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A Case Study for Business Integration as a Service

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Abstract

This paper presents Business Integration as a Service (BIaaS) to allow two services to work together in the Cloud to achieve a streamline process. We illustrate this integration using two services; Return on Investment (ROI) Measurement as a Service (RMaaS) and Risk Analysis as a Service (RAaaS) in the case study at the University of Southampton. The case study demonstrates the cost-savings and the risk analysis achieved, so two services can work as a single service. Advanced techniques are used to demonstrate statistical services and 3D Visualisation services under the remit of RMaaS and Monte Carlo Simulation as a Service behind the design of RAaaS. Computational results are presented with their implications discussed. Different types of risks associated with Cloud adoption can be calculated easily, rapidly and accurately with the use of BIaaS. This case study confirms the benefits of BIaaS adoption, including cost reduction and improvements in efficiency and risk analysis. Implementation of BIaaS in other organisations is also discussed. Important data arising from the integration of RMaaS and RAaaS are useful for management and stakeholders of University of Southampton.

Keywords: Business Integration as a Service (BIaaS); ROI Measurement as a Service (RMaaS); Risk Analysis as a Service (RAaaS); Organisational Sustainability Modelling (OSM); Monte Carlo Simulations; BIaaS Case Studies.

1. Introduction

Cloud Computing has become a buzz word and hot topic in academia and industry. There is an increasing number of organisations offering Cloud Computing products and services in industry. Amazon is a market leader in Public Cloud Computing and offers Elastic Compute Cloud (EC2) for computing capacity and Simple Storage Service (S3) for storage capacity. Microsoft provides Windows Azure services to allow developers to store their code and develop new applications for their clients or companies. Salesforce.com is a pioneer in Cloud Computing and offers their Customer Relation Management (CRM) applications to a large number of their users. Oracle offers several products and services ranging from hardware to application services after acquiring Sun Microsystems. IBM has Cloud Computing products and applications suites to help their customers. In addition, there are more Small and Medium Enterprises (SMEs) developing and selling their Cloud Computing services and products. They offer different types of business models and perspective. Computing Clouds are commonly classified into Public Clouds, Private Clouds and Hybrid Clouds (Ambrust et al., 2009; Ahronovitz et al., 2010; Chang et al., 2010 a; 2010 b; 2010 c; 2012 a; 2012 b; 2013 a; 2013 b; 2013 c). The type of Cloud an organisation adopts will depend on its needs and the volumes and types of services and data they plan to have and use. The examples described above are public clouds. There are researchers describing the design, implementations and user evaluation of private clouds, where Chang et al (2012 a; 2012 b; 2012 c; 2013 a; 2013 b; 2013 c) and Chang (2013 a; 2013 b; 2013 c; 2013 d; 2013 e) demonstrate the effectiveness of their implementations and positive impacts to organisations that adopt Private Clouds, including the technical demonstrations, results, discussions and positive impacts.

Academia also acknowledge the benefits of adopting Cloud Computing, particularly in operational management in scalability of data centre resources, cost saving, improvement in efficiency, green IT and agility to complete tasks (Foster et al; 2008; Amburst et al., 2009; Buyya et al, 2009; Weinhardt et al. 2009; Chang et al., 2011 a; 2011 b; 2011 c; 2012 a; 2012 b; 2012 c; 2013 a; 2013 b). Amburst et al (2009) identified cost reduction in IT services from using Cloud Computing. They also presented their Cloud Computing economics and ten major challenges for Cloud Computing. They emphasise a shift of risk from maintaining data centres and the capital costs of running them to the loss of data while managing Clouds. Buyya et al. (2009) assert that Cloud Computing offers billing-based Service Level Agreements (SLA) which can be used for operational management offering cost-savings and streamlining business activities and processes. Weinhardt et al. (2009) propose the business models for Cloud Computing services. Chang et al. (2011 a; 2011 b; 2011 c; 2011 d; 2012 a; 2012 b; 2012 c; 2013 a; 2013 b; 2013 c) and Chang (2013 a; 2013 b; 2013 c; 2013 d; 2013 e) provide their rationale, analysis and discuss to demonstrated added values offered by Cloud Computing adoption supported by their case studies.

The structure for this paper is as follows. Section 2 explains the integration-related problems faced by organisations. Section 3 presents Business Integration as a Service (BIaaS) overview and the research question associated with Cloud adoption. Section 4 explains system design and architecture of integrating two services: ROI Measurement as a Service (RMaaS) and Risk Analysis of Services (RAaaS). Section 5 shows the first BIaaS service, RMaaS, and Section 6 presents second BIaaS service, RAaaS, for the University of Southampton, including how to integrate RMaaS and RAaaS and its results. Section 7 further discusses results and its implications. Section 8 sums up conclusions and outlines future work.

2. The problems

Integrating different business activities together into the same environment can improve efficiency, reduce costs and improve collaboration. This is particularly true for big organisations with many locations and departments deploying Cloud Computing and for businesses to achieve long-term sustainability using Business Process as a Service (BPaaS) to improve business connectivity and streamline the essential process. Höing et al. (2009) use Grid Computing and WS-BPEL to demonstrate BPaaS as an Orchestration as a Service Infrastructure. Norta (2010) used his service hub system architecture to explain how BPaaS works. However, BPaaS is process dependent and focused on a particular process at a time, and is not necessarily connect different business activities together.

Integrating different Clouds take additional time and resources, and there is no guarantee that the outcome will be positive without the use of a consolidated framework to help with design, integration and evaluation (Buyya et al., 2010). Integrating between different services can provide long-term benefits, however, there are problems that need to be resolved presented as follows.

- Standard: Rings et al. (2009) and Buyya et al. (2010) point out that Cloud lacks of integration and interoperability standards. There are efforts from professional groups such as Open Grid Forum (OGF) and Cloud Alliance Security (CAS) to ensure standard is developed and becomes matured for Cloud adoption.
- Vendors' lock-in: The most well-known paper is described by Ambrust et al (2009) to explain the limitations imposed by vendors' lock-in. Knowledge and recommendations for Cloud integration becomes much harder due to this restriction to prevent sharing of code, methodology and lessons learned.
- Technologies: There are different types of technologies proposed by different academic groups and industrial solutions. Each has its own merit but also its limitation because certain criteria must be met before integration can take place. Additional details are described in Section 3 and 4.
- Legal issues: Copyright and legal challenges should be resolved if there are sensitive documents that are shared as a result of Cloud integration (Ambrust et al., 2009; Friedman and West, 2010).

Buyya et al (2010) propose their version of InterCloud to allow different clouds can work together. They describe their methodology and experiments in details. However, it is a platform that only works with their list of clouds, which is a proof-of-concept that works for a few but not a generic solution that can always be applicable under different circumstances. The proposal of InterCloud is a concept but not a product, and it is a notion but not a solution as yet. Often each Cloud service is independent. Some even involve multiple steps. Each service request has to be handled separately and there is a lack of communication between services leading to the following problems:

- There is no communication between services. Each time two types of service requests and activities have to done at different periods of time.
- Creation of additional work and cost. It also costs more to pay two service providers.
- It is difficult to check consistency of computational results from different service providers.

Integration between different types of services is required and all services need to be carried out within the same framework without communications and technological barriers (such as BPEL to BPMN). This motivates us to propose and demonstrate Business Integration as a Service (BIaaS), which aims to offer the following:

- To allow two or more different services to work together where traditionally each service would be separate from the others.
- To permit the outcome of one service to be used as input for another; integrating two services into one.

Details are presented between Section 4, 5 and 6.

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3. Business Integration as a Service (BIaaS) Overview

3.1 Business Integration Literature

This section describes related literature for Business Integration as a Service (BIaaS). Vinosk (2005) proposes Java Business Integration (JBI) by the use of enterprise application integration (EAI) offered by Java and Service Orient Architecture (SOA). Iyengar et al. (2007) introduce BI using IBM WebSphere Business Integration (WBI) technology which consists of Service Component Architecture (SCA), basic business processes and workflows. They use business process management (BPM), SOA BI scenarios, architecture, patterns and WS-BPEL related technologies to demonstrate BI. Rebstock et al. (2008) demonstrate ontology and semantic-based architecture and deployment on BI and explain their rationale and business cases. Chrisdutas (2008) consolidates the proposal from Vinosk (2005) and presents SOA Java BI. He explains the operation of JBI including each individual component and the interactions between different JBI containers. This work is based on SOA architecture which either focuses on JBI or semantic approaches.

