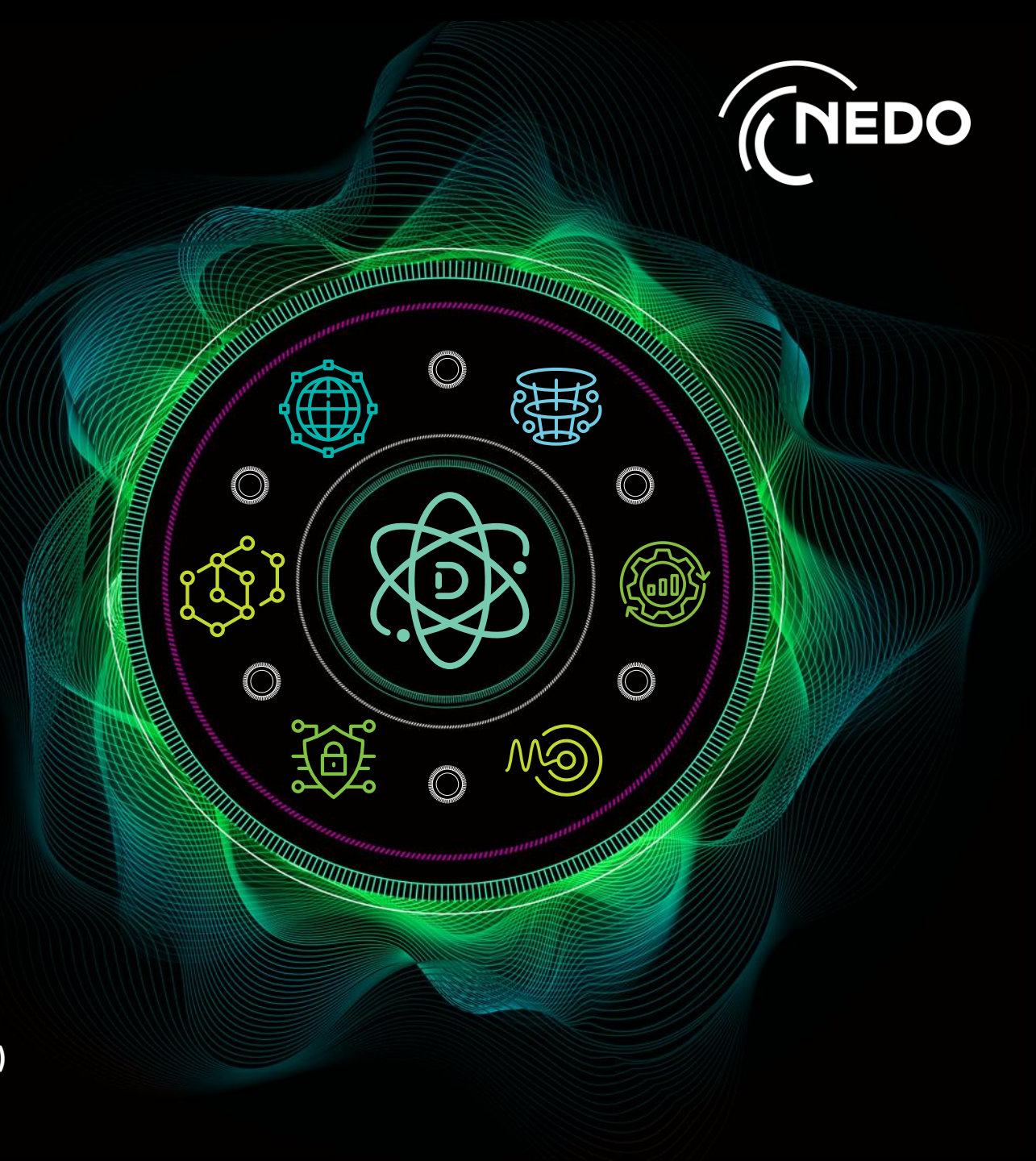
Quantum Computing Use Cases

Optimization of arbitrage in Financial instruments

Hitachi



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Finance
Process	securities
Method	combinatorial optimization
Category	Ising*

Background

- Hitachi is working to create services to improve customer business resilience against rapid changes in the business environment.
  - ✓ In financial transactions, for example, **it is necessary to solve a combinatorial optimization problem that takes various options into account in response to an ever-changing environment.**
- Hitachi has developed CMOS annealing as a technique for solving combinatorial optimization problems, and has applied it to customer business problems such as reinsurance portfolio optimization of non-life insurance and work shift optimization in call centers.
- This time, by utilizing the features of CMOS annealing suitable for combinational optimization processing, we will work on **portfolio optimization to support arbitrage of financial products** *1

Issues and motivation to be solved

- Financial instruments can bring large profits, but they also have the risk of falling in value. Instead of investing all funds in a single financial instrument, diversified investments are made by combining multiple financial instruments to reduce risks. **It is important to construct an optimal portfolio that balances profits and risks.**
- Conventional statistical methods combine multiple stocks to construct a portfolio of financial instruments with average reversion, *2. However, it is important to consider such constraints and indicators as trading rule constraints such as transaction fees and positions for each stock constituting the portfolio, and liquidity risk.

