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TOWARDS A STRUCTURED CLOUD ROI: THE UNIVERSITY OF SOUTHAMPTON COST-SAVING AND USER SATISFACTION CASE STUDIES

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Abstract: Organisational Sustainability Modelling (OSM) is a new way to measure Cloud business performance quantitatively and accurately, and is a key area offered by Cloud Computing Business Framework (CCBF). OSM combines statistical computation and 3D Visualisation to present the Return on Investment (ROI) arising from the adoption of Cloud Computing by organisations, and makes use of a highly structured and organised process to review and evaluate Cloud business performance. The School of Electronics and Computer Science (ECS), University of Southampton, focusing on cost-savings, is the case study used to illustrate. In addition, i-Solutions and Corporate Planning of the University of Southampton, focusing on user confidence level and service improvement, are another two case studies to support. Data measurements have been taken in the past three years and quantitative analysis has been carefully checked and calculated by OSM to measure ROI. The University of Southampton has achieved cost-saving and user confidence with service improvement offered by Cloud adoption and services, which have been deployed by several universities in the adoption of CCBF.

1. Introduction

Cloud Computing (CC) provides added value for organisations; saving costs in operations, resources and staff as well as new business opportunities for service-oriented models (Briscoe and Marinos, 2009; Schubert, Jeffery and Neidecker-Lutz 2010; Chen et al., 2010). In addition, it is likely that cloud computing focusing on operational savings and green technology will be at the centre of attention. Achieving long-term sustainability is an important success factor for organisations (Chang, Mills and Newhouse, 2007), particularly in an economic downturn. This makes cost-saving a common organisational goal across different sectors. Cost-saving offered by CC is a key benefit acknowledged by academia (Buyya et al., 2009; 2010; Celik; Holliday and Hurst; 2009; Khajeh-Hosseini, Greenwood and Sommerville, 2010; Schubert, Jeffery and Neidecker-Lutz 2010) and industrialists (Creeger, 2009; Dunn 2010; Oracle, 2009, 2010).

The definition and deployment of ROI varies in different sectors and research institutes. Our ROI measurement is a systematic and innovative methodology based on

i. Nobel-prize models such as the Capital Asset Pricing Models, CAPM (Sharp, 1990);
ii. the use of economic and statistical computation for data analysis (Chang et al., 2010 b; 2011 b; 2011 c)
iii. the use of 3D visualisation to present cloud business performance (Chang et al., 2010 b; 2011 b; 2011 c) and finally
iv. a unique way to use Quality Assurance (QA) to improve the quality of data and research outputs (Chang et al., 2011 b; 2011 c).

This leads to the development of Organisational Sustainability Modelling (OSM) which is designed to measure cloud business performance (Chang et al., 2011 b; 2011 c). Using OSM offers the following two advantages: (i) it allows performance reviews at any time; and (ii) it provides strategic directions and added-values for adopting the right types of cloud business for sustainability.

The structure for this paper is as follows. Section 2 presents a completed framework and how it can be used to measure ROI. Section 3 describes the University of Southampton case study and our methodology to analyse data. Section 4 presents another two case studies from other two departments in the University focusing on User Satisfaction, explaining how data analysis via OSM and 3D Visualisation can be presented. Section 5 lists seven topics of in-depth discussions. Section 6 describes our Conclusions and proposes future work.

1.1 Cost-Saving offered by Cloud and its influence to operations management

Cost-saving offered by Cloud Computing is a key benefit acknowledged by academia (Buyya et al., 2009; 2010; Celik; Holliday and Hurst; 2009; Khajeh-Hosseini, Greenwood and Sommerville, 2010; Schubert, Jeffery and Neidecker-Lutz 2010) and industrialists (Creeger, 2009; Dunn 2010; Oracle, 2009, 2010). It is one of the reasons for its popularity and organizational adoption in economic downturn.

