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Quantum Credit Risk Analysis

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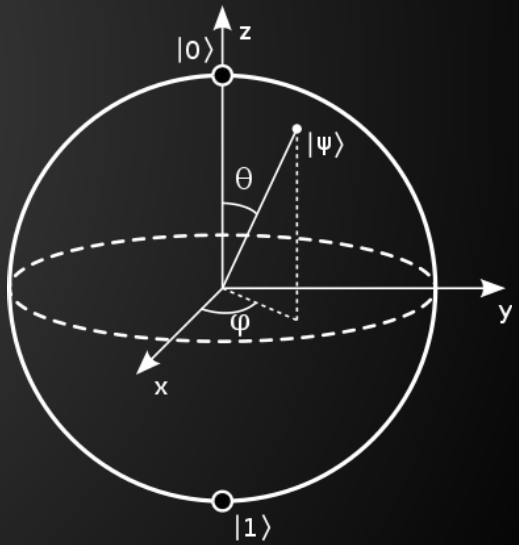

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Introduction

We introduce and describe an iterative algorithm of the Quantum Amplitude Estimation (QAE), known as the Iterative QAE (IQAE). This is used for estimating credit risk that outperforms Monte Carlo (MC) simulations on traditional computers. We calculate the Economic Capital (EC) required, which is the difference between the Value at Risk (VaR) and the predicted Loss Distribution Value (LDV). The calculation of the EC required is of interest, because it quantifies the amount of capital required to be solvent at a certain level of confidence, making it an important risk statistic. We implement this problem for a realistic LDV and analyze its scaling to a realistic problem size. We present estimates of the overall number of necessary qubits, the expected circuit depth, and how this translates into an expected runtime on future fault-tolerant quantum hardware under acceptable assumptions.

Problem

Description, Definition, and Parameters

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Problem Description

We can describe the problem as the simple default risk, that a lender takes on in the chance that a borrower will be unable to make the required payments on their debt obligation. Whenever a lender extends credit to a borrower, there is a chance that the loan amount will not be paid back. The measurement that looks at this probability is the default risk.

The default risk applies to both individuals who borrow money, and companies that issue bonds and due to financial constraints, are not able to make interest payments on those bonds. Whenever a lender extends credit, calculating the default risk of a borrower is crucial as part of its risk management strategy. Whenever an investor is evaluating an investment, determining the financial health

Problem Definition

We analyze the credit risk of a portfolio of

k

 assets. The default probability of every asset

k

 follows a Gaussian Conditional Independence model, i.e., given a value

z

 sampled from a latent random variable

Z

Problem Parameters

The introduced quantum algorithm for estimating the credit at risk, Iterative Quantum Amplitude Estimation (IQAE), does not rely on Quantum Phase Estimation (QPE), and is based on Grover's Algorithm, reducing the required number of qubits and gates needed. We provide a rigorous analysis of IQAE and prove that it achieves a quadratic speedup up to a double-logarithmic factor compared to classical Monte Carlo simulation. We test the algorithm in a two (2) assets portfolio.

Methods

MC, QAE, Grover's Algorithm, QFT, IQAE

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Methods

In order to further demonstrate the capabilities of IQAE, we used classical simulations of quantum hardware to show that it can also be applied to speed up the computation of risk measures of a simple two-asset (2) portfolio. Nevertheless, we notice that to achieve quantum advantage in a real-world scenario, the quality of current quantum hardware needs to be improved. Errors arising from the limited coherence time and cross-talk when measuring the states of qubits need to be substantially suppressed. Furthermore, because of this reason, the number of qubits must be increased.

