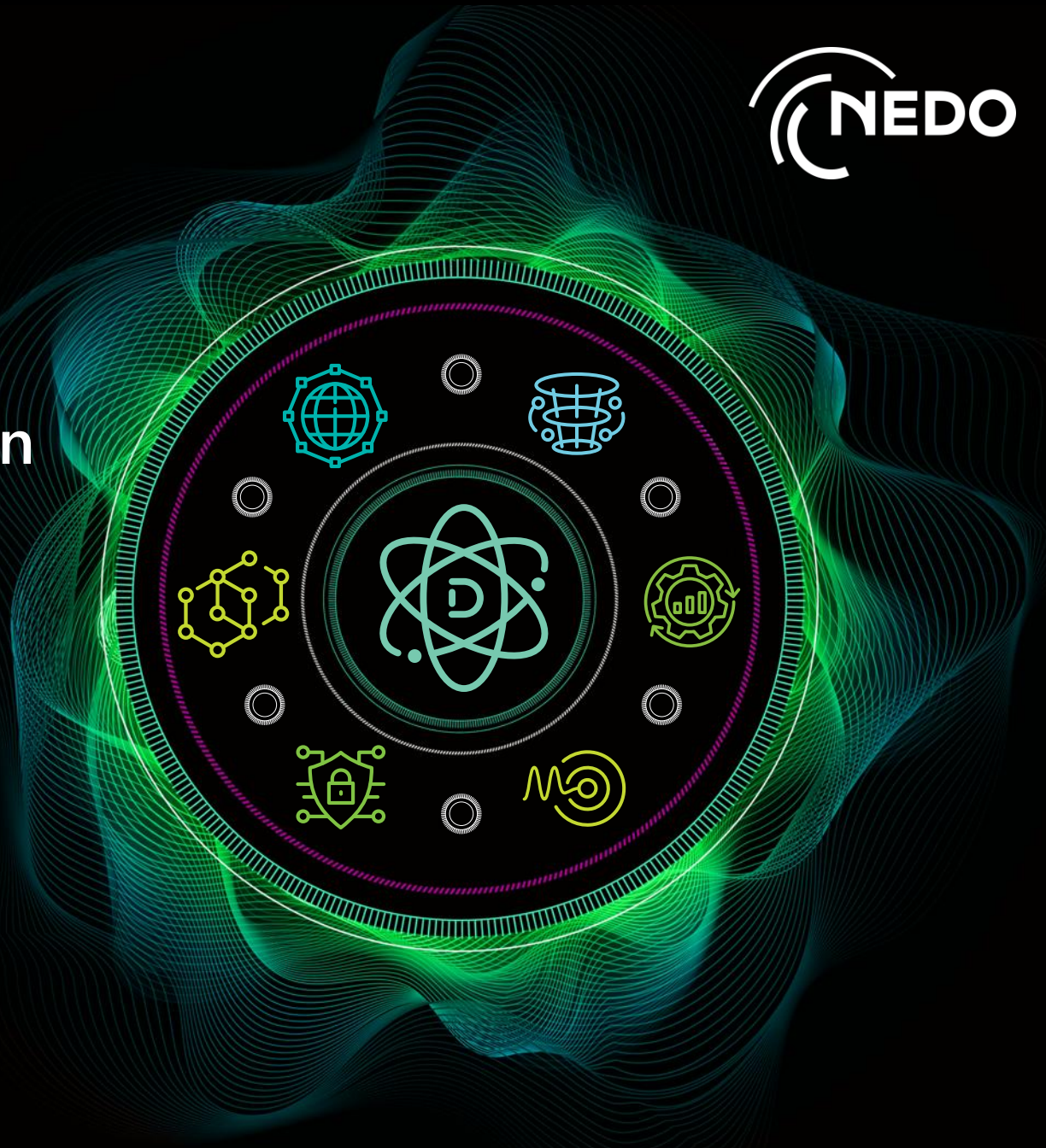
Quantum Computing Use Cases

Optimization of Power Distribution Demand Planning

Chubu Electric Power



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Energy
Process	power generation
Method	combinatorial optimization
Category	Ising*