*1: A transaction in which profits are made by using the price difference between the financial instruments to be bought and sold
*2: A property that approaches the average value over time

Reference: Hitachi Group, Ltd. "Technology for Applying CMOS Annealing Suitable for Combinatorial Optimization Processing to High-Speed Financial Instruments Trading and Development of" (https://www.hitachi.co.jp/rd/news/topics/2021/2110_cmos.html), Mitsui https://www.mki.co.jp/knowledge/column128.html Information Corporation How will quantum computers change finance?

*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

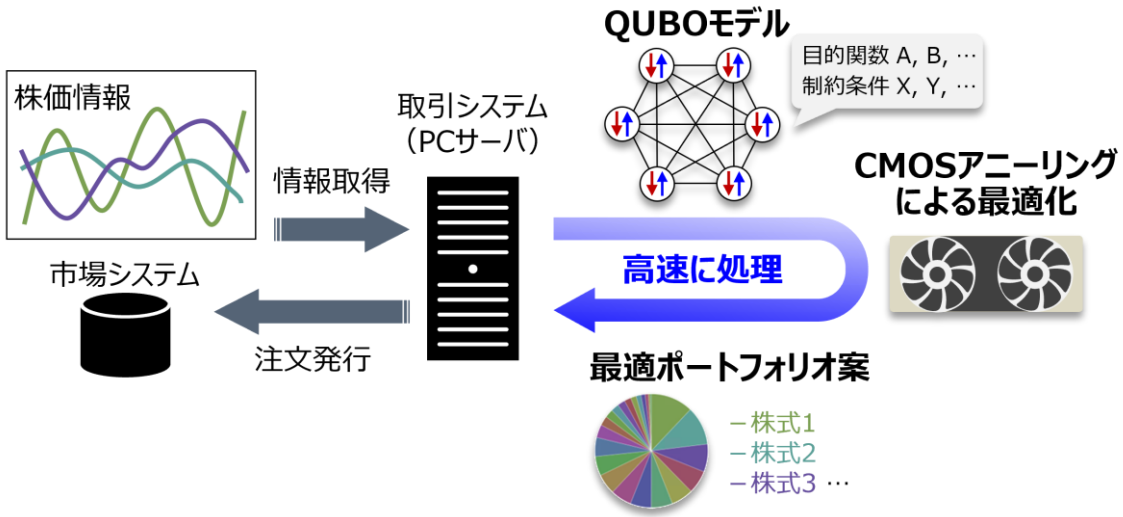
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Problem setting as a quantum computer

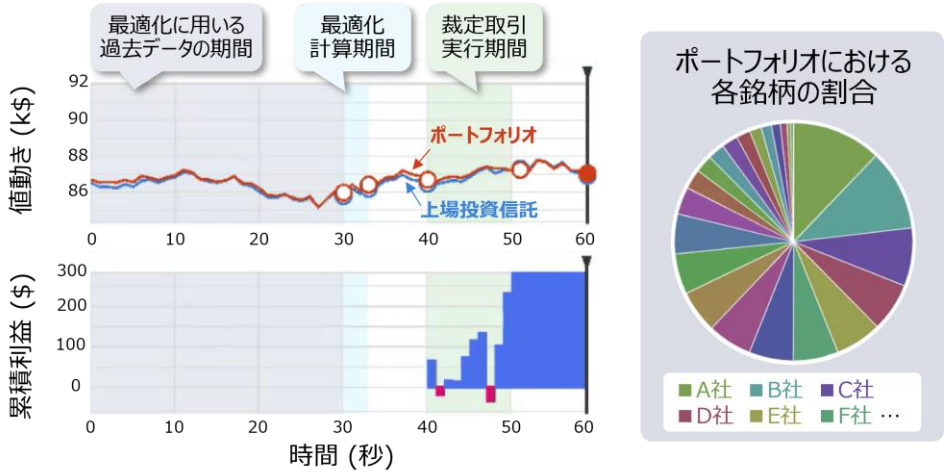
- **By writing down the matters to be considered in arbitrage as objective functions and constraints in QUBO form**, the problem of finding the optimal portfolio of financial instruments with mean reversion property is formulated.
  - ✓ Rules for buying and selling such as transaction fees and positions for each stock in the portfolio
  - ✓ Indicators: Liquidity risk, etc.
- The machine leverages **Hitachi CMOS annealing**

Expected business benefits

- **In CMOS annealing, as long as the number of variables is unchanged, the computation time does not change, and arbitrage trading is both practical and fast.**
- An assessment using historical transaction data was conducted to verify the effectiveness of the indicators and constraints considered in arbitrage
- By performing a valuation using approximately 100 stocks while switching historical data, we were able to confirm that CMOS annealing **can construct an optimal portfolio within a few seconds and use it to make arbitrage returns.**



High-Speed Financial Instruments Trading System Using Cmos Annealing



Screen of transaction simulation results in conjunction with CMOS annealing

Reference: Hitachi Group "Development of CMOS annealing technology suitable for combinatorial optimization processing for high-speed financial instruments trading" (https://www.hitachi.co.jp/rd/news/topics/2021/2110_cmos.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

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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".