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The Business Intelligence as a Service in the Cloud

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ABSTRACT

Limitations imposed by the traditional practice in financial institutions of running risk analysis on the desktop mean many rely on models which assume a "normal" Gaussian distribution of events which can seriously underestimate the real risk. In this paper, we propose an alternative service which uses the elastic capacities of Cloud Computing to escape the limitations of the desktop and produce accurate results more rapidly.

The Business Intelligence as a Service (BIaaS) in the Cloud has a dual-service approach to compute risk and pricing for financial analysis. The first type of BIaaS service uses three APIs to simulate the Heston Model to compute the risks and asset prices, and computes the volatility (unsystematic risks) and the implied volatility (systematic risks) which can be tracked down at any time. The second type of BIaaS service uses two APIs to provide business analytics for stock market analysis, and compute results in the visualised format, so that stake holders without prior knowledge can understand. A full case study with two sets of experiments is presented to support the validity and originality of BIaaS. Additional three examples are used to support accuracy of the predicted stock index movement as a result of the use of the Heston Model and its associated APIs.

We describe the architecture of deployment, together with examples and results which show how our approach improves risk and investment analysis and maintaining accuracy and efficiency whilst improving performance over desktops.

1. Introduction

There are limitations to desktop-based financial software to run a large number of simulations. Often activities of large-scale software simulation to calculate risk and pricing take hours without simplifying the model [1]. Simplification of the model was used in finance industry for some time prior 2008 crisis. It is known as "Gaussian copula" to model rates for mortgage, bonds and derivatives. His model could work on the desktop and results could be calculated for an acceptable amount of time. However, his model did not check risks properly and did not have any suggestions to counter risks when extreme events happened [1]. Here is a real story describing the background that leads to the development and widely adoption of "Gaussian copula" and our proposal to rectify problems caused by this model.

1.1. Background

David X Li improved concepts implemented by financial services and modelled 'credit derivatives' to calculate collateralised debt obligation (CDO), which is a type of structured asset-backed security (ABS) with multiple series issued by special purpose entities for debt obligations including bonds and loans. Li allowed his model to get yields of a corporation's bonds or the prices of the new credit swaps to model the 'survival time' of an individual corporation (the time until it defaults). Li resolved this issue by introducing 'copula function' that he learned in statistics. Copula function is commonly used in mortgage lending concept to calculate the impacts of defaults due to deaths of one of the spouses [2]. Copula function can calculate the set of marginal functions (to specify the probability that the wife will die before a given age, and separate function that specifies that the husband will die at or before another age) to form the joint or 'multivariate' distribution function (to specify the probability that the wife will die before a given age AND the husband will die at or before another age). This is one of the fundamental errors that Li has implemented, since probability for both events to happen is different from one event to happen and results can be varied widely in extreme conditions.

Li then combined a popular financial software, CreditMetrics, and copula function together to establish the "Gaussian copula" model, which has been used by the finance industry since 1997 [1]. The "Gaussian copula" model is often called as the CDO solution, since it is a term easily understood by the finance sector. By combining both approaches, the finance sector could enjoy benefits from both sides—Gaussian's simplicity and familiarity and

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copula's unified and easy-to-use approach. The Gaussian copula model allowed analysts to buy a pool of bonds or loans, raising their money to do so by selling investors' securities claimed on the cash flow generated from the pool. The drawback for this approach is the assumption that correlation stays low. If correlation goes too high, the holders of the highest investment were at risks, and there was no detailed way to compute the extent of volatility in such extreme conditions [1], since the model takes assumption on the 'bright side' of the trading due to simplification of the "Gaussian copula" model to compute complex financial derivatives, prices and volatility.

Li then developed his final version of software called CDO Evaluator, which became more and more popular amongst quantitative developers and investment banks. There were a few reasons according to MacKenzie and Spears [1] and their interviews with experts and developers working in financial services. Firstly, developers needed not to think of many variables which are time-consuming to obtain. Secondly, they could possibly avoid using Monte Carlo simulations that took overnight and the weekend to run through all simulations and perform exhaustive testing of financial derivatives. Thirdly, it was easier to understand the problems, since there were fewer variables to know. Fourthly, it was also easier to communicate with other teams. Financial problems and derivatives were difficult to understand and even within teams with different skills and focus, communications were not easy or lengthy. The use of concepts of "Gaussian copula" model and the CDO Evaluator could ease the level of difficulties during communications. Fifthly, developers found it easy to reproduce Li's concepts due to the simplicity of the model and the problem. Sixthly, his software was backed by some leading quantitative developers at that time, and had widespread use in investment banks.