Buyya et al (2010) propose their InterCloud, and they explain their architecture. Services in their infrastructure allow clouds from a selected number of service providers to work together. They encourage all other researchers to use their InterCloud for proof-of-concepts and have promoted their InterCloud as the platform for testing and collaboration amongst Cloud researchers and scientists who have close affiliation with IEEE.

Papazoglou and van den Heuvel (2011) present two models related to BI. The first is cloud delivery model in which they explain interactions between virtualised applications, clients and a stack comprising IaaS, PaaS and SaaS suitable for Business Process as a Service (BPaaS). Their second model, the blueprint model, is proposed to allow BPaaS or SaaS applications to run dynamically on virtualised clouds to enable service virtualisation. There are three components to the model: (i) blueprint definition language (BDL); (ii) blueprint constrain language (BCL) and (iii) blueprint manipulation language (BML). They also explain an architectural scenario showing how blueprint support for the cloud service life cycle can work. However, their approach is at the system design level without details of implementation, testing or use cases. Moran et al (2011) present Rule Interchange Format (RIF), RIF Mapping, RIF-expressed rules and a use case. They explain how semantic-based integration can be achieved on IaaS level. However, their notion of BI is not the same as ours for the following reasons. Firstly, their integration is based on data exchange between different VMs to update RIF status in the Cloud. Secondly, it is not clear whether their use case only works for IaaS, although they seem to imply this approach may work on PaaS and SaaS level in future work. Ring et al. (2009) explain the integration of Grid and Cloud systems using two approaches. Their first is to redesign architectures of different Grid systems and their second is to implement interoperability, which includes re-implementations of Unicore 6, Globus 4, GLite, OMII Grid and so on which also contain other components such as security, standardisation and service discovery. However, that is interoperability and includes re-implementations of existing systems and components. That method is suitable for Grid but improvements must be designed to accommodate the use of Cloud with the followings:

- Use of Virtual Machines (VMs) is not a pre-requisite
- There is no pay-as-you-go characteristic
- It does not have a good scalability like what Cloud does.

However, there are positive elements for approaches offered by Ring et al. (2009), who propose their "Next Generation Network" (NGN) to allow different Cloud services to work together. Their rationale is that no matter the service is Grid or Cloud, the use of network is a pre-requisite and NGS must cater the need to run multiple numbers of Cloud services, as well as integration between different Cloud services. They take on different standards and integrations technologies to propose their NGN architecture. Based on their description, NGN overall architecture consists of the following core components.

- PSTN/ISDN (Public switched telephone network/Integrated Services Digital Network) Emulation Subsystem (PES): PES supports the emulation of PSTN/ISDN services or access gateways for terminals connected to the NGN.
- Core Internet Protocol (IP) Multimedia Subsystem (IMS): IMS supports the provision of Session Initiated Protocol (SIP)-based services.
- Other subsystems, Internet Protocol Television (IPTV) dedicated systems and applications

- Common components for accessing applications, charging functions, user profile management, security management, routing database which are used by other subsystems.

The NGN architecture is presented in Figure 1 and there are three use case options for NGN network which is described as follows.

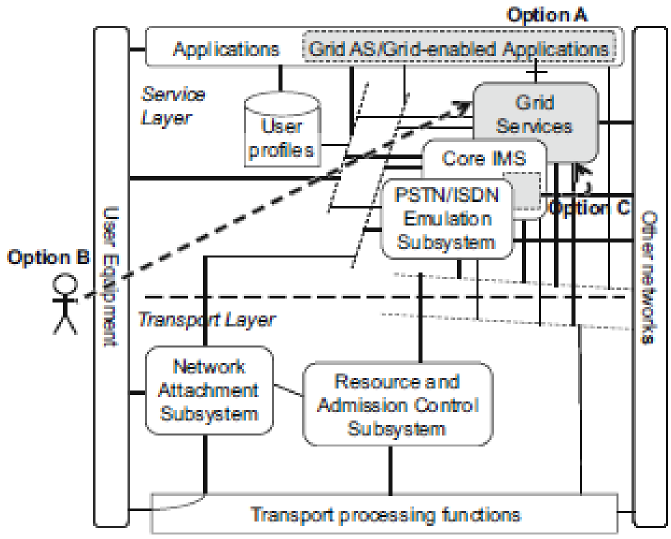

Figure 1: NGN Architecture and use case options

The architecture has the transport layer at the bottom and service layer on the top, where the service layer is connected to applications, user profiles and Grid-enabled applications as shown in Figure 1. There are three options in getting the services working. Firstly, Option A allows the users to use the Grid-enabled applications directly for accessibility, which are connected to Grid services, core IMS, PES and other subsystems via authorisation and authentication. Secondly, option B allows the authorised user to use the security certificate (usually X.509), which is authenticated to the Grid-enabled applications. Once the user profile is getting authenticated access, the rest of procedure for Option B is similar to Option A. Thirdly, there are also other authorised subsystems in Option C which are connected to the NGN, which often include the use of a virtual private network to the secure Cloud/Grid services. These three options allow authorised users to get to the secure private clouds where Software as a Service (SaaS) services are available to the users. While getting access to the NGN, there is another internal architecture, which will be presented in Section 4.

3.2 Challenges in Cloud adoption

Chang (2013 c) explain that apart from security and privacy, there are three major Cloud adoption challenges faced by organisations in the process of adopting private clouds, which include

- How to model and analyse risk for Cloud adoption systematically and coherently
- Risk mitigation of migrating to Cloud
- Integrations with other services or clouds

The topic, "integrations with other services or clouds", is the research question that this paper discusses. After the smooth transition and migration to Cloud adoption, organisations experience a number of risks which are directly involved with migration, since a change in service model has implications in terms of lack of control, staff morale, system management, service availability and benchmarking (Chang, 2013 c). Their next phase of challenge is the integrations of two or more services (Buyya 2010). Chang et al. (2011 d; 2012 a) also demonstrate that the benefits allow two departments to work on the different aspects of the same project (or service) together. There is no need to start from the beginning to understand the requirements of the request (or problem), and then try to resolve the issues by the lone department without the opportunities to report the same learning process and experience to the other departments of the same project. Then the first department that is involved with the project needs to explain to the second department of the project about the same process from the beginning to the end. This is a process that is time-consuming and does not provide the adopting organisations sufficient added values for benefits of Cloud adoption such as improvement in efficiency and collaboration. Instead, it is still the 'same old problem' that has been ongoing in the large organisations in the use of new IT services (Khajeh-Hosseini et al, 2010). Another observation for private cloud adoption is that organisations over-rely on the IT department to resolve all the issues and use IT department as the middle-man to resolve ongoing challenges. This method works fine but may overload the IT department but also may prolong the process of the service delivery and reduce the extent of efficiency if problems are not resolved in time and customers of the internal services become less happy with the services (Khajeh-Hosseini et al, 2010). Therefore, integrations between different Cloud services is an important agenda for adopting-organisaitons.

Although vendors' lock-in is a technical challenge (Ambrust et al., 2009; Papazoglou and van den Heuvel; 2011), integration of different services is another challenge. Here is an example. An organisation needs to use Cloud service provider A for measuring and analysing business performance. They use Cloud service provider B for identifying and quantifying risk analysis. Both services are managed and offered by different providers and have different requirements and technical solutions. Costs are nearly double than an integrated service that can provide both services. This motivates us to propose Business Integration as a Service (BIaaS). The objective is to allow two or more activities/services at any level (IaaS, PaaS, SaaS) that are traditionally separate services to integrate as a single service. This saves costs, improves efficiency, serves more purposes and provides more added values for businesses.

