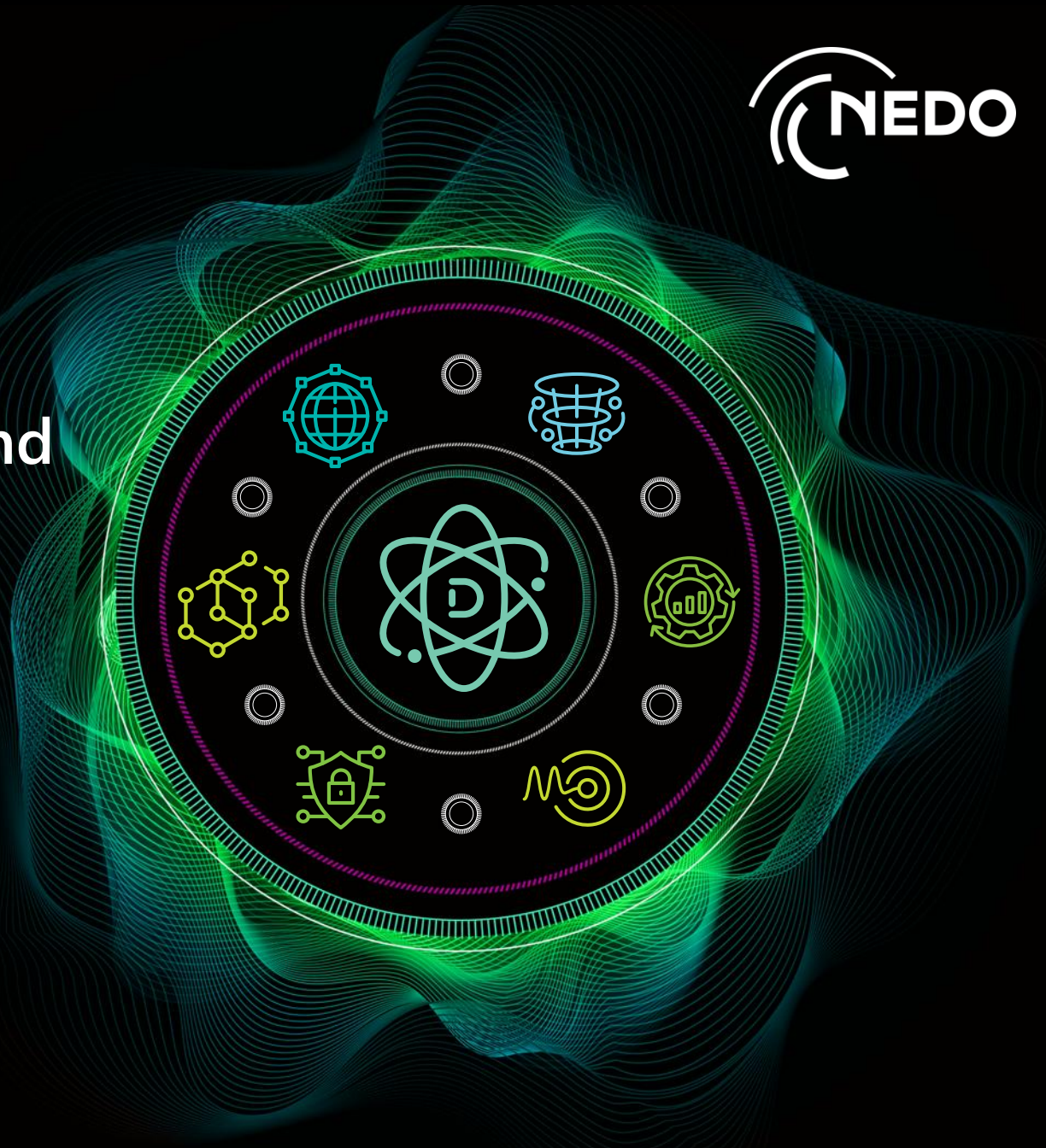
Quantum Computing Use Cases

Application for Optimizing Inbound and Outbound Routing in Large-Scale Logistics Warehouses

Sharp



New Energy and Industrial Technology Development Organization (NEDO)

Sharp: Application for Optimizing Inbound and Outbound Routing in Large-Scale Logistics Warehouses [2026/7] 1/3

Validation

Industry	Transportation
Means	land transportation
Method	combinatorial optimization
Category	Ising*

Background

- With the rapid expansion of the e-commerce market, **logistics volumes and the number of handled items have increased**, driving the growth of larger logistics centers and stronger demand for advanced automation
- **Constraints that are difficult for individual operators to address alone are also increasing**, including labor shortages due to population decline and compliance with labor-related regulations, such as the "2024 Problem" (new overtime limits for truck drivers in Japan)
- Since FY2016, **Sharp has operated a comprehensive solution business for transport robots (AGVs), and as of 2023 has deployment experience at about 120 sites with more than 1,000 transport robots**. As a core technology, it has an RCS (Robot Control System) capable of centrally controlling up to 500 units
- However, **responding to the growing scale and complexity of customer sites has become a challenge**, including large warehouses with more than 500 units and as many as 37.5 × 10^12 possible combinations of major routes alone. **Conventional classical computers have difficulty optimizing such problems within practical time limits**
- To address this, Sharp began basic verification in FY2024 aimed at **accelerating large-scale route optimization through quantum annealing technology**, and was selected for Phase 3 (practical application development phase) of NEDO's Cyber-Physical Development Project for Quantum-Classical Hybrid Technologies