From the academia point of view, Buyya et al. (2009) introduced Service Level Agreement (SLA) led cost saving models and explain how to calculate in detail. Further to their work, Buyya et al. (2010) introduce a Return of Investment (ROI) power model, which can calculate power cost-saving and also present it using 3D visualisation. Celik, Holliday and Hurst (2009) introduce their Broadcast Clouds techniques which allow communications and cost-savings. They use simulations to support their proposal. Khajeh-Hosseini, Greenwood and Sommerville (2010) use qualitative research methods to explain how industry can save costs. They present case studies of two companies and demonstrate cost-saving in infrastructure costs, and support and maintenance costs. Schubert, Jeffery and Neidecker-Lutz (2010) present an overview and opportunities including cost-saving for the EU, and presents cost-saving as an added value offered by Cloud Computing. In the industrial practices, CA Technologies (a global IT firm) use cloud for cost-saving including: US $6.5 million for labour costs; and US $2.4 millions of operational costs in 5 years; and closure of 19 server sites. This allows CA Technologies to consolidate their infrastructure and remove maintenance costs such as staffing and resource expenses (Dunn, 2010). Similarly, Oracle faced a similar challenge after acquiring Sun Microsystems, and they consolidated their infrastructure, resources and migration with Cloud Computing. After spending about six months of transition period, both Oracle and Sun Microsystems are able to share and use the similar level of IT resources and data centres before acquisition, instead of doubling its size. This is largely due to virtualization. Many of their servers and services are in clusters of virtual machine (VM) farms, facilitating effective management from architects and management (Oracle 2009, 2010).

1.2 Selective models in Green IT

More organisations have used Green IT to manage their resource consolidation, cost-saving and operational management. There are innovative approaches as follows. Firstly, Butler (2011) introduce his Compliance-to-Product (C2P) application model, allowing regulations, policy, technologies and processes to be maintained and managed between manufacturers, organisations and external collaborators. Garg and Buyya (2011) describe a comprehensive review about Green Cloud Computing, and explain a typical usage model for how it can be achieved. They also present a Green Cloud Architecture to explain their rationale, and they use a Case Study to support their Architecture. Thirdly, Zhang, Liu and Li (2011) propose a goal requirements language (GRL) model to review and present efficiencies in Green IT. Despite their presentation is focused on conceptual model and workflow, they also show that calculations for carbon footprint and cost saving can be done in a quantitative way by using their GRL model.

GRL model is a way to demonstrate how Return on Investment (ROI) can be presented quantitatively. However, the Zhang, Liu and Li (2011) do not show detailed example for how these data is measured and calculated, which is a core area that need be explained, where Buyya et al. (2010) demonstrate how they define and compute their calculations. Chang et al. (2010 b; 2011 b; 2010 c) demonstrate that their Organisational Sustainability Modelling (OSM) can help organisations to measure its ROI which include a highly structured methodology and the use of statistical computing and 3D Visualisation. These advanced techniques are described in their proposed Cloud Computing Business Framework (CCBF).

2. The Role of Cloud Computing Business Framework (CCBF)

Chang et al. (2011 a; 2011 c; 2011 d) demonstrate three business challenges while deploying and migrating organisational infrastructures, applications and services over Cloud. This is the main motivation of proposing Cloud Computing Business Framework (CCBF), which aims to help organisations achieve good Cloud design, deployment and services. The core concept of CCBF is an improved version from Weinhardt's et al. (2009 a) Cloud Business Model Framework (CBMF) where they demonstrate how technical solutions and Business Models fit into their CBMF.

The Cloud Computing Business Framework is a highly-structured conceptual and architectural framework to allow a series of conceptual methodologies to apply and fit into Cloud Architecture and Business Models. The CCBF can provide the most suitable approaches and methodologies. It has the following objectives.

- Classification of business models to offer Cloud-adopting organisations right strategies and business cases.
- Offer a framework to review cloud business performance accurately.
- Deal with communications between desktops and clouds, and between different clouds offered by different vendors, which focus on enterprise portability.
- Provide linkage and relationship between different cloud research methodologies, and between IaaS, PaaS, SaaS and Business Models.

Chang et al. (2011 a; 2011 b; 2011 c; 2011 d) demonstrate that CCBF has four key areas to work with: (i) Classification; (ii) Organisational Sustainability; (iii) Portability and (iv) Linkage. This paper focuses on the second key area, Organisational Sustainability. This includes modelling to review and evaluate cloud project performance in the past and present, and enables forecasting for cloud businesses in the future. Organisational Sustainability Modelling (OSM) is suitable for all IaaS, PaaS and SaaS. CCBF fits well in our research investigation in relations to Green IT and cost- saving, which fit for OSM.