3.3 BIaaS for risk analysis – calculating different types of risks

According to Sharpe (1990), there are two types of risks: uncontrolled and controlled risks. Uncontrolled risks are unplanned events beyond human interventions such as earth quakes and financial crisis, which include the beta risk. The controlled risks can be managed and minimized with the human interventions, which include operational risks. In this paper, BIaaS computes two types of risks, where the first service computes the beta risk (uncontrolled risk) and the second service computes the operational risks (controlled risks). However, a challenge is to calculate the accurate beta risk and new method needs to be in place to ensure the probability of calculating the beta risk is as close to the reality as possible. BIaaS can compute both uncontrolled and controlled risks to ensure that Cloud-adopting organisations understand the status of risk management, whether the risks are out of control, or the extent of the risks is either reducing or increasing at different time scale of the Cloud adoption.

This paper describes our own flavour of Business Integration as a Service (BIaaS) and case studies confirming its benefits for organisations adopting cloud. In our demonstration of integration, we are connecting two different services to allow a user request to be performed as thought they were one service rather than two separate services.

4. System Design and Architecture for BIaaS

We develop two different Cloud services and their descriptions are as follows:

- ROI Measurement as a Service (RMaaS): The aim is to measure risk in relations to Cloud adoption. It starts as a PaaS-based statistical service to compute and analyse key statistical data. It then gets to the second step of RMaaS, which is a SaaS-based service to present key analysis in a 3D Visualisation. The third step of RMaaS is a Quality Assurance (QA) SaaS-based service to ensures that the 3D data has a high quality and to further analyse the implications of data.
- Risk Analysis as a Service (RAaaS): The purpose of this service is to calculate risks and evaluate its impact on an organisation. RaaaS starts with a SaaS-based risk analysis offered by Variance-Gamma Process (VGP) which reduces inconsistencies and errors and calculates the risk pricing. It then moves to second step of RaaS, another SaaS-based service based on Least Square Method (LSM) that computes high-performing simulations and to calculate the most expected risk pricing and its most likely range. Risk pricing means the expected risks involved and can be quantified as a numeric number (used in financial options: European or American) or a percentage (such as presenting percentage of loss) (Hull, 2009; Waters, 2008). If a risk pricing is 20%, it means it will cause 20% of undesirable impacts such as loss of revenues.

We first present how each service works and then how the two services can work together in the BIaaS framework.

Trends in E-Business, E-Services, and E-Commerce: Impact of Technology on Goods, Services, and Business Transactions, IGI Global

4.1 System Design and Architecture

BIaaS provides linkage between different types of services which in turn leads to efficiency improvement and time reduction in business processes. Services in BIaaS can work within the same framework without barriers in communications by connecting all services and ensuring (interim) service output formats are acceptable input for the next. BIaaS can offer services and connect services together to save businesses time and resources for analysis. It also allows them to compute complex models while keeping easy to use concepts and features (Chang et al., 2011 d).

Our System Design and Architecture is similar to Papazoglou and van den Heuvel's (2011) cloud delivery model except we avoid using a new language. A number of technologies is used for each step of the service. The major advantage being that each step has a preference for certain technologies or platforms due to its functionality. For example, a statistical computing service favours statistical languages or packages. Figure 2 shows System Design and Architecture, the structure of each service, how different services are connected to each other and how data is exchanged between different virtualised layers. The network infrastructure is based on the NGN concept proposed by Rings et al (2009). Our BIaaS demonstration is based on the development of two proposals – the virtualisation and architectures from Rings et al (2009) and Papazoglou and van den Heuvel's (2011).

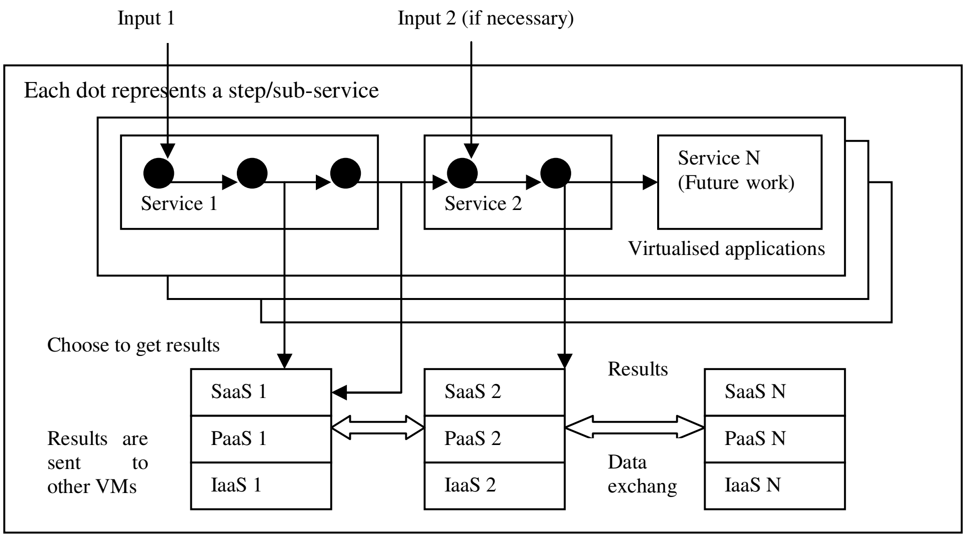

Figure 2: System Design and Architecture for BIaaS in Southampton Private Cloud sitting on top of NGN

Service 1 is RMaaS which includes three steps. It requires completion of at least the first two steps before presenting results. Each step in RMaaS is considered as a sub-service as follows:

1. **Statistical service**: This computes Cloud business performance with key statistical data offered by SAS, a statistical program.
2. **Visualisation service**: Results from statistical service pass onto this step which presents key data using 3D Visualisation enabled by Mathematica. Completion of this step is the minimum requirement for RMaaS.
3. **Quality Assurance service (optional)**: This is an additional step required when connecting to another service. It ensures data quality and performs further analysis of the implications of data.

Results are saved in text formats readable by each service and then passed onto the next step. Service 2 is RAaaS which is itself comprised of two steps. Results from the last step of RMaaS are passed onto the first step of RAaaS. Similar to RMaaS, each step in RAaaS is a sub-service and the two steps are:

1. **VGP risk analysis service (optional)**: This reduces inconsistencies and errors and calculates the risk pricing. It computes results showing frequency of occurrence and risk pricing.
2. **LSM risk analysis service**: This computes high-performing simulations and calculates the most likely risk pricing and its upper and lower bounds.

Integrating RMaaS and RAaaS requires the following:

- Results from the end of RAaaS and the end of each step need to be saved as text and passed to the next step, allowing results from each service to be passed onto the next.
- Use requests (ROI measurement and risk analysis) are completed in one rather than as two separate services.

The experiments are performed using a private cloud located in Southampton, distributed between two sites; two high performance servers with multiple VMs located at University of Southampton and two clusters of eight servers with VMs located at the lead author's home. All are connected to form a private cloud.

4.2 How to validate BIaaS and Hybrid Case Study

Projects and services implemented by BIaaS require verification which needs a number of techniques and focuses. A case study approach is the primary method of verifying BIaaS. This is relevant to our framework to help organisations to achieve good Cloud design, deployment and services. In each organisational case study, experiments are used for validation. Each experiment consists of a number of simulations and models which are often packaged as a SaaS.

Table 1: An overview of verifying BIaaS

Organisations	BIaaS focus	Method with qualitative focus	Method with quantitative focus	Remark
University of Southampton, See Sections 5	To demonstrate how RMaaS and RAaaS can work together	Hybrid Case Study	Experiments, simulations and modelling Hybrid Case Study	It computes relevant analysis to help stake holders making right decisions.

A hybrid case study is an approach that adopts both qualitative and quantitative methods. Kaplan and Duchon (1988) are the pioneers of this type of approach. They explain what led them to integrate both methods and how to use the integrated approach which is particularly useful when analysing performance of clouds in businesses that use organisational data or computational analysis that requires more details from users. Methods include surveys and interviews from qualitative methods, modelling, simulations and experiments from quantitative methods.

Each case study uses simulation and modelling which are mainly done by MATLAB or Mathematica as described in Financial Clouds Review (Chang et al., 2011 a). A challenge is to get a platform to integrate different simulations together.

