REPLY

QUBO - QUADRATIC UNCONSTRAINED BINARY OPTIMIZATION

THE QUANTUM INSPIRED ALGORITHM FOR COLLATERAL OPTIMIZATION

Among its current Quantum Computing activities, Reply has started a project in collaboration with the Investment Banking Division of one of Italy's main players in the financial arena. The project focuses on risks and treasury liquidity management, from context-defining indicators to the optimization of collateral credit.

REPLY specialises in the design and implementation of solutions based on new communication channels and digital media. As a network of highly specialised companies, Reply defines and develops business models enabled by the new models of AI, big data, cloud computing, digital media and the internet of things. Reply delivers consulting, system integration and digital services to organisations across the telecom and media; industry and services; banking and insurance; and public sectors.

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FINANCE IN THE ERA OF QUANTUM COMPUTING

The globalization of financial markets, the exponential increase in the regulations and volumes of data required by Supervisory Authorities, and the constant increase in capital requirements means organisations in the Financial Services industry operate in a highly complex trading conditions, with significant operational and economic consequences.

Technology plays a crucial role in making processes and checks more efficient and in increasing response speed. It also has a powerful structural impact on financial and credit institutions. Many industry leaders have started technology experimentation programs aimed to keep them one step ahead of the competition in different fields, such as **portfolio optimization, payment systems, fraud detection and high-frequency trading**.

Financial services companies, who are aware that Quantum Supremacy will give rise to a new era in information technology thanks to unprecedented computing power, are increasingly investing in **Quantum Computing**. By replacing traditional sequential processing with parallel processing, it will be possible to solve problems that even the most powerful computers are currently unable to solve and reduce processing times from thousands of years to just a few minutes.

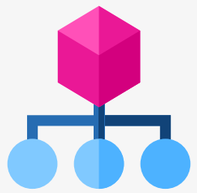
Quantum computers are able to analyze exponential (non-linear) problems. In combinational optimization, they are able to find the best solution – that is, the one with the highest business value – by considering a multitude of possibilities with a slim margin of error.

TIME-TO-MARKET AND EFFICIENCY

Providing users with the optimal solution to bring to market or allowing operators to drastically reduce collateral management inefficiencies means it is possible to solve the challenge of minimizing a loss function expressing the value related to specific payment configurations, and to seek a function's "best available values" in a specific domain.

At the moment, these problems are usually solved by linear optimization algorithms which, as well as having to process a huge amount of data, also have to consider an increasing number of parameters.

LINEAR OPTIMIZATION ALGORITHMS



Reduction of inefficiencies in collateral management

Acceleration of programming speed

Consideration of an increasing number of parameters

For example, where margin calls are concerned, algorithms must be able to manage the growing variability in constraint types, which in turn increasingly depend on the regulatory body's eligibility rules and on the assets of the counterparties involved in the operations. Finding algorithm classes which are able to model more and more complex and diversified realities while responding quickly is therefore increasingly crucial.

WHERE REPLY CAN MAKE THE DIFFERENCE

As well as its proven Risk Management and Regulatory & Credit experience in the Financial Services market, Reply, has had multidisciplinary teams exclusively dedicated to Quantum Computing for the past 2 years. They have forged partnerships and practices aimed to test this technology's disruptive potential.

Quantum Inspired techniques have made it possible to **create a model able to optimize collateral credit exposure** in order to generate real value/benefits within a regulatory framework that is constantly evolving, forcing operators to adapt quickly.

We, therefore, enter into risk mitigation and collateral management mechanisms with a focus on **MVA** (Margin Value Adjustment), i.e. value adjustments linked to liquidity costs, which have an impact on both economic cost and capital and represent the estimated cost of financing the initial margin and variation margin request for both bilateral and CPP negotiated derivatives.

As intermediaries get larger, regulations and limitations progress and businesses change, the Corporate & Investment Banking Division of one of our **Client Banks** deemed it important to collaborate with Reply to design an algorithm which would not only respond to collateral management but also approach new use cases flexibly to adapt to future needs.

Reply's Quantum Computing team has produced a high-performance quantum-inspired algorithm that supports the Client by reducing collateral management inefficiencies to minimum levels, with a specific focus on measuring specific KPIs.

The algorithm is able to operate on conventional or pseudo-conventional machines, especially GPUs (graphic processing units) already in use by the Client, without the need to replace existing technological infrastructure.