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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Issues and motivation to be solved

- **Specific issue to be solved:**

Simultaneous optimization of inbound and outbound routes in a large-scale logistics warehouse with around 1,000 transport robots. Even the combinations of major routes alone reach 37.5 × 10^12, making the problem impractical to solve within realistic time using existing classical computing technologies

- **KPI to be improved:**

Average inbound/outbound processing speed (target: within 10 seconds), warehouse-wide picking throughput, the number of demand-forecasted products that can be handled (target: around 1 million items), and the number of Ising machines that can be supported

- **Why quantum computing technology is effective:**

Classical mixed-integer linear programming (MILP) and similar methods are generally limited to problem sizes of about 10,000 variables, making them difficult to apply to route combination optimization at the scale of 1,000 AGVs. Quantum annealing, by contrast, is well suited to the rapid processing of massive combinatorial problems

Problem formulation for quantum computer

- **Objective function:**

A cost function was designed to minimize **AGV travel distance and waiting time while maximizing warehouse-wide picking throughput (number of picks / total processing time), reflecting actual operating conditions such as priorities**

- **Constraints:**

AGV priority, avoidance of aisle congestion and route conflicts, number of operating units (up to 1,000), and distributed processing across multiple solvers and multiple Ising machines

- **Input data:**

Demand forecast data by day, hour, and product generated by AI demand forecasting (DeepAR) at a scale of 500,000 to 1.5 million items, together with shelf layout and aisle configuration data, and AGV operating status data

- **Why classical methods are difficult:**

The search space is enormous, with 37.5 × 10^12 combinations for major aisles alone plus route candidates for 1,000 AGVs. MILP and similar methods (practical limit: about 10,000 variables) cannot solve the problem within realistic time; the problem is therefore decomposed by clustering and processed at high speed using quantum annealing (D-Wave, SQBM+, Sharp's in-house SQA computing accelerator, etc.)

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Expected business benefits

- A demonstration with 1,000 AGVs **confirmed an average improvement of 49.1% (up to 52.1%) in picking throughput (picks per minute) compared with classical methods**
- **Implementation of the RCS platform for centralized control of 1,000 AGVs has been completed, and preparation for real operation is in place**
- Sharp's robotics (RB) business aims to expand to JPY 10 billion in sales by FY2027, and this application is positioned as a core solution within that business. Social implementation, including mass production and sales launch, is planned for FY2027
- Publications: Nguyen, Q.T. et al. (Scientific Reports, December 2025; IEEE Access, July 2026)

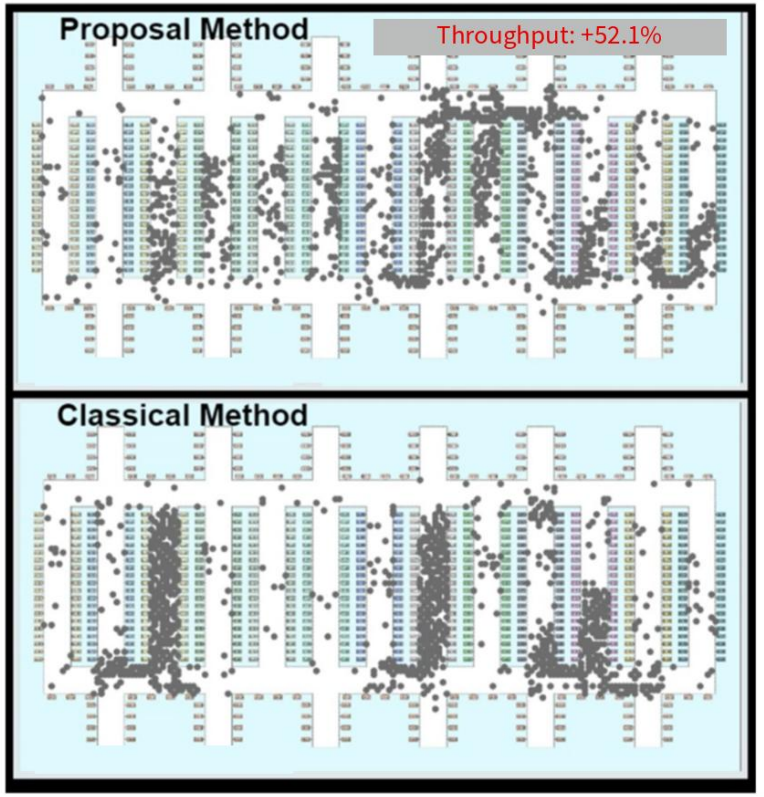


Figure: Validation of the quantum × AI hybrid application
(The upper figure shows the results of the proposed method, and the lower figure shows those of the conventional classical method. The gray circles represent AGVs. In the lower figure, the classical method causes frequent congestion, resulting in longer overall processing time, whereas the proposed method in the upper figure successfully alleviates congestion, confirming an improvement in overall throughput)

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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

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