5. Case Study at the University of Southampton: ROI Measurement as a services (RMaaS), the first major service of the BIaaS

The objective is to present the case study of University of Southampton, where the current status and results of BIaaS have been reviewed. This includes at least three different departments: School of Electronics and Computer Science (ECS), i-Solution Group (providing ICT services) and Corporate Planning. This case study describes how different services work together such as ROI Measurement as a Service (RMaaS) and Risk Analysis as a Service (RAaaS) and demonstration of how RMaaS and RAaaS can work together as an integrated solution.

5.1 Background information

The purpose of the case study is to demonstrate OSM by using cost data to study the extent of cost-saving. The School of Electronics and Computer Science (ECS), University of Southampton, has used VMware and virtualisation since 2007 for different research projects. This fits with the University's long-term Green IT strategy. Some infrastructure consolidation took place in 2008. The final implementation started in late 2008 and was fully completed prior to Easter 2009. Cloud IaaS services commenced in April 2009. The initial focus was to reduce the number of servers running continuously to meet green technology requirements. It is the University's aim to save costs and also consolidate number of servers required. By using virtualisation, email servers, storage servers, School web servers, student record servers and database servers can be implemented as virtual machines (VM) running on private clouds. The benefits include the following:

- It is far easier to replicate and clone a VM than physical server images.
- If VMs fail, they can easily be recovered from snapshots or via other recovery tools. This reduces down time and is also useful if security is compromised.
- It allows multiple servers to run at the same time within each physical server, thus saving resources and power consumption.

The work is divided into three stages of development described as follows.

- Stage 1: This stage is to identify the cloud project focus of ECS and to define what to measure. The focus is cost-saving from reduced electricity consumption and operational costs. Three years data between November 2007 and June 2010 detailing the electricity consumption and invoices for ECS facilities is obtained and used for analysis. This requires an analysis of electricity consumption (and bills) for the ECS data centre and a forecast of results from the University's estate and another research group. A joint effort with ECS is made to ensure the range and quality of the data is good prior to analysis in Stage 2. In addition, collaboration with the i-Solutions Group (providing IT services for the University) has been in place to obtain two years of user data about rating of Cloud and HPC services for different users. Data has been carefully examined and studied.
- Stage 2: This involves using OSM for quantitative analysis. The data is firstly used in OSM statistical computing, which provides a summary. In the process of statistical computation, the Durbin-Watson statistical test is used to establish the accuracy of the output. OSM then computes the actual and predicted values of analysis by linear regression to calculate beta. OSM uses Mathematica to compute results for 3D visualisation, which simplifies the complexity of analysis. The rationale is that all analysis can be visually presented, enlarged and rotated in a 3D format which allows stakeholders to understand more easily. Quality Assurance (QA) is used at the end of stage 2 to help accuracy of the data. The most effective data ranges from October 2008 and September 2010.
- Stage 3: The data between June 2010 and December 2010 are compared with the expected values calculated in Stage 2, and to identify any similarities and differences. A minimum of six months data is required for Stage 3. QA is used to improve the quality of actual and predicted analysis. For the i-Solutions Group, the data used for comparison was from September 2010 and January 2011.

5.2 Organisational Sustainability Modelling (OSM), the model behind ROI Measurement as a services (RMaaS)

Organisational Sustainability Modelling (OSM) is a model to process thousands of datasets and uses SAS for statistical analysis and Mathematica for 3D Visualization, of which SAS is more suitable than others since it can compute more in-depth analysis (Chang et al., 2010 a; 2010 b; 2011 b; 2011 c). The objective of ROI Measurement as a Service (RMaaS) is to calculate cloud business performance, so that the organization can be aware of their ROI and can help stake-holders to make the right business decisions. This involves with two mini steps. The first step is a PaaS service analysing business performance by computational statistics and the second step is a SaaS which involves computing statistics and presenting them into 3D Visualization.

Before discussing RMaaS, introduction for OSM is useful. Rationale for OSM is as follows. Return on Investment (ROI) needs to consider the input and output of Cloud adoption and risks associated with adoption (Khajeh-Hosseini et al, 2010, 2011). The formula (3) shows three metrics are required for the input: the expected return value, the actual return value and the risk-control rate. The OSM formula can compute output which can present the ROI as a whole and demonstrate that Cloud adoption can achieve the following:

- Meet the expected target, and record expected return values each time before analysis.
- Present the actual return values, and record each time (such as every week).
- Present the risk-control rate for manageable risk and uncontrolled risk (beta) during the measurement of expected and actual return values.

Based on the improvement of Capital Asset Pricing Model (Chang et al., 2011 b; 2011 c), the OSM formula is presented as

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$$e = r_c + (\beta(a - r_c)) \qquad (1)$$

where ***a*** is the actual return (or performance) of a large computing systems project or investment.

$\boldsymbol{r_c}$ is the risk control rate. It can be interpreted as the rate that is free of risk, or the rate that risk can be managed. This is the rate for manageable risk.

e is the expected return (or performance) of a large computing systems project or investment, and β is the beta value to represent risk measure or uncontrolled risk. These are unpredictable events which cannot be managed and have a direct impact on the adoption of the system

The uncontrolled risk, beta, can be calculated once when the expected value, the actual value and risk-control rate in each dataset are available. A good approach is to calculate all beta values and average them out. Another approach for calculating beta is to perform linear regression, where the gradient of the slope is the value for beta (Sharpe, 1990; Chang et al., 2013 d). So the formula becomes

$$\beta = \frac{e - r_c}{a - r_c} \qquad (2)$$

The steps above require the following input:

- Actual return values (a): the actual values obtained from the measurement.
- Expected return values (e): using the previous data (or previous measurement) as the benchmark, or using computation technique to model the expected values.
- Risk-control rate (r_c): the percentage that does not affect risk if targets are not met. It is often managed and controlled under 5%.

After collecting at least several hundred of metrics, these data can use OSM to calculate beta, and compute the overall risk and return values to present to stakeholders.

5.3 OSM Output Results

Computational modelling of OSM will use a, e, r_c as the input to compute risk. Output should contain the following.

1. Beta (β) is a value to determine the risk measure (or the extent of the volatility), which is the uncontrolled risk that may affect the Cloud project.
2. Standard Error (SE) of the mean is the range of the mean that the experimental results fall into for OSM. The smaller the standard error, the smaller the difference between expected and actual return values (Hull, 2009; Lee et al; 2010).
3. Durban-Watson (DW) is a test used to detect the presence of autocorrelation (a relationship between values separated from each other by a given time lag) in the residuals (prediction errors) from a regression analysis. The result of Durban-Watson (DW) should be above 1 (Hull, 2009; Lee et al; 2010). Durban-Watson is used to test regression computed by OSM and accuracy of the output, and also the statistical behaviours. The value for Pr > DW corresponds to the negative autocorrelation test (residuals eventually wither off) and is a preferred method in the OSM approach, and the value of Pr > DW should ideally get as close as to 1 to reflect the accuracy of the OSM regression. The p-value used by most of statistics is the positive autocorrelation value and can be work out by subtracting the value of Pr > DW by 1. See Table 2 for results.

Additional OSM outputs are presented as follows.

- Mean Square Error (MSE) is an estimator to quantify the difference between estimated and actual values. A low MSE value means there is a high correlation between actual and expected return values.
- R-squared value is used to determine how the regression fits in a line. Both 95 and 99.99 Confidence intervals (CI) are computed. In this context, it is referred as "R-squared value for firm", a term that is commonly used in econometrics to describe the percentage of risks in proportion to the external or internal organizations or factors [Lee et al., 2009; Teoh et al., 2009]. For example, if an organization has an R-squared value (99.99 C.I) of 0.4, this means 40% of risks are from external bodies or the market, and 60% of risks come from the organization such as poor adoption decision, overspending, poor selection of

equipment (resulting in accidents). Cloud adoption also introduces risks and the R-squared value provides a good indication for the percentage and sources of beta risks.

The results for OSM regression is as follows.