We went on to show how IQAE can be applied to the task of pricing an asset using real quantum hardware. However, the current pace of advances in research directed at improving both quantum hardware and quantum algorithms makes us optimistic that real quantum advantage in risk analysis can be achieved in the

Classical Method: Monte Carlo (MC)

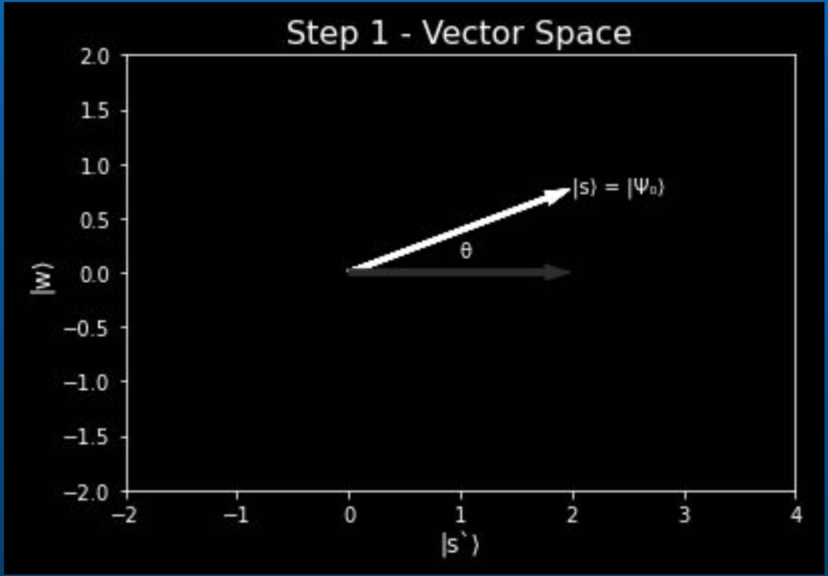
The Monte Carlo (MC) method is a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results. The underlying concept is to use randomness to solve problems that might be deterministic in principle. MC predicts a set of outcomes based on an estimated range of values versus a set of fixed input values.

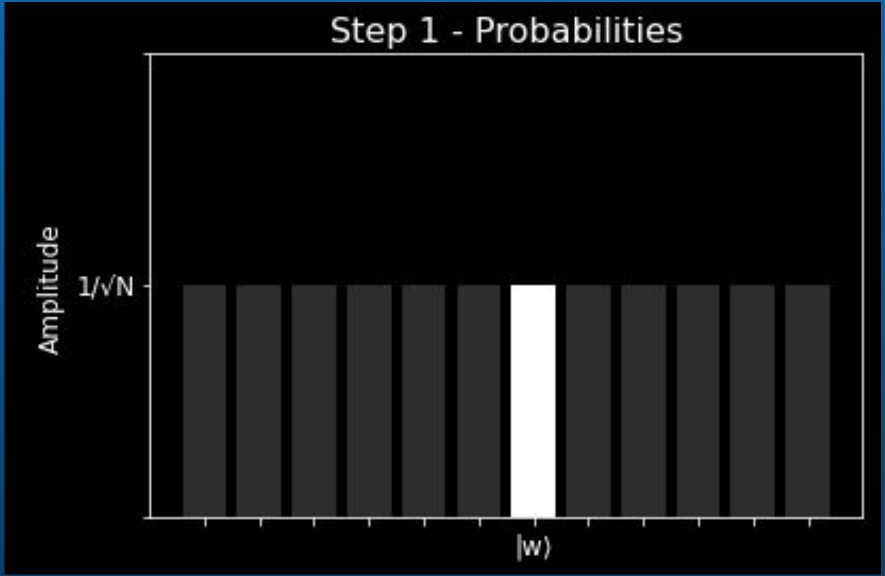
In other words, a MC simulation builds a model of possible results by leveraging a probability distribution, such as a uniform or normal distribution, for any variable that has inherent uncertainty. It recalculates the results over and over, each time using a different set of random numbers between the minimum and maximum values. In a typical MC experiment, this exercise can be repeated thousands of

Quantum Amplitude Estimation (QAE)

