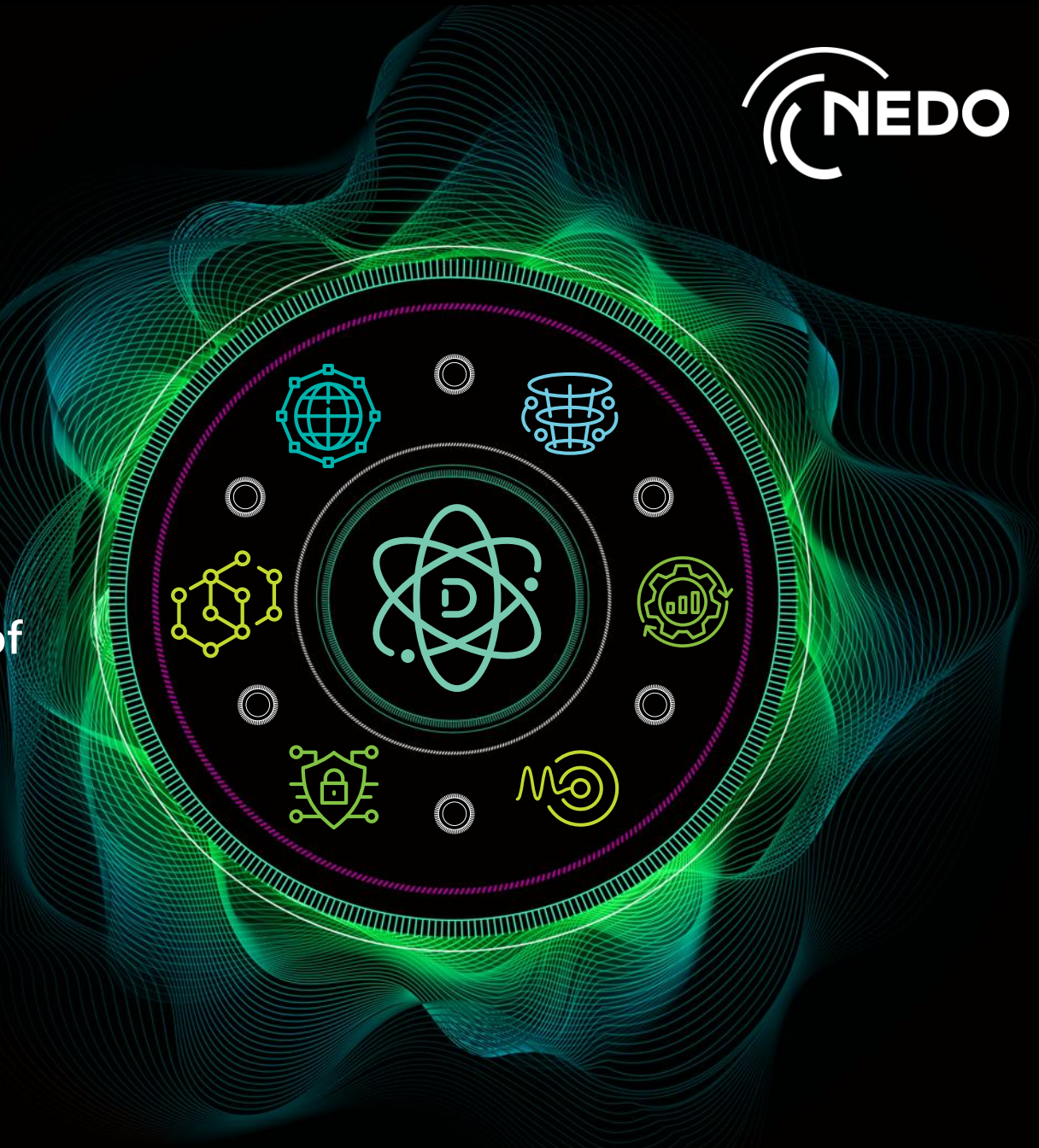
Quantum Computing Use Cases

Optimization of Traffic Signals in Large Cities

TOYOTA CENTRAL R&D LABS. / The University of Tokyo



New Energy and Industrial Technology Development Organization (NEDO)

TOYOTA CENTRAL R&D LABS. / The University of Tokyo: Optimization of Traffic Signals in Large Cities [2021/02] 1/2

Validation

Industry	Transportation
Means	Human Movement _ Land Transport
Method	combinatorial optimization
Category	Ising*