Table 2: OSM key statistics for calculating ECS cost-saving

Beta **0.77% of risks: external and 99.23% of risks: internal**	-0.0783	**Durbin-Watson** **Pr>DW (negative autocorrelation: maximum of 1 in favour of OSM)** **Positive autocorrelation (p-value)**	1.2838 0.9921 0.0079
Standard Error	0.1410	Regress R-Square (99.99 C.I)	0.0077
Mean Square Error (MSE)	0.14844	Regress R-Square (95 C.I)	0.5132

Further explanations are presented as follows.

- Beta is equal to -0.0783. The low beta value suggests the project is not exposed to the extent of risks after the completion of this project. However, circumstances for negative beta values are subject to changes. If electricity prices and consumption are more than expected rates, beta may turn positively which will reduce all cost-saving values immediately.
- Standard error is 0.1410. The low value suggests most metrics are close to each other and the data has fewer extremes. There is a high consistency between all metrics.
- The first order Durbin-Watson: Pr > DW is the p-value for testing negative auto-correlation which favours OSM. Results show that there is a high negative auto-correlation (0.9921), which means a good quality of data and standard errors. The p-value is the positive autocorrelation and is equal to 0.0079.

In addition:

- The low Mean Square Error (MSE) value suggests a good consistency between actual and expected return values.
- Main regression R-square is 0.0077 and below 0.5. It means Regress R-Square (95 C.I) is required and the value is 0.5132. It also means 0.77 % of risks are from the externals such as funders' cost-saving plans and 99.23% of risks are from the internals, which include the following reasons as confirmed by the users of ECS.

5.4 3D Visualisation for ECS Cost-saving model

Further statistical analysis can be computed. However, this often requires those with relevant training to perform such tasks. Our major contribution in this project is to present complex statistical analysis using 3D Visualisation, so that no data is missed for analysis, and also those without advanced statistical backgrounds can interpret the results. This is useful for many decision-makers and directors who need to know business analytical results quickly but do not wish to spend too much time understanding them. 3D Visualisation techniques are used to present CBP results for their participating collaborators, which include NHS UK in its two healthcare cloud projects, and organisations such as Vodafone/Apple, SAP, and OMII-UK (Chang et al., 2011 b; 2011 c; 2013 c).

The data is computed in Mathematica and 3D visualisation models are presented in Figure 3, which can help to explain low R-squared value. It indicates a high return of cost- saving between 21 % and 22% on the y-axis, which represents a significant reduction in operational costs. It also shows the expected cost-saving between 22 and 26% on x-axis. The z-axis presents risk-control rate (4.0-5.0%), which means minimum expenses to keep operation running. This percentage range can guarantee cost-savings.

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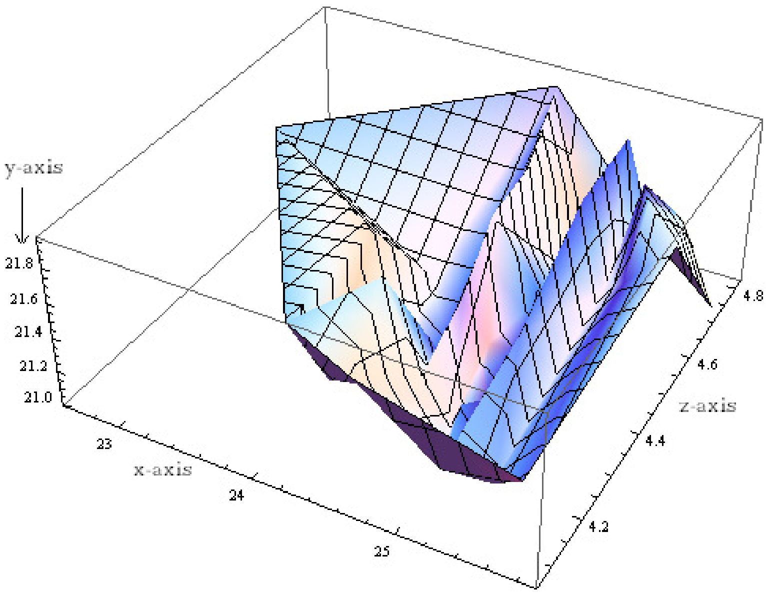

x-axis: Actual ratio of cost-saving (22.5% - 26%)
y-axis: Expected ratio of cost-saving (21.0% - 22.0%)
z-axis: Risk-control rate (4.0% - 4.8%)

Figure 3: 3D visualisation for ECS Cost-saving

The implication for the figure confirms:

1. Both actual ratio and expected ratio have high values between 21 and 26%. There is an overall consistency in the data. The actual ratio is higher than the expected ratio, because ECS has a stringent policy to achieve cost-saving which has exceeded their targets.
2. Some values have high actual ratio with low expected ratio, which shows as troughs and peaks (right lower corner). Some values have a lower actual ratio with a higher expected ratio, which stays on the top (left upper corner). This is probably because the increased consumption has happened due to some scheduled or unexpected events.
3. The risk-control rate is kept within 5%, but it is always above 4% since a few break downs per year (on the average of once a month) were experienced in the data centre although it was infrequent.

The objective of ROI Measurement as a Service (RMaaS) is to measure return and risk status, so that the organisation can be aware of their ROI and can help stake-holders to make the right business decisions. This involves with two mini steps. The first step is a PaaS service analysing business performance by computational statistics and the second step is a SaaS which involves computing statistics and presenting them into 3D Visualisation. For this paper, quality assurance service is optional. A different way for quality assurance method is used which deals with data integration and it will be presented in Section 7.3.

6. Case Study at the University of Southampton: Risk Analysis as a Services (RAaaS), the second major service of the BIaaS

Simulations in Risk Analysis become more popular in organisations investing in new technologies and new areas. Risk Analysis as a Service (RAaaS) is a specialised area to present. Chang et al. (2011 a) describe how Financial Software as a Service (FSaaS), which is close to RAaaS, can work in the context of Clouds. This includes Monte Carlo Methods (MCM) and Black Scholes Models (BSM) are used to calculate pricing and risk, and present some selected results for visualisation particularly risk analysis. This ensures there is no hidden or missing data for risk analysis, and visualisation allows stake holders to understand the impacts of risk more easily. FSaaS can be used as a stand alone solution. Similarly, RAaaS can be used in the BIaaS and to allow results from RMaaS to be used and presented as an integrated solution. RAaaS development is made up of the following sequence (see Table 3).

- Variance-Gamma Process (VGP) in MCM, focusing on error corrections. VGP service is optional for this paper.
- Monte Carlo Simulation as a Service (MCSS), which uses Least Square Method (LSM) to focus on fast and reliable calculations with an excellent performance.

Table 3: RAaaS development following this sequence

Sequence	Process	What is aimed for	Outcomes
1.	MCSS	Provide fast and reliable calculations with an excellent performance. Obtain benchmark. Additional features presented below	Most of calculations and benchmark can be obtained here. If errors are found, go back and check. The improved analysis can be passed onto next sequence.

6.1 Monte Carlo Simulation as a Service (MCSS), the model behind the Risk Analysis as a Services (RAaaS)

This section explains the need for MCSS. It is becoming more important for computer scientists to develop better models to improve the analysis and resolution of problems in the finance industry. Better ways to calculate pricing and risks, rectify errors and perform accurate and fast simulations are highly desirable. Requirements for MCSS are thus as follows:

1. ***Based on the reputable models*** – MCSS adopts reputable models including Monte Carlo Methods to run single and exhaustive cases and compute the best pricing and risks for different scenarios.
2. ***Accuracy: MCSS can offer 'precision method'*** – This means pricing and risk values can be calculated to several decimal places, as a mean, with a lower and upper range, thus producing results which are as accurate as possible.
3. ***High-performance simulations*** – it was reported that banks may take days to run large-scale simulations. There were also practices to simplify the number of simulations to ensure all simulations could be completed quickly. However, our MCS should not allow simplicity as the expense of the accuracy. Our MCSS should offer a high number of simulations such as up to 500,000 simulations within a short timescale.
4. ***MCSS allow a 'simplified model'*** - a key input variable can be reduced without affecting accuracy.
5. ***Multi-platform on Clouds*** - MCSS can be functional on different platforms.