2.1 Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model (CAPM) is a model to calculate investment risks and to determine what the expected return on investment is. In the context of cloud computing, it is a quantitative model for organisational sustainability. CAPM was introduced by Jack Treynor in 1961, William Sharpe in 1964, John Lintner in 1965 and Jan Mossin in 1966, based on Harry Markowitz' work on diversification and modern portfolio theory. CAPM divides risk into two groups. The first group is Systematic Risk (also known as beta), the market of which cannot be diversified away, including recessions and interest rates. The second group is unsystematic risk, the risk of which is specific to individual stocks and can be diversified and managed by investors (Hull, 2009). In CAPM, beta is the only relevant measure of a stock's risk and measures a stock's volatility.

In some interpretations, the security market line (SML) is used to calculate the reward-to-risk ratio. When the expected rate of return for any security is deflated by its beta coefficient, the reward-to-risk ratio for any individual security in the market is equal to the market reward-to-risk ratio, thus:

$$(r - r_f)/\beta = r_m - r_f \quad (1)$$

$$(r - r_f) = \beta (r_m - r_f) \text{ [the security market line (SML)].}$$

Finally, to best represent CAPM, the formula is given as:

$$r = r_f + (\beta \times (r_m - r_f)) \quad (2)$$

where r is the expected return of a capital asset
r_f is the risk free rate
r_m is the expected return on the market and
β is the beta of the cash flows or security being valued.

The term $r_m - r_f$ is the market risk premium, which is usually considered implicitly rather than explicitly. Therefore, the term $\beta \times (r_m - r_f)$ is the risk premium on the cash flows (or security) being valued. CAPM example: If the risk-free rate is 1.0%, the beta (risk measure) of the firm is 1.5 and the expected market return over the period is 3%, the stock is expected to return (1.0%+1.5(3%-1.0%)) = 4.0%.

2.2 The 3D organisational sustainability modelling and other systems

The CAPM modelling is represented by statistical computation, which needs advanced techniques to present results in visualisation. Although more data can be analysed, a drawback with statistical computing is that more data are generated and often this requires statisticians to understand and further analyse the outcome, and more results and more data are generated. The 3D visualisation can simplify the data analysis process, and it becomes more common to present data in visualisation format in some Web Services, Grid and Cloud research (Pajorova and Hluchy, 2010). Selected results computed by CAPM can be used for 3D Visualisation, which is enabled by Mathematica. While referring back to the market standard for business performance, the stock market is widely accepted and presented business performance in 2D format. Despite stock market is an indication for business performance, it is not a fair system as stock markets are subjective to speculations and a great extent of fluctuations in particular to volatile and uncertain economic periods (Prechter and Parker, 2007). On the other hand, Service Level Agreements (SLA) are often used to present cloud business performance. A drawback is that SLA tends to review cloud business at operational level in terms of usage per hour (Buyya 2009, 2010), which lacks of strategic directions for achieving cloud sustainability. This means SLA approach permits calculation of a periodic income over time from usage scenarios, however, if the business models are not proposed and executed according to the winning strategy, income over time can be low or below investors' expectations.

To present cloud business performance best, a graphical and dynamic system independent of human-oriented speculations is ideal, and this also provides the best correlation between the organisational focus, strategies and data related to each organisation's cloud computing business models.

2.3 Organisational Sustainability Modelling

Organisational Sustainability Modelling (OSM) is based on the CAPM which is the analysis of return and risks for organisations or projects. Chang et al. (2011 a; 2011 b; 2011 c) demonstrate how OSM can be used to measure Cloud business performance for SAP, Vodafone/Apple and two projects in National Health Services, UK. The proposed approach is to divide return and risk in three areas: Technical, Costs (Financial) and Users (or clients) before and after deploying cloud solutions or products/services. In some context, it can be defined as expected return and actual return. The data to be collected are dependent on organisational focus, which is flexible dependent on different characteristics for any type of technical or business cloud solutions. In this paper, the focus is on Costs and Users from three different departments at the University of Southampton, and they are as follows:

- Technical: This can be improvements in performance, or improvement in reliability, or any added values or technical gains supported by experiments. This type of data is easier to obtain as experiments can be performed by researcher or collaborators. Risks can be time reduction or percentage of break down or relevant technical risks.
- Costs (Financial): This can be profits, or cost-saving gains, or any fund related. Risks can be loss, or sharp rise in operational or electricity costs.
- Users (or clients): This may mean increases in user confidence, or user community growth or user related area. Risks include reductions in user confidence or numbers or community growth due to factors such as funding, or quality of software, etc.

2.4 Organisational Sustainability – how does it fit into the CCBF

Figure 1 show the simplified CCBF diagram and explains how Organisational Sustainability fits into the CCBF. Organisational Sustainability is relevant for all organisations adopting or selling Clouds, whether they are IaaS, PaaS and SaaS. Refer to yellow boxes in Figure 1.

