Water Sustainability in the Panama Canal

Blaise Pasqal Quantum Challenge

Who we are ?

Quantum Beech Hill

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Introduction

The Panama Canal System

The Panama Canal

- Vital maritime route connecting the **Atlantic** and **Pacific** Oceans

- Operates on a system of **locks** using **freshwater** to cross the canal

Panama Canal Water Usage

Miraflores Lake Water Levels

- **Gatún Lake** is the primary source of **drinking water** for Panama City

- A ship uses **200 million litres** of freshwater per crossing

- Climate change has caused an **increase in droughts**

Cross Filling at Panamax Locks

Details

Parallel lanes which utilize **subterranean culverts** to transfer water
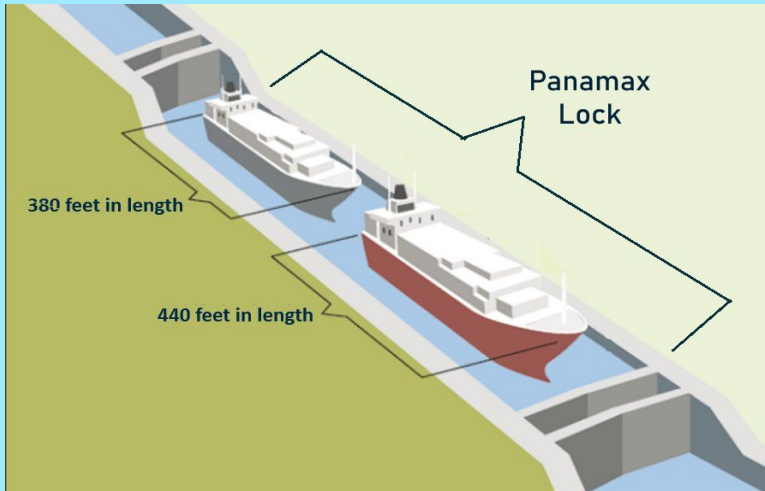

Trade-Off

- Causes Delays in Vessel Movement

- Saves 6 crossings of water per day

- Requires lots of coordination and scheduling

Tandem Lockage

Details

Simultaneously **transits two ships** in a single lock chamber

380 feet in length

440 feet in length

Panamax Lock

Trade-Off

- Constrained to ships whose combined length does not exceed **lock capacity**

- **Reduces** number of required lockages

- Requires complex **scheduling**

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02

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Theory

QUBO & Ising problems,
and adiabatic computing

QUBO and Ising Problems

$$f_Q(x) = x^T Q x = \sum_{i=1}^{n} \sum_{j=1}^{n} Q_{ij} x_i x_j \qquad H = \sum_{i,i'} J_{i,i'} s_i s_{i'} + \sum_{i} h_i s_i$$

A **QUBO** problem finds a binary vector **x*** that is minimal with respect to the function.

It transfers to an **Ising** problem by converting binary variables to spin variables.

This allows for the use of **adiabatic computing**

Adiabatic Quantum Computing (AQC)

AQC applies the **adiabatic theorem** to find the **optimal solution** of a problem

**Optimisation
Problem** → **Energy
Landscape**

The problem is mapped onto an energy landscape
where the **ground state** is the optimal solution

Neutral Atoms

- Ground state $|0\rangle$ and highly excited Rydberg state $|1\rangle$

- Laser pulse sequence applied to an array of atoms.

- Pulse drives system towards final quantum state

- Global measurement via fluorescence imaging.

03

Implementation

How to apply QUBO for optimisation

Implementing QUBO

Define binary decision variable
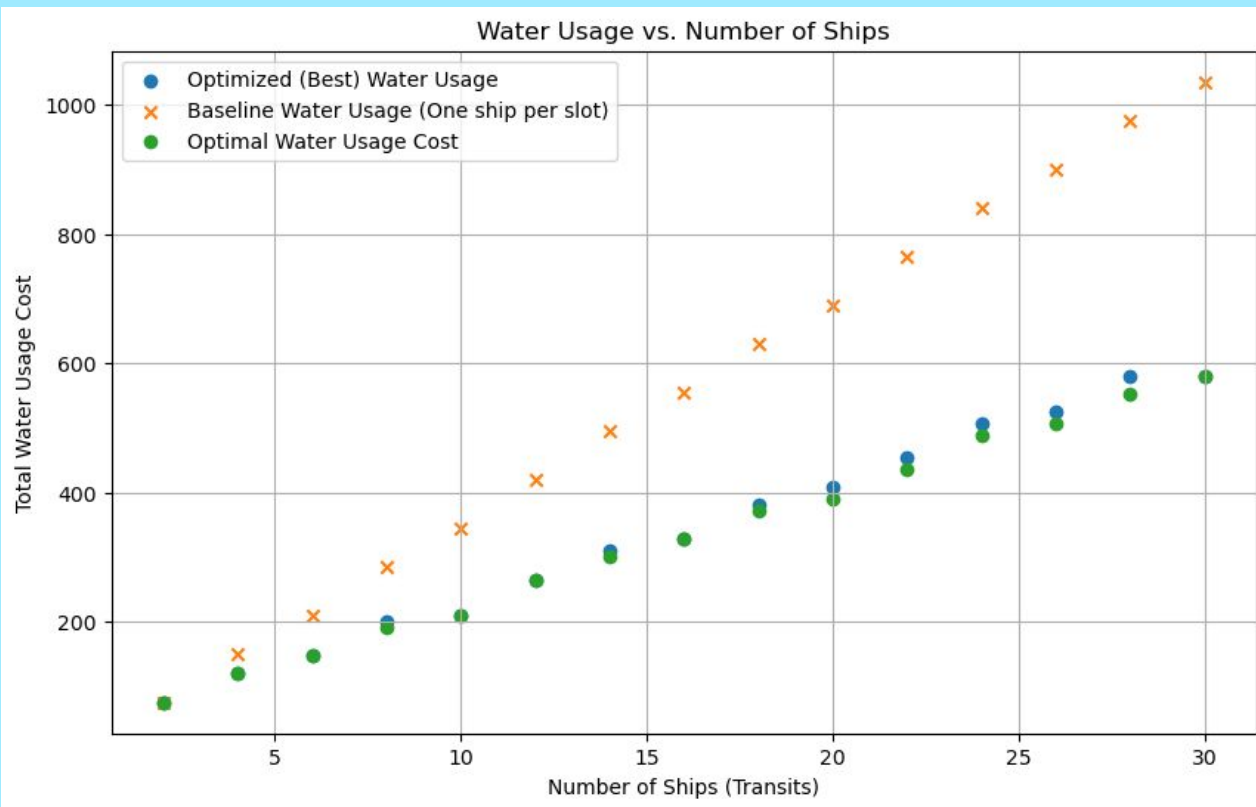
Define penalty coefficients