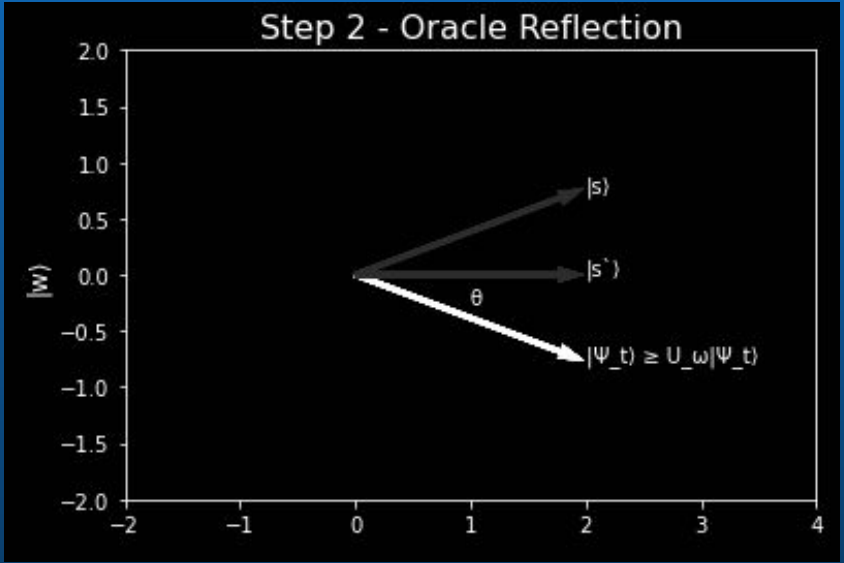
Grover’s Algorithm

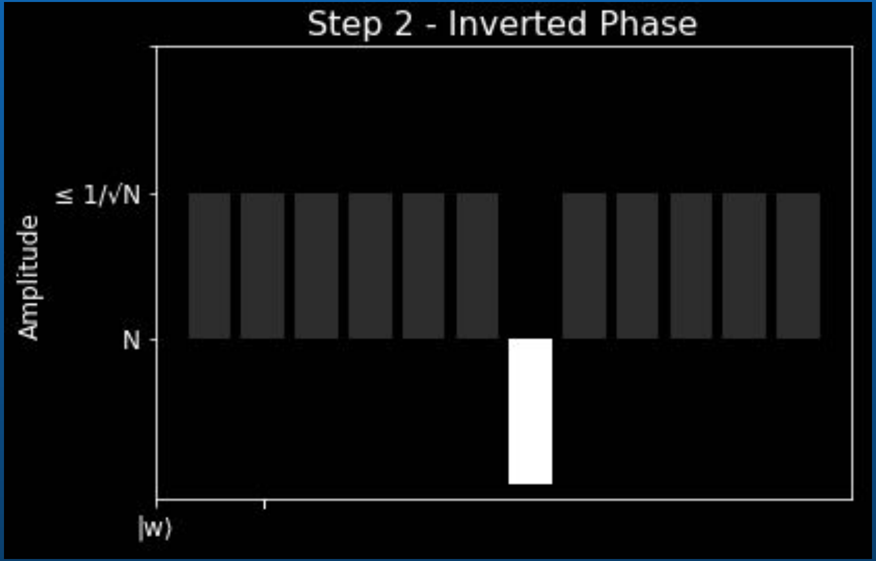
Step 1 - Initialize System