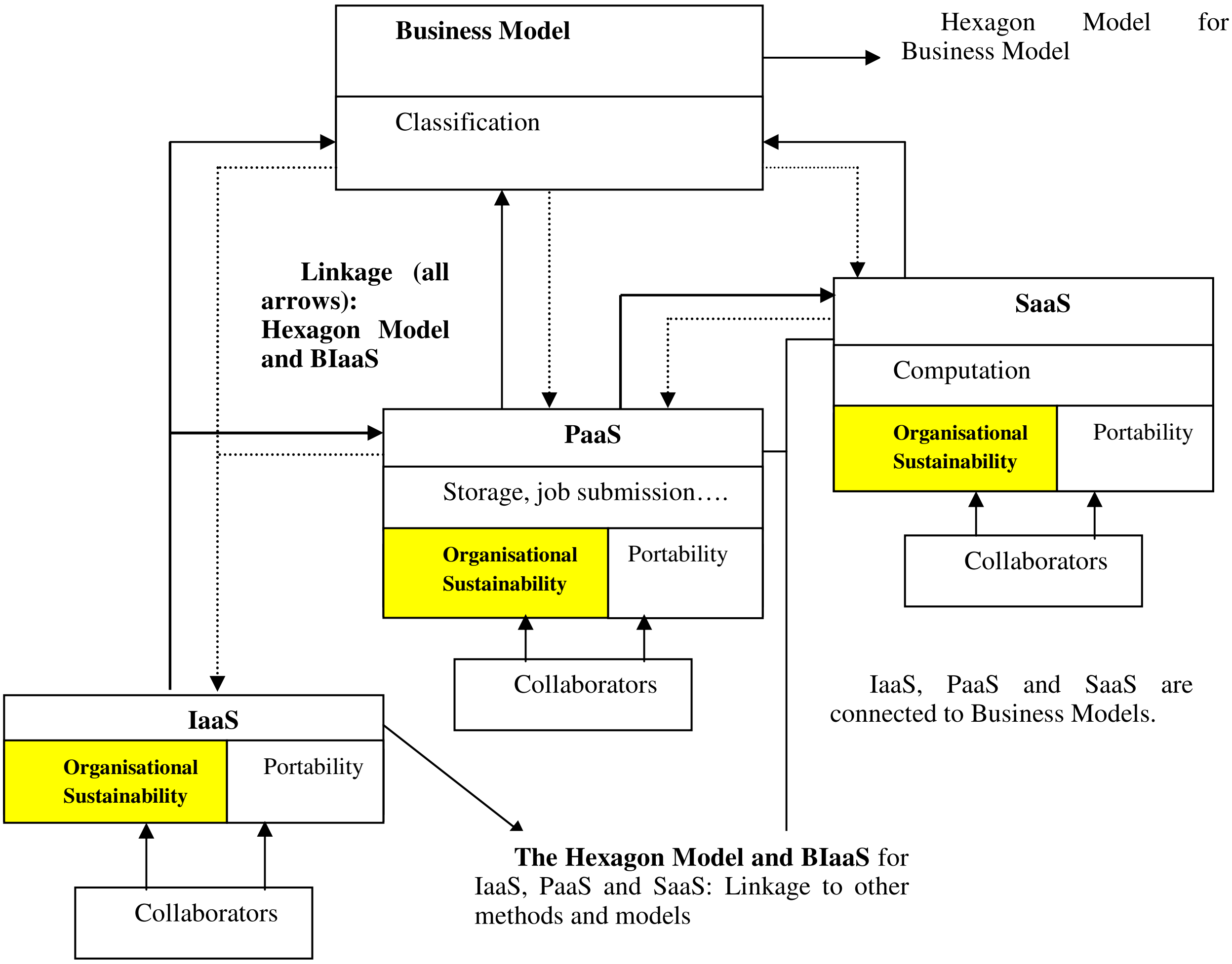


Figure 1: The Cloud Computing Business Framework (CCBF) highlighting Organisational Sustainability

3. The University of Southampton – Cost-Saving offered by Green Cloud Computing

The School of Electronics of 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 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 used as virtual machines (VM) running on private clouds.

This project has two case studies. The first case study is cost-saving, which is the focus in this paper. The second case study is technical added values such as efficiency improvement and time reduction to complete tasks, is in the process of data analysis.