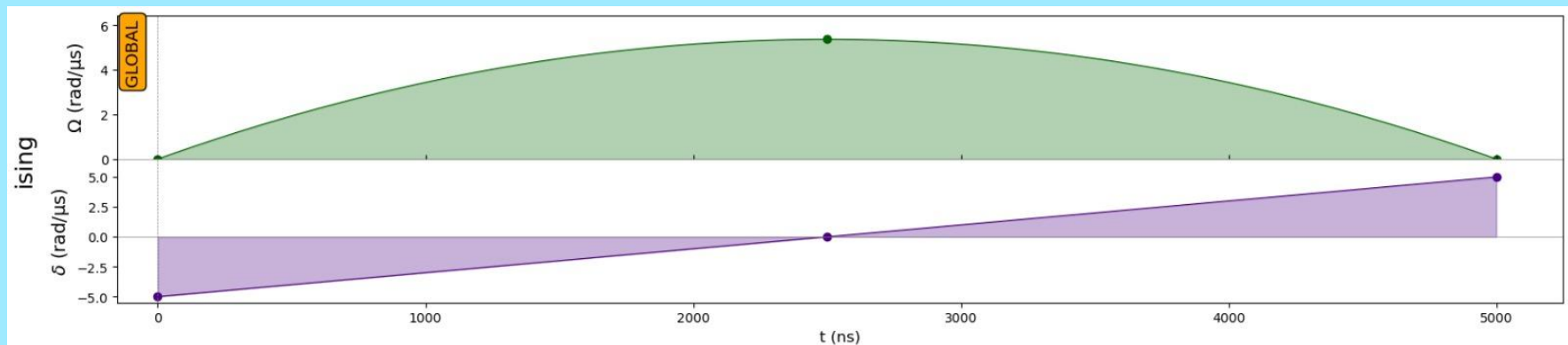Define constraints

04

Results

Optimising the Panama Schedule

Current vs Timetabled Operations

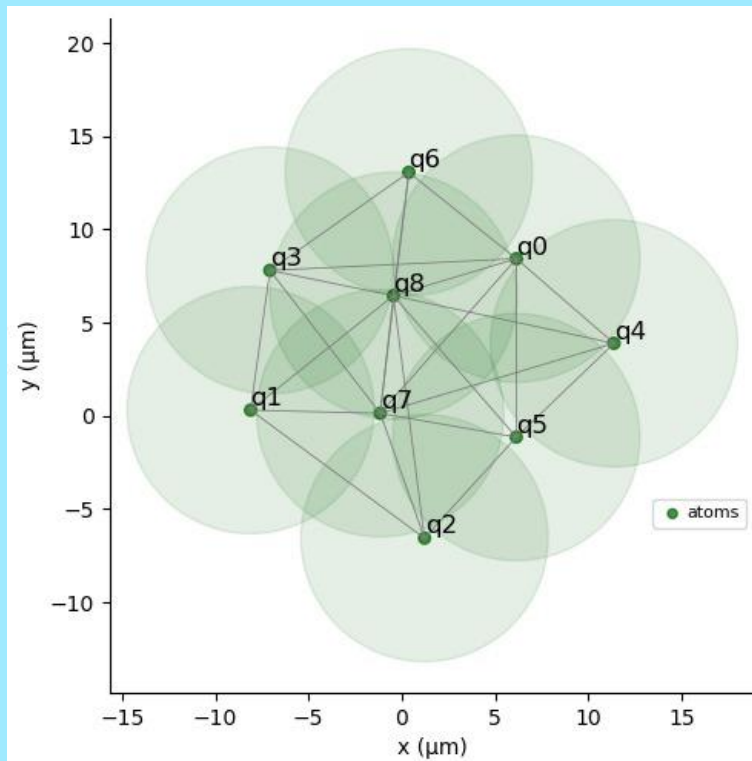Water Usage vs. Number of Ships

4 Qubit Pulse

4 Qubit Embedding

Reduction in CO2 emissions

Key KPIs

Increase in ship transits during droughts

Reduction in runtimes

Thanks!

Optimizing Ship Scheduling in The Panama Canal

Tackles **SDG Sustainable Industries and Transport** challenge by aiming to optimise ship scheduling in the Panama Canal.

Tackles current issues such as **freshwater scarcity** and reduced ship transits during droughts.

QUBO used to formulate optimisation problem with quantum annealing being explored via **neutral atoms**.

Explores **AI Reinforcement Learning** to dynamically adjust QUBO parameters

Simulated annealing proof of concept shows a **40% reduction** in freshwater usage.

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