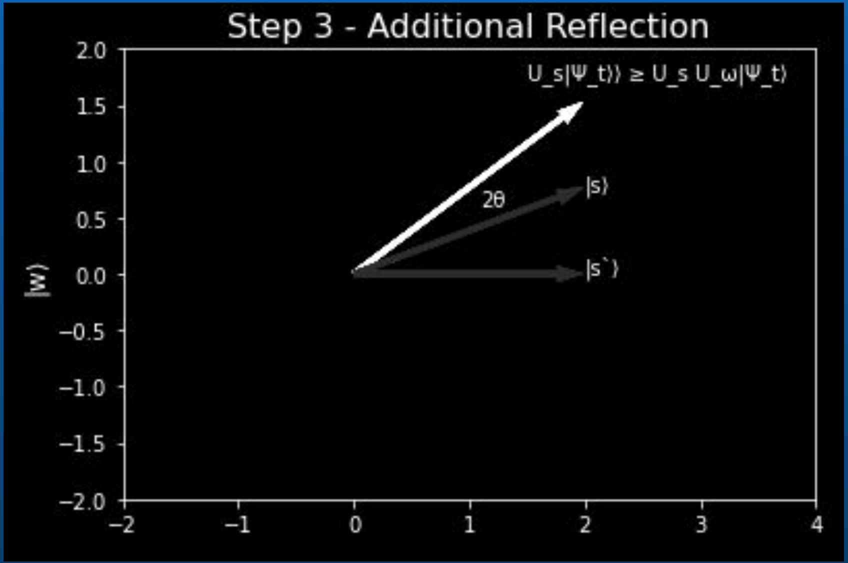


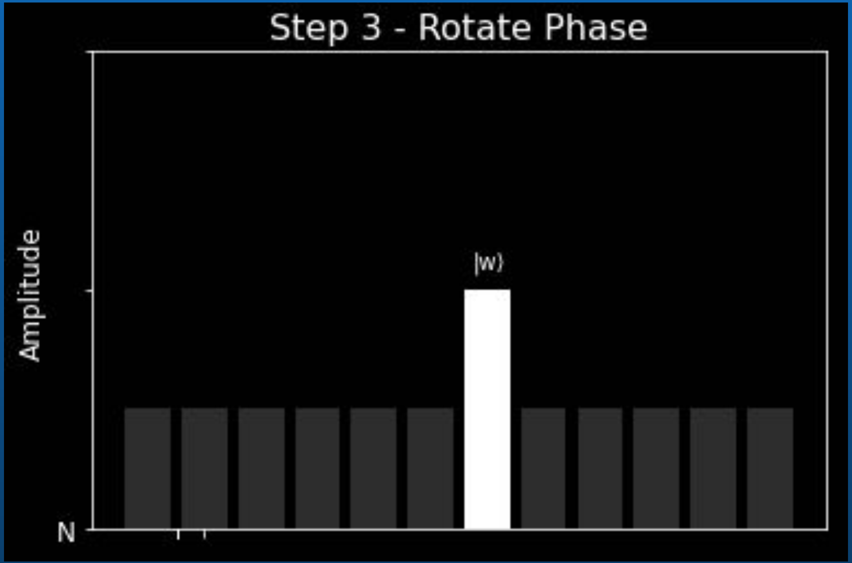
Step 2 - Oracle Reflection and Inverted Phase