1.2. Business Intelligence as a Service (BIaaS) in the Cloud

There are some Grid based financial applications but they cannot be transferred to Cloud Computing easily [3]. Where applications can be moved, there are advantages to moving risk assessment calculations to Clouds including risk reduction, the opportunity to compare results and the capability to run less conventional models able to identify errors and uncertainties which are currently missed. However, factors such as accuracy, speed, reliability and security of financial models and their attendant costs must be considered [4]. Public clouds are not suitable due to privacy and data ownership issues [5]. A hybrid cloud could be used but this requires implementation of security technologies which are not the focus of our research. Private clouds are the obvious choice for the financial sector and also relevant to our objective.

The term "Business Intelligence" refers to a set of methods, processes, architectures and technologies that can process and transform collected datasets into meaningful and useful information for business purposes, and often used in business-critical servers, applications and services. Advanced simulations and processing in financial computing such as derivatives, stock analytics and financial software are part of Business Intelligence (BI), which aims to simplify the complexity of datasets and presents them with information for IT strategies and operational activities [6]. Daily activities performed by investment banks can be used by BI systems as an alternative, and another additional advantage is that BI systems can integrate with other technologies such as Cloud Computing to offer more added values to organisations [6–8]. There are two examples here to illustrate the added values of using BI systems in the Cloud. Firstly, Xu [7] designed and developed Cloud BI systems for manufacturing, and demonstrated how Cloud BI can transform the way that manufacturing was used to work. Cloud BI allowed different machines to work collaboratively and efficiently. Secondly, Marston [8] explained the added values of Cloud BI systems for business perspective and they demonstrated examples on how organisations could get different levels of contributions by using Cloud services such as Cloud BI services. These examples acknowledge the benefits of adopting BI in the Cloud for improved technical and business perspectives, thus, a hybrid solution of integrating BI in the Cloud is another motivation for this paper.

We propose and describe Business Intelligence as a Service (BIaaS) which is a Cloud based service designed to improve the accuracy and quality of both pricing and risk analysis in financial markets, compared with traditional desktop technologies. BIaaS is a type of Software as a Service (SaaS) with the emphasis on how the application offers quality services in private cloud environments. This is important because incorrect analysis leads to excessive risk taking which may then lead to financial losses, damage to business credibility or destabilised markets. We illustrate its use with an example which shows price and risk assessments for investments such as stocks and shares or financial derivatives in the context of different levels of volatility, maturity and risk free rates.

BIaaS has the dual-service approach to address the following challenges:

1. Compute the risks and asset prices, and computes the volatility which can be tracked down at any time.
2. Performing a sufficiently high number of simulations in acceptable time.

The breakdown for this paper is as follows. Section 2 describes problems with the existing and popular model used by financial services and the proposal of BIaaS. Section 3 explains all formulas associated to Heston Model, the model behind BIaaS. Section 4 explains the system architecture, including their associated services and APIs. Section 5 presents the setup and deployment of a private Cloud. The two stages of BIaaS are described in Sections 6 and 7, which use a number of experiments to validate the results. Section 8 describes two sets of experiments to demonstrate the validity and originality of BIaaS. Section 9 compares BIaaS and other models running on desktop. Section 10 discusses the use of BIaaS and benefits of adopting BIaaS for risk modelling. Section 11 describes conclusion and future work.

2. Problems with existing Gaussian copula modelling and our proposal

This section is aimed at describing the problems caused by Gaussian copula modelling, a model widely adopted by financial services and investment banks to calculate the lending. It starts with backgrounds, the process of getting popularity and explanations about the problems associated with the model.

2.1. Simplicity at the expense of accuracy and performance

However, Li's contributions to the finance industry were known as "receipt to disaster" after the financial crisis since 2008. The model underestimated the probability of the risks and did not have any measure to counter the risks when they began to take an immediate effect. Several assumptions he made in his model did not work in extreme conditions [1]. His model could work on the desktop and results could be calculated for an acceptable amount of time. By taking simplification of Li's model, financial services could run their services and get the results quickly. This can avoid the need to run days and hours of Monte Carlo simulations. However, risks are not properly checked as a consequence. His model took the simplicity and ease-of-use at the expense of the risk modelling and controls [1]. Li also admitted his weakness of the model and wrote: "The current copula framework gains its popularity owing to its simplicity.... However, there is little