

QUANTUM ALGORITHM DESIGN FOR FINANCE

THE PROMISE OF QUANTUM COMPUTING FOR FINANCIAL APPLICATIONS

Financial models and instruments are increasing in complexity. Forward-looking organizations are turning to quantum computing as a promising source of competitive advantage. Why is that the case?

By deploying algorithms that are adapted to the unique capabilities of quantum computers, financial professionals gain key advantages:

- They can complete sophisticated calculations in a fraction of the time it would take to complete them on a classical computer.
- They can run financial models that were too complex to execute within a reasonable timeframe on a classical computer.

The upside is undeniable: quantum computers will allow organizations to react faster to changing market conditions, as well as to analyze financial models with greater precision and certainty.

Finance algorithms for quantum computers fall into three main categories:

1. **Optimizations.** Algorithms that optimize portfolios, or find arbitrage opportunities are examples of multivariate problems where quantum computers shine because of their ability to analyze many scenarios simultaneously. Some of these problems are Quadratic Unconstrained Binary Optimization (QUBO) problems that are often implemented via VQE/QAOA quantum algorithms
2. **Monte Carlo simulations.** These are stochastic models that are executed multiple times to estimate the expected value of options, analyze risk, etc. The complexity of the models and the target certainty levels often lead to colossal computational requirements on classical computers. Quantum Amplitude Estimation (QAE) is a common quantum algorithm that helps emulate Monte Carlo methods efficiently and naturally on a quantum computer
3. **Quantum machine learning.** This can be used for credit scoring, principal component analysis, and more.

WHAT IS NEEDED FROM QUANTUM SOFTWARE PLATFORMS?

Corporations are turning to quantum computing to help, To facilitate rapid, effective and efficient work, quantum software platforms need to offer several capabilities:

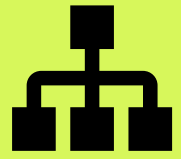
- **Build the Hermitian matrix (Hamiltonian) that characterizes the cost function to be minimized**
- **Execute VQE, QAOA, QAE, and other quantum algorithms**
- **Estimate the required resources from a quantum computer to determine the feasibility on a given hardware platform**
- **Make it easy to port the algorithm from one machine to another as needed**

One wishes to have these capabilities available in a flexible platform that allows rapid exploration of alternatives, takes into account the desired algorithmic and hardware constraints, and allows the financial analyst to focus more on finance and less on the intricate details of qubits and quantum gates.

THE CLASSIQ QUANTUM ALGORITHM DESIGN PLATFORM

By working at a high level, not the gate level, Classiq’s technology helps quantum teams model, synthesize, and analyze quantum circuits that were impossible to create otherwise. The platform converts meaningful, high-level specifications into optimal quantum designs, overcoming the complexities of working at the gate level and the limitations of existing building blocks.


The Classiq platform offers three pillars of functionality for teams focused on financial analysis:

 **MODEL**


High-level modeling at the functional level. Pre-defined building blocks include:

- **Amplitude estimation**
- **State and ansatz preparation**
- **Quantum arithmetic**
- **Combinatorial optimization**



Includes the ability to create quantum/classic hybrids.

 **ANALYZE**

- Estimate the required resources
- Define the desired synthesis constraints
- Quickly explore tradeoffs between number of qubits, circuit depth, levels of entanglement, available gates and much more
- Determine the optimal hardware choice for your algorithm

 **SYNTHESIZE**

- Convert functional definitions into gate-level designs
- Perform system-wide and hardware-specific optimizations
- Output to Qiskit, Q#, Cirq and other gate-level compilers
- Work with all leading quantum cloud providers and any universal gate-based hardware



Real-world financial models are complex, and creating quantum circuits that describe them cannot be done at the gate level. Classiq’s synthesis platform makes it possible to design, analyze, execute and optimize such circuits.

Amir Naveh, Head of Algorithms