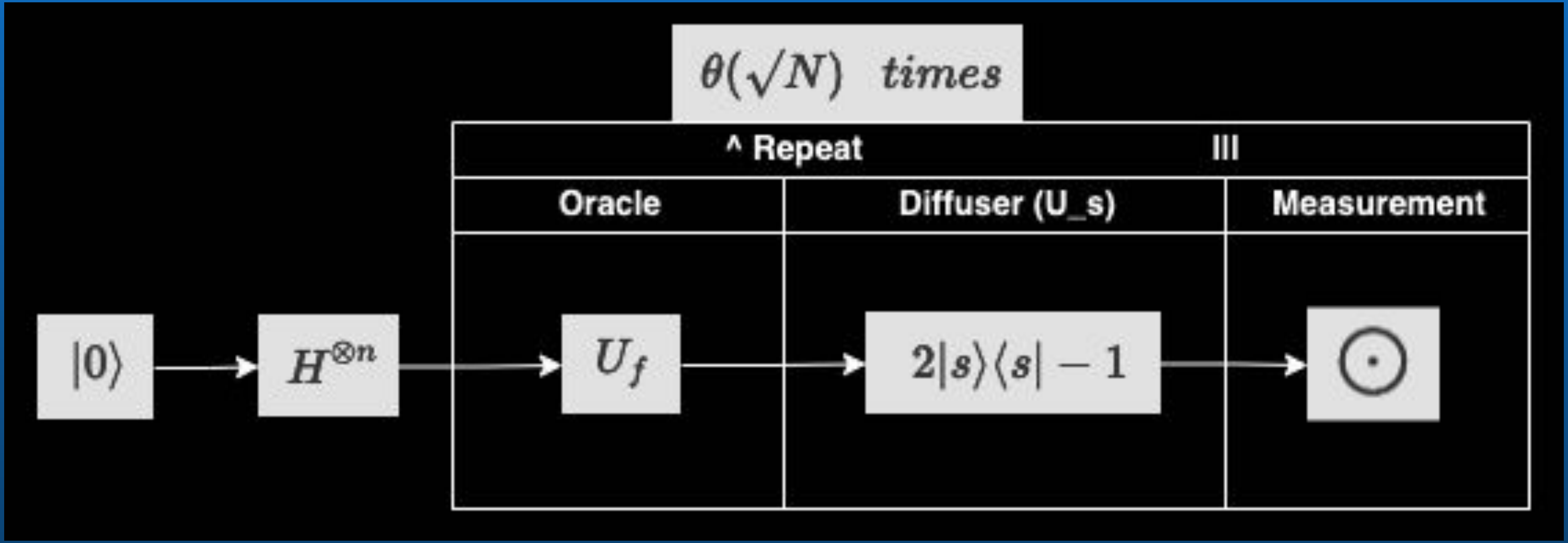


Step 3 - Additional Reflection and Rotate Phase





Grover's Algorithm Diagram

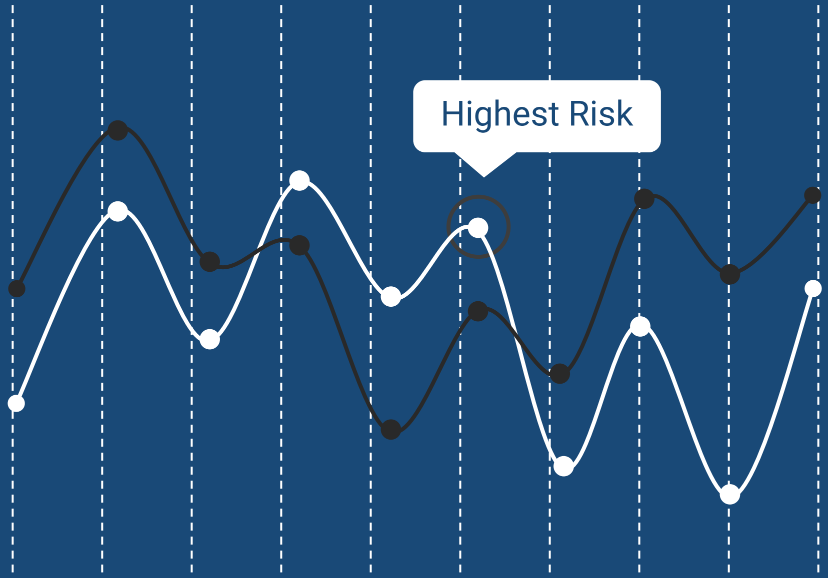


Quantum Fourier Transform (QFT)

Iterative QAE (IQAE)

Results

UM, EL, VaR, CVaR



Uncertainty Model (UM)

Expected Loss (EL)

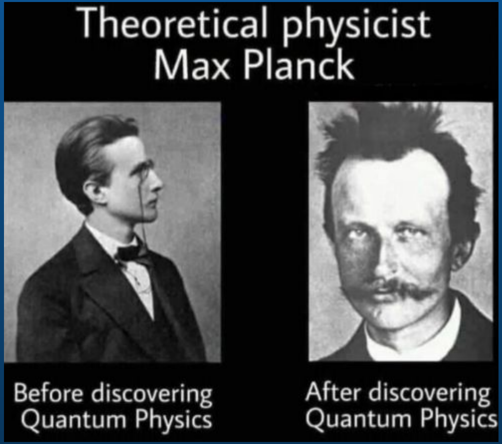
Value at Risk (VaR)

Conditional Value at Risk (CVaR)

Conclusions

<Conclusions goes here>

Thank you for your time



The problem

Company

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Context

Ut enim ad minim veniam, quis nostrud exercitation

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Problem statement

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Challenges deep-dive

Challenge 1

Expand audience

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Challenge 2

Up 30-day actives

Ut enim ad minim veniam, quis nostrud exercitation

- Duis aute irure dolor in reprehenderit in voluptate velit

Challenge 3

Increase conversion

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The team


CEO
Wendy Writer
Dir. of Sales
Ronny Reader
Dir. of Engineering
Abby Author
North America Lead
Perry Presenter
Asia Lead
Vinny Viewer
Europe Lead
Molly Maker
Front End Lead
Casey Creator
Back End Lead
Berry Books