3.1 Our approach

Measuring ROI requires a structured process, which is useful to begin with during data collection and data analysis, to ensure the quality of presentation. Our ROI approach is a structured process and is divided into three stages, and is described as follows.

- Stage 1: This stage is to identify the cloud project focus of ECS and to define what to measure over a period of time. The focus is cost-saving, which mainly includes cost-saving from reduced electricity consumption (and bill). No account is taken of any cost-saving due to reduced staffing costs. Three years data is obtained detailing the electricity consumption and bills for ECS facilities. This requires analysing electricity consumption (and bills) for ECS servers and storage. The data between November 2007 and June 2010 is used for analysis. Joint effort with the ECS IT and Facilities Teams 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 the two years 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 CAPM 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. CAPM statistics then computes the actual and predicted values of analysis in linear regression. The predicted values can be used as an expected result in the next phase. In addition, the data is then used by Mathematica to create a 3D visualisation of the results. 3D Visualisation simplifies the process of analysis; all analysis can be visually presented, enlarged and rotated in 3D format. The Quality Assurance (QA) process is based on advanced statistical methods to verify data presented in 3D Visualisation has reliable and high quality and accuracy (Chang et al., 2011 b). Similarly, the user data from the i-Solutions Group is used for statistical analysis to interpret the impact and benefits offered by Cloud and HPC services. 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 ISS, the data used for comparison was from September 2010 and January 2011.

The collected data covers November 2007 to July 2010. CAPM can be modelled by statistical languages, in which SAS is a statistical computing language more suitable than others since it can compute more in-depth analysis (Chang et al., 2010 b). SAS code is written to predict the Risk Premiums of an organisation, ECS versus the Market (expected values).

Table 1: Regression summary of ECS cost-saving

```
ECS cost-saving CAPM        The AUTOREG Procedure
Dependent Variable r_ecssave Risk Premium for ECS cost-saving
                 Ordinary Least Squares Estimates
SSE              5.9374272    DFE              40
MSE                0.14844    Root MSE         0.38527
SBC             44.4976402    AIC              41.022301
Regress R-Square       0.0077    Total R-Square       0.0077
Durbin-Watson          1.2838    Pr < DW              0.0079
Pr > DW                0.9921
                        Standard          Approx
Variable   DF Estimate  Error  t Value  Pr > |t|  Variable Label
     Intercept  1    18.6120    2.8950    6.43   <.0001
     r_mkt      1    -0.0783    0.1410   -0.56   0.5817 ECS cost-saving Risk Premium for Market
```

The data is carefully calculated and examined with data consistency and coding algorithms. Thirty two months of in-depth data can best represent sustainability from the initial phase to establishment. The SAS program for the CAPM is coded to plot required data with a suitable regression method. Table 1 shows a summary of this statistical computing.

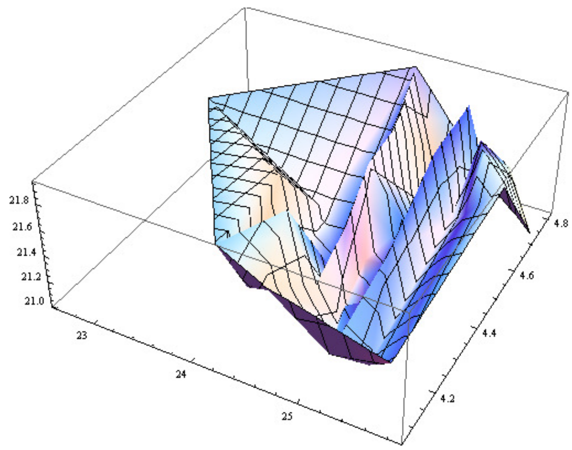
Market is referred as the Expected values. The risk-free rate in this case study means the minimum operational costs in staffing and IT resources. ECS confirms their risk-free rate is reliable, and thus the risk premium is the difference between the expected values and risk-free rate. Table 1 presents the result of auto linear regression summary with Ordinary Least Squares used (OLS), which calculates accurate estimates. The lower the Mean Square Error, the more accurate the regression result. Durbin-Watson is also used to test auto-regression and accuracy of the output. CAPM statistics then computes the actual and predicted values of analysis in linear regression. The predicted values can be used as an expected result in the next phase.