6.2 Related theory to Monte Carlo Simulation as a Service (MCSS)

Various alternative methods were considered including stochastic simulation, Terms Structure Models (Piazzesi, 2010), Triangular Methods (Mullen et al., 1988; Mullen and Ennis, 1991) and Least Square Methods (LSM) (Longstaff and Schwartz, 2001; Moreno and Navas, 2001; Choudhury et al., 2008). Of these, Least Square Method (LSM) is chosen because it provides a direct method for problem solving, is appropriate for large problems and can be divided into sections which can be calculated independently. Robust algorithms have been developed which estimate best values efficiently and precisely using LSM in combination with MCS which are popular and versatile (Longstaff and Schwartz, 2001; Moreno and Navas, 2001; Choudhury et al., 2008).

Here is the explanation for the LSM. A data set $(x_1,y_1), (x_2, y_2),....,(x_n, y_n)$ with the fitting curve $f(x)$ has the deviation $d_1, d_1, ... , d_n$ caused by each data point, the least square method produces the best fitting curve with the property as follows.

$$\text{Minimum Least Square Error } (\Pi) = d_1^2 + d_2^2 + \ldots + d_{n-1}^2 + d_n^2 = \sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} [y_i - f(x_i)]^2 \qquad (3)$$

The least squares line method uses an equation $f(x) = a + bx$ which is a line graph and describes the trend of the raw data set $(x_1,y_1), (x_2, y_2),....,(x_n, y_n)$. The n should be greater or equal to 2 ($n \geq 2$)in order to find the unknowns a and b. So the equation for the least square line is

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$$\prod = d_1^2 + d_2^2 + \ldots + d_{n-1}^2 + d_n^2 = \sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} [y_i - (a + bx_i)]^2 \quad (4)$$

The least squares parabola method uses an equation $f(x) = a + bx + cx^2$ which is a parabola graph. The n should be greater or equal to 3 ($n \geq 3$) in order to find the unknowns a, b, and c. When you get the first derivatives of $\prod$ in parabola, you will have

$$\prod = d_1^2 + d_2^2 + \ldots + d_{n-1}^2 + d_n^2 = \sum_{i=1}^{n} d_i^2 = \sum_{i=1}^{n} [y_i - (\sum_{i=1}^{n} a + \sum_{i=1}^{n} bx_i + \sum_{i=1}^{n} cx_i^2)]^2 \quad (5)$$

The LSM has been mathematically proven and allows advanced calculations of complex systems. $f(x) = a + bx + cx^2$ is the equation for LSM. LSM provides a direct method for problem solving, and is extremely useful for linear regressions. LSM simulates and performs calculations by linear regression, which attempt to fit to the parabolic function to get a precise approximation to the actual values closely. LSM computation can either use data or mathematical predictive modelling (no data). If data is not provided, key variables should be defined before calculations.

Monte Carlo Methods (MCM) are suitable to calculate best prices for buy and sell, and provide data for investors' decision-making (Waters, 2008). MATLAB is used due to its ease of use with relatively good speed. While the volatility is known and provided, prices for buy and sale can be calculated. Alentorn (2007) demonstrated his examples of how to calculate both call and put prices, with their respective likely price, upper limit and lower limit.

As discussed earlier, MCM simulations in the banks take hours and days. Performance improvements are necessary, including the use of another HPC language or a better method. Adopting a better methodology not only enhances performance but also resolves some aspects of challenges. Barnard et al. (2003) demonstrate that having the right method is more important than using a particular language.

The Least Square Methods (LSM) fits into the improvement plan with the following rationale. Firstly, LSM provides a quick execution time, more than 50% faster compared with other models such as Variance-Gamma Process (VGP). Secondly, it allows up to 500,000 simulations to be performed at one go to calculate pricing and risk. By offering these two distinct advantages over other models, LSM is therefore a more suitable method for MCS to achieve speed, accuracy and performance. In addition, LSM has been extensively used in robots, or intelligent systems where a major problem is divided into sections, and each section is performed with fast and accurate calculations.

6.3 Risk calculations offered by MCSS

This section is part of the second and fourth MCSS requirement (time step =10) but it also covers the precision method to calculate the precise numeric price and risk options. Precision method falls under the fourth requirement as the results need to be as accurate as possible. Risk analysis is carried out using models of both the American and European styles of option as both are popular. The difference is that whereas an American option may exercise at any time, European options may only be exercised at expiry (Hull, 2009; Lee et al., 2010). The majority of exchange-traded options are American. A European option may be exercised only at the expiry date of the option, which means at a single pre-defined point in time (Hull, 2009; Lee et al., 2010). Calculations in both options is suitable because American option can illustrate the average performance, and European option can illustrate the best pricing or risk at the time that research work takes place. Both American and European options can be converted to percentages (Hull, 2009). This means if a risk is calculated and equal to 2.42 as the risk price, it can be interpreted that 2.42% is the percentage that the risk can happen and the price to accept it is 2.42.

Using LSM permits these models to be divided into sections, each of which can be calculated independently allowing them to be distributed across clouds or grids with consequent improvements in efficiency (Longstaff and Schwartz 2001; Moreno and Navas 2001; Choudhury al. 2008). LSM can be adopted to allow 100,000 MATLAB simulations to be run in the cloud, allowing such a calculation to be completed in a few seconds as documented in "Financial Clouds Review" (Chang et al., 2011 a). The following is the result of running LSM to calculate the expected risk price.

MCAmericanPrice = 2.435 (risk price)

MCEuropeanPrice = 2.227 (risk price)

This means the average performance for risk price is 2.435 (2.435 % for operational risk to happen. The best risk pricing that the completion of project or the end of investment (exit/expiry) to happen is 2.227 (2.227% for operational risk to happen).

Here is a short description about the precision method to fulfil the third MCSS requirement (time step = 10). The next stage is to calculate the range of lower, upper and medium limit. This is an important step to calculate precise options and to produce results as accurately as possible. Numerical calculations performed without the precision method may have a wider range in the final result. This needs to be tightened up considerably to calculate the likely range of risk pricing with the greatest frequency of occurrence. The put price is used to calculate risk pricing as it represents a price to accept this risk (Hull, 2009; Lee et al., 2010). The result shows the expected European option (for risk price) is 2.22728 with its upper limit as 2.24039 and lower limit as 2.21430. MCS calculations allow computation of accurate results of up to five decimal places including its exact price, lower limit and upper limit. See Table 4. Results are consistent with each other when the number of simulation goes up to 500,000 by 50,000 each time.

Table 4: Calculation of the exact risk prices for European options (time step = 10)

	Lower Limit	MCPrice (exact risk price)	Upper Limit
Put Prices:	2.21430	2.22728	2.24039

6.4 High performance simulation offered by Monte Carlo Simulation as a Service (MCSS) and the associated experiments

Various simulations and experiments for MCS have been performed using a high specification desktop environment, private and public clouds. The desktop machine has 2.67 GHz Intel Xeon Quad Core and 4 GB of memory (800 MHz). The deployment includes private Cloud clusters at the author’s home in Southampton, which connects to ECS computing servers and also University of London Computing Centre (ULCC) Data Centre, which has ten high-end rack servers and ten storage servers. Each server at ULCC has up to ten virtualised server and each virtualised server serves for different functions and services for the internal and external users. ULCC Data Centre has advanced Cloud and parallel computing infrastructure and network attached storage (NAS) service. In total it has CPUs totalling 30 GHz, 60 GB of RAM and 12 TB of disk space in place. Experiments performed in this environment get the best benefit of advanced optical fibre networking. There are two servers at London Greenwich, with a total of 9 GHz CPU and 20 GB RAM. The two servers at University of Southampton both have 6.0 GHz and 16 GB RAM. For the home cluster, the total hardware capability is 24.2 GHz CPU and 32 GB RAM.