Background

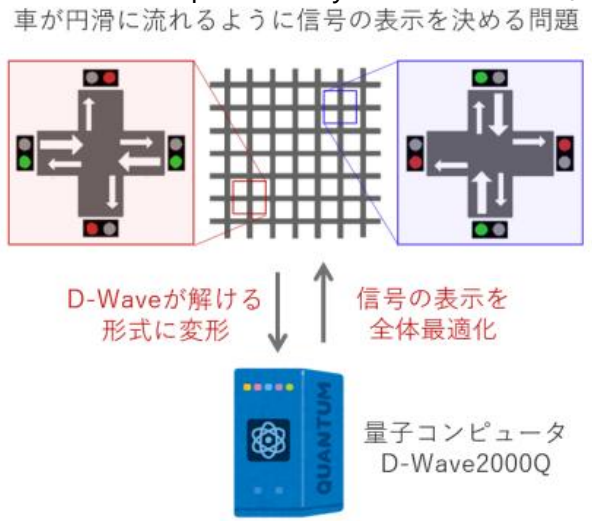
- **Adaptive control of traffic signals according to traffic conditions is an important issue** to alleviate congestion in large cities.
- Traffic light control in large cities is a complex problem, and optimizing the overall traffic flow to minimize the likelihood of traffic congestion **is almost impossible with traditional Methods.**
- Various workarounds have been proposed, most of which are **local control methods** that divide the network into smaller pieces and control each signal using only information about the neighborhood of the intersection

Issues and motivation to be solved

- Traditional traffic light control only considers local information around each intersection, **not a way to simultaneously optimize traffic conditions for the entire city.**
- The Toyota Central Research Institute and the University of Tokyo jointly **planned to develop a method to control traffic signals in large cities in consideration of traffic conditions throughout the city.**

Problem setting as a quantum computer

- Developed a method to solve the **traffic signal optimization problem** considering the traffic conditions of the entire city using quantum technology
  - ✓ **An optimization problem is solved to determine the state of traffic lights at each intersection so as to minimize the traffic flow bias.**
- **Road networks are vertically and horizontally orthogonal grids,** and **traffic on the road network is modeled by a group of vehicles turning right and left with a certain probability.**
- A numerical experiment was conducted to simultaneously control traffic signals in a city consisting of 50×50 roads, and **the value of the evaluation function representing the magnitude of traffic flow deviation was compared with the conventional method**
- The machine is powered by **D-Wave 2000 Q,** D-wave quantum annealing.



Conceptual diagram of traffic flow control method

Reference: The University of Tokyo, "Successful Development of Optimization Technology for Controlling Large Traffic Signals Using Quantum Computers" (https://www.tytlabs.co.jp/cms/news/pdf/press/20210210_%20press.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.

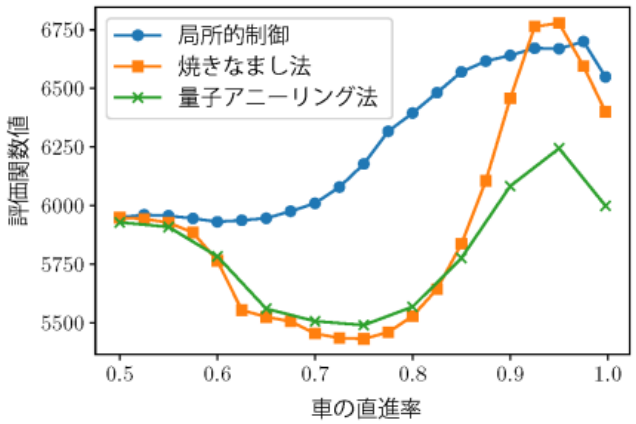
TOYOTA CENTRAL R&D LABS. / The University of Tokyo: Optimization of Traffic Signals in Large Cities [2021/02] 2/2

Validation

Industry	Transportation
Means	Human Movement _ Land Transport
Method	combinatorial optimization
Category	Ising*

Expected business benefits

- As a result of comparing a conventional method with a method using quantum technology, we were able to **improve the ease of traffic flow by approximately 10%**
- It was also found that **the quantum annealing machine is faster and more efficient than the annealing method,** although the conventional optimization method, the annealing method, can be used.
- This result **is expected as a basic technology to control traffic lights in real cities at high speed and efficiently according to the traffic conditions of the whole city.**



Comparison of evaluation function values representing the magnitude of traffic flow deviation
(Small value of evaluation function = smooth traffic flow)

Reference: The University of Tokyo, "Successful Development of Optimization Technology for Controlling Large Traffic Signals Using Quantum Computers" (https://www.tytlabs.co.jp/cms/news/pdf/press/20210210_%20press.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.

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".