WHY COLLATERAL MANAGEMENT SHOULD BE OPTIMIZED

In light of the credit rationing that has affected the whole banking industry due to the recent economic and financial crises, managing collateral (and, more generally, liquidity) correctly has become even more important.

In terms of technology, it is a dynamic optimization problem, as the database that needs to be managed, the rules that need to be considered and the response that needs to be allocated all change on a daily basis. Having sufficient computational power and algorithm flexibility is therefore key to managing complex problems.

Computational speed

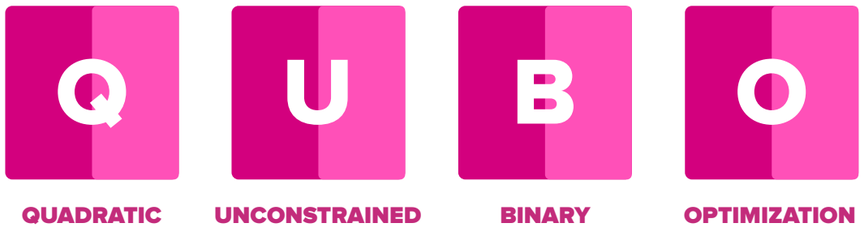
Algorithmic flexibility

Currently, the absence of Quantum Computing means collateral management takes place manually and arbitrarily through treasurers, i.e. people who know the database very well. An alternative is using non-quantum algorithms which regularly analyze the database and try to optimize the problem, albeit with far lower levels of flexibility, using approximations where necessary.

QUBO - THE QUANTUM INSPIRED ALGORITHM

Qubo is the acronym for Quadratic Unconstrained Binary Optimization.

It is a model designed to solve quadratic combinational optimization problems with binary variables where, unlike traditional algorithms, the entire model fits within a penalty matrix which makes the mathematical formulation elegant and compact. This **flexible**, **high-performance model** lends itself to parallelization thanks to its compact structure. It is also able to manage high levels of complexity, while remaining extremely fast regardless of the number of constraints. Continuously evolving regulations, the concentration constraint (which must be included in optimization ex ante), and managing specific market conditions can be seen as resolved challenges or, at least, challenges that can be overcome in time.



The QUBO formulation is an algorithm that scales very well, even when the complexity of the model increases. The software developed over the course of the project makes it possible to manage and optimize the bank's forecasted response to the set of collateral costs and margin costs (daily), following margin calls. It involves a financial benefit (saving on cost) of up to 9%for each call. It can also significantly reduce allocation inefficiencies for margin call cover.

Among the benefits of the **QUBO algorithm applied as above**, which can be obtained by an existing framework, are the modelling of non-linear variables: the possibility of introducing new rules and flexibility criteria to manage the database, including through segregation logic, depending on the counterparties. The possibility of appropriately managing an increasing number of margin calls (forecasted), and using all these elements to feed the algorithm by installing a complete collateral cost metric.

In the future, after making an investment, it will be possible to design a data architecture and IT infrastructure able to manage requests from national and supranational Supervisory Authorities quickly and at the same time; to fulfil internal data analysis requirements needed for company management; to guarantee a data set that meets transparency, integrity and quality requirements over a short time; and to capitalize (by accumulating, collecting and re-elaborating) on available data patrimony, creating a realistic representation of the optimization problem based on market evolution.

SUCCESS AND POTENTIAL OF QUANTUM COLLATERAL OPTIMIZATION

On the one hand, it is imperative to guarantee the best possible solutions and streamlined processes while respecting clients' time-to-market. On the other hand, regulatory requirements must also be met. The latter leads to a significant increase in collateral management costs through the demand for high-quality liquid assets. Regtech Council estimates that banks will spend 10% of their income on regulatory and compliance-related activities by 2022.

Quantum Collateral Optimization is only the first use case. Its success proves how Quantum Computing can really transform complexity (and the burden of regulation) into a competitive advantage, even against an ever-changing economic backdrop. The **Financial Services** sector – particularly investment banks – faces several optimization challenges, from detecting market instability and developing trading strategies, to optimizing portfolios, financial forecasts, market simulations, determining asset prices and rebalancing statutory reserves in the field of insurance.

Knowledge turns complexity into opportunity. Reply's added value is built on its constant focus on innovation, on its experience in the fields of Risk Management and Regulatory & Credit, and on its specific expertise in the study of Quantum Computers and Quantum Algorithms, developed both through experimental and lab activities and through real-life projects. Reply's goal is to use knowledge to contribute to the process of creating value for its Clients, even in the **Age of Quantum Supremacy**.