Although the experiments take place in private clouds and desktop, public clouds can be used to compare relative performance between different platforms for running exhaustive tests. For this reason, one Amazon EC2 public clouds has also been used. It has multiple 2.33 GHz dual core processors and 7.5 GB memory with Ubuntu 8.0.4 virtual machine on the public cloud. Simulations and experiments on a desktop, a public cloud and two private clouds (one in Southampton and one in London) get the same results, and thus execution time to complete all simulation is the benchmark to differentiate their performance on different platforms.

Gaussian Collateralised Debt Obligation (CDO) is a commonly used service used in financial institutes to compute the interest rates for currencies, mortgages and bonds. It is widely used before financial crisis and its excessive uses with the lack of regulations is one of the reasons that has caused financial crisis in 2008 (MacKenzie and Spears, 2012). The purpose of the experiment is to demonstrate that MCSS can complete computations with accuracy and also in a short period of time. In addition, it is also useful to compare MCSS with Gaussian CDO so that experimental results can support that MCSS offers a reliable and fast service. In this experiment, the same inputs, variables and set ups are used for both MCSS and Gaussian CDO.

Both MCSS (private cloud of London and Southampton) and Gaussian (CDO) on desktop compute the same numerical pricing results. The average execution time for MCSS is always under 20 seconds for up to 500,000 simulations comparing to Gaussian CDO in Figure 4. Performance of MCSS on private cloud is better than its own performance on desktop. However, the main difference is that the maximum number of simulations Gaussian CDO can compute is increased to 300,000. Gaussian CDO crashes out beyond 300,000 simulations per attempt and leaves the system unstable.

MCSS has a significant performance improvement over Gaussian CDO software under the same circumstances for modelling. This means LSM adopted by MCSS can achieve high-performing simulations by completing all option calculations promptly and is also more capable of running higher numbers of simulations. Instead of being unable to run beyond 300,000 simulations in one go by a Gaussian CDO desktop, MCSS can run up to 500,000 simulations with a much better performance. This experiment fulfils the third MCSS requirement.

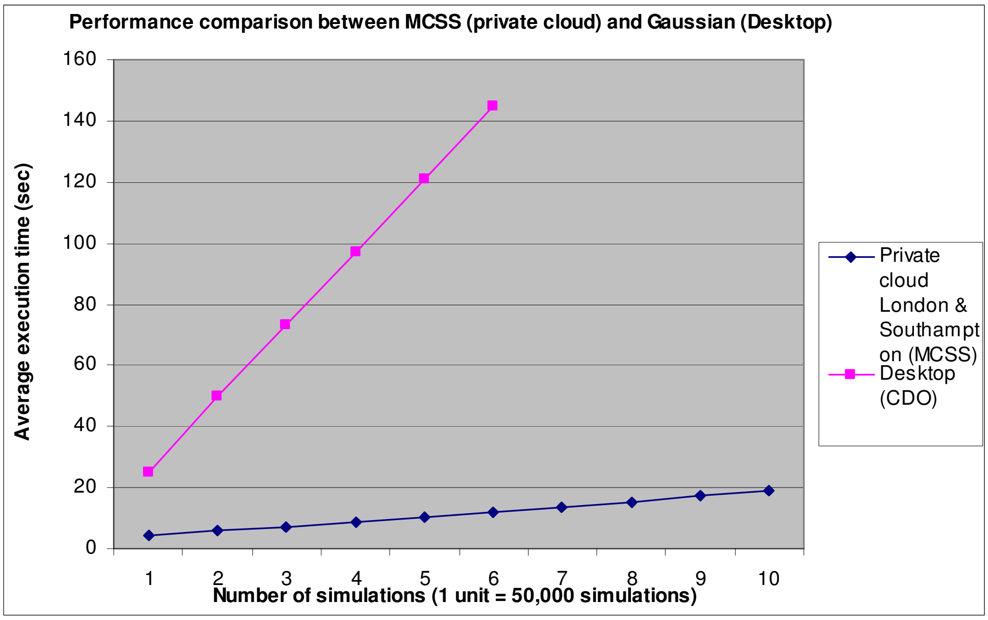

Figure 4: Performance comparison between MCSS in the private cloud (new method) and Gaussian CDO on desktop (traditional practice) for time step = 10

6.5 High performance simulation offered by Monte Carlo Simulation as a Service (MCSS) and the associated experiments

Three different sets of experiments were designed, and each set of experiments records execution time from 50,000 to 500,000 simulations. Using MATLAB 2009 the code can achieve up to 500,000 simulations in one go. Time step is fixed to 10 to accommodate large amount of simulations per attempt. Results for each set of experiments are recorded. All experiments are running under the same conditions and parameters. This means the average execution time is the performance indicator. In the experiments, all option calculations are completed between 18 and 22 seconds for all the platforms. The difference between the quickest (private cloud Southampton and London) and the slowest (desktop) platform is close to three seconds.

LSM is an optimisation technique to allow high-performance calculations to be completed in a short period of time, which explains why up to 500,000 simulations can be completed between 18 and 22 seconds. Although there are only a few seconds faster in terms of performance, the rate of improvement (using private cloud: Southampton and London for comparisons) stays at an acceptable rate. See Table 5 for results.

Table 5: the average performance improvement by adopting LSM for Clouds

Platform (use **private cloud: Southampton and London** as the one to compare)	Public cloud	Private cloud (Southampton)
Percentage of improvement	Private cloud is 11.64% better	Private cloud is 4.23% better

6.6 Integration of RMaaS and RAaaS for University of Southampton

This case study is about managing Cloud and utility computing to minimise costs and risks, and demonstrates how to integrate two services, RMaaS and RAaaS, so they can be viewed as a single service. RMaaS service includes three steps. The first step involves statistical service to compute several key data and variables, which are passed onto the second step, 3D Visualisation service, to present its cost-return analysis visually with actual return between 21 and 22% against expected return between 22.5 and 26%. The result is then passed to the third step, QA service, which checks data reliability and suggests implications from data analysis. Selected output from RMaaS together with management's data is passed on the first step of RAaaS, which offers VGP service to reduce errors and calculate the risk price. The outcome is passed to the second step of RAaaS, which offers LSM service to provide a precision technique to calculate the exact risk pricing and its maximum risk pricing. LSM also can compute 100,000 simulations per service to ensure an accurate and reliable result. This data is useful for University management board.

7. Discussions

BIaaS provides linkage between different types of services and this offers efficiency improvement and time reduction in business processes. Each sequence of activities in BIaaS is distinctive but different services in BIaaS can work together within the framework in which all services use data formats which are readable by others. Output from one process can be used by the next. In this way BIaaS is able to integrate different services and business activities and ensure a streamline process in place.

Benefits from BIaaS adoption include improvements in efficiency, cost reductions, improved risk analysis and connecting business activities together. These are demonstrated in two case studies. In the first, the University of Southampton derived benefits of computing cost-saving and risk analysis of Cloud adoption and integration of different activities from different departments.

7.1 How BIaaS can be used by organisations

Based on the analysis, the University of Southampton has gained the more positive impacts as a result of BIaaS. The cost-saving performance has an expected return of cost-saving between 22.5% and 26% and the actual return cost-saving is between 21.0 and 22.0%. This is above the business analysts' initial forecasts of around 10%, a basic forecast based on previous experience without adopting Cloud. With the QA process in place to ensure 3D analysis is of high quality, the added percentage of cost-saving is due to the use of virtualisation, Green IT policies and on-demand usage that can eliminate underutilised resources and ensure resources are only in use when there is a demand. RAaaS computes the risk prices using precision method which also has a good performance and reliability based on both experimental results and the user feedback. LSM is then used to calculate more accurate risk pricing with upper and lower limits identified using high-performing simulations. Our case studies also demonstrate how different layers of services such as PaaS and SaaS can be used together in an integrated way. The way BIaaS can be used by organisations and its key benefits and features are summed up in Table 6.