Background

- The distribution division of Chubu Electric Power Power Power Grid is engaged in **construction and maintenance of utility poles and wires to deliver electricity to customers' homes.**
- In the daily maintenance and operation work, the personnel in charge of operations at each sales office apply for the supply, suspension, and expansion of electricity from customers in their area, and when they receive information about a power outage due to a failure, they **go to the site to perform construction, inspection, and restoration work as necessary.**
- In the work plan (demand response plan), **the operation manager of the sales office prepares the schedule considering the daily work and the number of personnel.**

Issues and motivation to be solved

- The combination of visit order and job allocation is not always obvious, but it would be useful to automatically optimize **manual** scheduling
- When an unexpected event occurs during work (an emergency event leading to a power failure or an electric shock), **it is necessary to reschedule according to the situation** based on the work situation at each site and the position information of each person in charge of work.
- Since the number of possible combinations of work plans is enormous when constraints such as the order of patrolling the customer's house, the work skill of the person in charge of the work, the time period when the work can be done, and the travel time are taken into account, **in this demonstration, the effectiveness of Fujitsu's digital annealer is verified against an enormous number of combinatorial optimization problems**

Problem setting as a quantum computer

- Chubu Electric Power Power Power Grid **automatically created a work plan under the following objective function and constraint conditions using a part of the daily work results at 1 sales office (40 works extracted from electronic data) as test data**
  - ✓ As an objective function, only **reduction of business hours** was targeted.
  - ✓ **Limits are as follows:**
    - Each task is performed only once
    - Each worker cannot perform other tasks from start to completion
    - Each worker cannot perform other tasks while on the move
    - Some tasks have time to run
    - The first task is defined as coming to work, and each worker starts work at the specified time.
    - The last task is defined as returning to the office, and each worker returns to the office at some time and cannot execute the task thereafter.
- In addition, the following **incidental conditions of actual operation** are taken into account:
  - ✓ All SEs return to the office at 12:00 and have a break until 13:00
  - ✓ The travel time by car varies depending on the time of day.
  - ✓ Unexpected work may occur. Reschedule the demand plan from that point when it occurs
- The machine **utilizes Fujitsu digital annealer**

Reference: Fujitsu Limited, "Optimization of Power Distribution Demand Planning by Digital Annealer" (https://www.fujitsu.com/jp/about/resources/publications/technicalreview/topics/article010.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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Expected business benefits

- In the optimization verification of the demand response plan, **we compared the digital annealer with the classical commercial solver (Gurobi) and showed the effectiveness of the digital annealer in terms of solution time and work completion time** using test data.
- Regarding the solution time, **digital annealer is dominant in all patterns** in patterns (1), (2), (3), and (4) (refer to the figure on the right)
  - ✓ In pattern (1), **digital annealer** found a 17: 40 business completion solution, **whereas Gurobi did not find a valid optimal solution over time.**
  - ✓ Even in the case of pattern (3), the digital annealer was able to solve the problem in about 1.5 times more time than pattern (2), and **it was faster than Gurobi**.
- The effectiveness of the digital annealer was confirmed with regard to the work completion time.
  - ✓ With more than 5 workers, all jobs were completed at 17:00.
  - ✓ Although direct comparison with human system performance is not possible, **we confirmed the feasibility of efficient scheduling by digital annealer** and it was possible
    (There was a paper slip job that could not be reflected in the test data, and the work completion time by human systems was not measured under the same conditions.)

パターン	検証結果		
	業務完了時刻	デジタルアニーラ 求解時間（秒）	Gurobi Optimizer 求解時間（秒）
① 作業担当者数：4人	17:40	857	— （17:40の解得られず）
② 作業担当者数：5人	17:00	35	120
③ 作業担当者数：5人＋突発的な作業	17:00	35＋16※	120＋19※
④ 作業担当者数：6人	17:00	5	12

※＋の後の数値は，突発的な作業発生時の再計算に要した時間。

Reference: Fujitsu Limited, "Optimization of Power Distribution Demand Planning by Digital Annealer" (https://www.fujitsu.com/jp/about/resources/publications/technicalreview/topics/article010.html)
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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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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”.