Quantum Annealing-Assisted Next Generation HPC Infrastructure
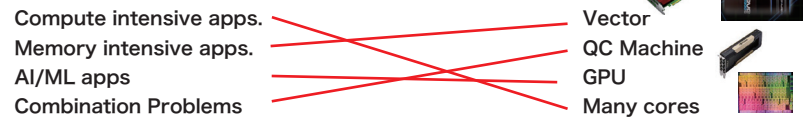
Background

TOWARD SOCIETY 5.0

Higher expectations for the next-generation application development that combines computational science and data science toward the realization of Society 5.0.

Rapid evolution of computational and data sciences
- by leading edged HPC systems
- by the deployment of IoT technologies

WHAT IS SOCIETY 5.0?

New society "Society 5.0"

Society 1.0 Hunting & gathering

Society 2.0 Agricultural

Society 4.0 Information

Society 3.0 Industrial

A human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space.

THE END OF MOORE'S LAW

Although the performance of HPC system might be increased by enhancing current technologies (vector/SIMD processing, many-core, high-bandwidth memory, etc.). It is difficult for a single system to efficiently execute a wide range of applications. We have to find **the right system for the right apps**.

- Compute intensive apps.
- Memory intensive apps.
- AI/ML apps
- Combination Problems

- Vector
- QC Machine
- GPU
- Many cores

To efficiently execute diverse applications in the society 5.0 era, we need to properly combine various systems depending on the characteristics of the application!

Project Overview

Innovative applications in the fields of computational and data sciences, and their fusion

QA-Assisted HPC Infrastructure

- Deductive Processing (for computational science)
- Inductive Processing (for data science)

Coupling

- X86-assisted vector computing platform
- QA-based AI-ML platform
- QA platform

- SX-Aurora TSUBASA and its successors
- D-wave machines

Provides transparent accesses to not only classical HPC resources but also Quantum Computing one in a unified fashion.

Quantum Computer

AN IDEAL SOLVER FOR COMBINATIONAL PROBLEMS

Quantum computers for quantum annealing are commercialized by the D-wave systems, and their applications are developed world-widely. The quantum annealing is a metaheuristic for finding the global minimum of a given objective function over a given set of candidate solutions (candidate states), by a process using quantum fluctuations.
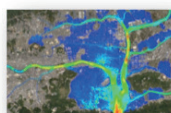
Optimum solution

Simultaneous Search to reach optimal one by Quantum Fluctuation
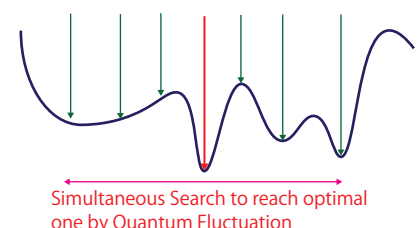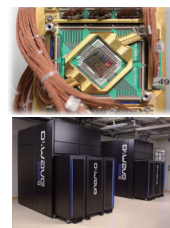
\# Tohoku University has established an interdisciplinary priority research institute, named Q-HPC, for Quantum Computing-Accelerated HPC in 2018

Target Applications

QA-ENHANCED REAL-TIME TSUNAMI INUNDATION FORECASTING AND OPTIMAL EVACUATION PLANNING

- Fault Estimation with MCMC
- Tsunami Inundation Simulation
- Optimal Evacuation Planning with Quantum Annealing

Integrated Programming Framework

- D-wave machines
- SX-Aurora TSUBASA Vector Host (Xeon)
- SX-Aurora TSUBASA Vector Engine

DIGITAL TWIN NUMERICAL TURBINE

SX-Aurora TSUBASA

Simulations based on many Scenarios

Simulation Database

Numeric Turbine as Digital Twin

Estimation of internal situation of real systems

AI/Machine Learning

Real System

Observed Data from the Real-system