Table 6: How BIaaS can be used

Types of BIaaS	**Case studies**	**Key benefits to adopting organisations**	**What type of business orientation for service providers?**	**Additional features and remarks**
Integration of RMaaS and RAaaS	University of Southampton Cost-saving and risk analysis.	It can integrate different business activities. It can compute cost-saving, risk and any risk related analysis. It helps stake holders to make good decisions.	Consultancy. Service providers using a consolidated framework, can offer valuable consultancy to design and deploy Cloud services based on clients' needs.	This integration has a high research and commercial values. The benefits include improvement in efficiency, cost reduction, risk analysis and connect business activities altogether
Automated and secure Risk Software as a Service	University of Southampton	This service introduces three step process, which calculate risks in depth and also present them in 3D. Automation will ensure all three steps are done.	It can be consultancy or software contractor. Consultancy is a better model as SaaS development needs to fully understand business process and integration.	Simulations for EU crisis have been calculated and presented. This work is not for this paper.

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7.2 BIaaS: Operational risks for Cloud adoption

Operational risks in finance often mean risk to company operations including fraud, earthquakes, volcanoes, riots, damage to assets and damage to the company due to lawsuits (Hull, 2009;Lee et al., 2010). However, operational risks are referred as "the risk of Cloud adoption including how quick, efficient and experienced that a company can deliver services smoothly to the customers and stakeholders" (Lee et al., 2010). For example, a finance firm is new to the Cloud before their adoption. After the implementation of a Cloud service and extensive staff training, operational staff and business analysts become more experienced to use Cloud services. The risk to deal with their daily work such as calculation of risk and pricing is lower (but it still exists), because their tasks can be completed with a good quality in a reasonable amount of time frame. In addition, their calculations for predicted values are as close as to the actual investment values. If an operational risk value is 2.227, or 2.227%, it means there is an uncertainty of 2.227% that the calculated values for risk and pricing may fall outside of 95% of the confidence interval (CI) for the actual values.

Operational risks can be divided for internal and external uses. Their explanation is as follows.

- Internal: Calculate the operational risk for Cloud adoption, which meets the interests of the operational staff.
- External: Calculate the operational risk for clients. In this case, the type of operational risk is not Cloud but the clients' investments, which meets the business analysts' interests.

MCSS can be used for both internal and external calculations of the operational risk dependent on the source and availability of key variables.

The objective for operational risks is to demonstrate that Cloud adoption works well for the finance industry and improves work efficiency and allows calculations of risks and pricing (as their daily job) to be carried on smoothly. Additional benefits such as high performance calculation and simplification of the model without affecting accuracy can help justifying the benefits of Cloud adoption.

Calculating operational risk values are useful to inform the stakeholders about the status of the risk. Operational risks associated with Cloud adoption are important for stakeholders, in particular the finance industry which have experienced volatile and uncertain periods. The use of BIaaS services allow to compute operational risks for Cloud adoption effectively and accurately, thus saving the Cloud-adopting organisations time and resources to compute.

7.3 BIaaS: The Next Generation of Statistical Services

It is common for scientists to present their work with statistical analysis which may become difficult to reproduce the same experiments under the same conditions. Statistical analysis also takes time and effort to interpret the data and understand the implications of the analysis. There is a long process involved to understand fully the data, including any hidden or unexploited areas. The use of 3D Visualisation can help to discover any unexploited data (Chang et al., 2011 a; 2011 b; 2011 c; 2012 a; 2013 b). However, statistical analysis should also provide "statistical visualisation" service at the end of the computation, which explains why the next generation of statistical analysis is required for BIaaS. The benefits include the followings:

- Present complex data into a format which can be easily understood.
- Compute data (prior quality assurance process) in a way that a pre-screening process of visualisation and quality assurance service.
- Improve the existing process and methodology adopted by the quality assurance process.
- Compute results and also present visualised statistics at the same time to improve efficiency.

Figure 5 shows the Next Generation of Statistical Services (NGSS) for the University of Southampton. BIaaS can groups thousands of datasets into groups and then computes them for RMaaS services. There are 42 groups altogether, where each group has 50 sets of datasets which contains different key input variables for analysis. The term "observations" is used to describe the statistical behaviour of these 42 groups of datasets which checks whether all data records are consistent with each other. The observations presented in Figure 5 confirm that data records are consistent with each other, which also agree with computational analysis in Section 5.3 about the data consistency. The computational results in Section 5.3 have low standard error and mean square errors, which mean that there is a good data consistency between datasets and also they are close to the mean values. The future plan for 2013 is to consolidate the development of NGSS to ensure that all computation including statistical analysis and 2D/3D

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Visualisation can be completed within 5 seconds for grouping and computing thousands of datasets. Further results will be published in the coming year.

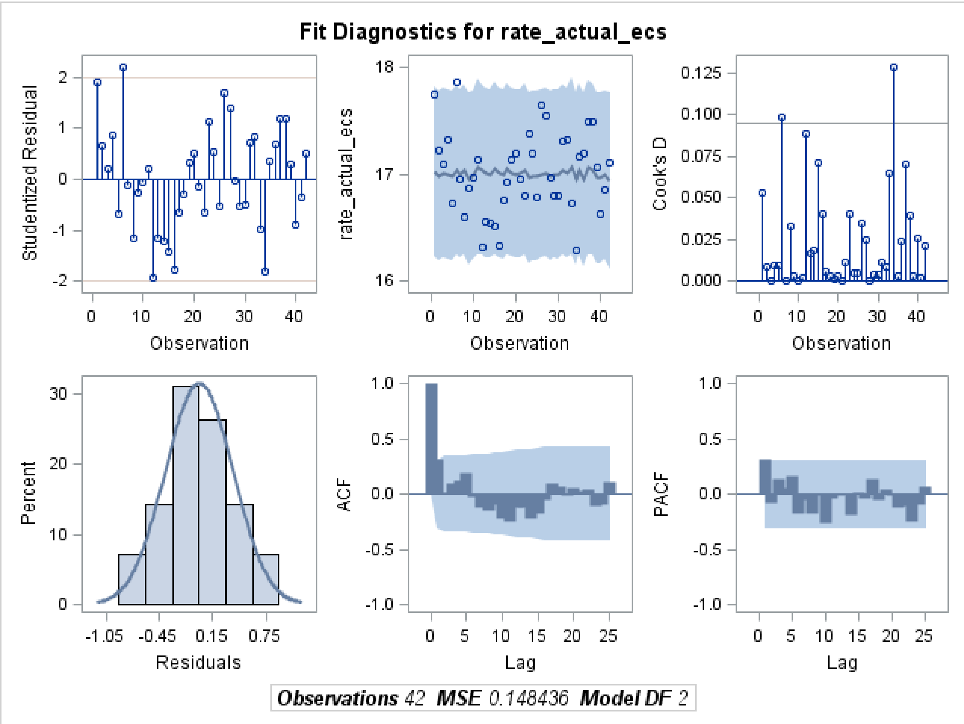

Figure 5: The Next Generation of Statistical Services for the University of Southampton

8. Conclusion

This paper presents Business Integration as a Service (BIaaS). Its objective is to connect different services together into an integrated environment, with the output of one service being used as input to the next bringing business activities together. The combined use of Risk Analysis and Quality Assurance also allows risk control and data quality to be reviewed and monitored which helps management to make good, informed, decisions. The use of Organisational Sustainability Modelling (OSM) helps to compute RMaaS and provides accurate and reliable results. The analysis also helps the University of Southampton to understand their extents of cost-saving and operational risks as a result of Cloud adoption. The use of Monte Carlo Simulation as a Service (MCSS) helps the University of Southampton to calculate risks rapidly, accurately and conveniently, with the support of the experimental results.

A BIaaS case in this paper shows BIaaS in action integrating RMaaS with RAaaS at the University of Southampton. At University of Southampton this has reduced the level of manual data extraction and enabled management to quantify the extent of its cost-saving compared with associated risks so that stake-holders could make the right decisions. Risk price calculations presented this way have been useful for stakeholders, who are reported to fully understand the analysis and implications offered by BIaaS. They are aware of operational risks associated with Cloud adoption and also ensure a consolidated process is always in place to improve on the return-risk status. Future plan also includes the consolidation of the NGSS service to allow computation of thousands of datasets can be completed accurately and rapidly.

The key advantage of adopting BIaaS is to allow different services to be performed, computed and managed in one platform. This saves time and resources compared with performing activities at different times and locations. It improves efficiency, and consolidates streamlining of processes and communications between different departments of large organisations.

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