3.2 3D Visualisation for ECS Cost-saving Model

Further statistical analysis can be computed. This requires advanced statistical skills and also needs to analyse more data from results of statistics. Our major contribution in this project is to present complex statistical analysis using 3D Visualisation, so that no data can be missed for analysis, and also those without advanced statistical backgrounds can understand. This is useful for many decision-makers and directors who need to know business analytic results quickly but do not wish spend too much time to understand them. Chang et al (2010 b; 2010 c; 2011 b; 2011 c) have described how 3D Visualisation techniques are used to present Cloud business performance and quantitative ROI for their collaborators, which include National Health Service (NHS) UK in its two healthcare cloud projects, and organisations such as Vodafone/Apple, SAP, and OMII-UK.

Data from statistical analysis is used for computation, where data is computed in Mathematica. The 3D visualisation models are presented in Figure 2, which is the default 3D model that indicates a high return of cost- saving between 21 % and 22% on the y-axis, which is significant reduction in operational costs. It also shows the expected cost-saving between 22 and 26% on x-axis. The z-axis presents risk-free rate (4.0-5.0%), which means minimum expenses to keep operation running. This percentage range can guarantee cost-savings.

3D visualisation takes minimum operational costs (risk-free rate), which include minimum staffing costs, are presented as z-axis. With Cloud Computing, statistics can analyse the cost-saving from consumption and resources required. But the 3D calculation takes hidden areas such as staffing costs into consideration, which means fewer people are required to do the same amount of work. Similarly, Buyya et al. (2010) and Pajorova and Hluchy (2010) use similar 3D Visualisation techniques to present Cloud Computing analysis and challenges.



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

Figure 2: 3D visualisation for ECS Cost-saving

4. User Satisfaction – an important aspect

User satisfaction is an important aspect in organisational Cloud computing adoption. Chowhan and Saxena (2010) explain the role of Customer Relationship Management (CRM) in their customer life cycle (CLC) perspective. They believe using CRM in CLO and Business Strategy perspective can improve customer satisfaction, and eventually exceed their expectations. Nick, Cohen and Kaliski (2010) explain the development of virtual private clouds also require good user satisfaction to guarantee the delivery of Cloud projects.

4.1 i-Solution Group, University of Southampton User Data and Analysis

The i-Solutions Group (providing Information Systems and Services) of the University of Southampton have offered Cloud Computing, Grid Computing and HPC services for students and staff since 2007 through a number of pioneering projects, which have proven successful and popular. Those services were officially resumed in 2008, serving thousands of users across different campuses for different needs and challenges. The user feedback and rating have been recorded since 2008. We have obtained three years of data between 2008 and 2011 to study the impact of the Cloud Computing and HPC services for University staff and students, particularly more comprehensive data is available for 2009-2010, and 2010-2011 rating. The main objective of this investigation is to identify the level of user satisfaction, as it is an important factor for achieving good Cloud design, deployment and services (Chowhan and Saxena, 2010). The approach is identical to Section 3.1 with Stage 1 and 2 in place, with the difference in the Stage 3, which collected data between April 2009 and March 2010 by i-Solutions, which used surveys for metrics collection with focus in three aspects: (i) Service Rating; (ii) User Confidence and (iii) Overall performance. Out of all responding surveys, there are 817 valid entries, see Table 2. There are additional questions in each section to measure detailed extent of performance comparing to the previous year.

Table 2: i-Solutions, University of Southampton data overview between 2009 and 2010 (817 valid entries)

	Excellent	Good	Adequate	Poor
Service Rating	16%	44%	27%	13%
	Complete	Some	Little	None
User Confidence	31%	51%	14%	4%
	Better	Same	Worse	
Overall performance	44%	48%	8%	

In terms of Service Rating, 87% of respondents have positive comments about the use of Cloud computing for resources and services, which include 16% for 'Excellence', 44% for 'Good' and 27% for 'Adequate'. User Confidence has obtained 82% of support, which include 31% for 'Complete', and 51% for 'Some'. Overall performance for Cloud adoption is encouraging, as it indicates of 44% of better performance, although 48% of respondents still feel the same. Some survey questions also record the rationale of choosing those answers, and details of these data analyses are presented in Section 5: Discussions.

4.2 Corporate Planning, University of Southampton Data and Analysis

Another user survey led by the Corporate Planning of Southampton University took place in March 2011 to measure the user satisfaction rating between 2010 and 2011. Corporate Planning overviews the University's business strategy where Cloud Computing is a core area, in particular providing a good quality of infrastructure and related services. The research method is based on survey with one month spent for data collation. There are 914 valid responses and at least 908 respondents answered all the questions. Table 3 is the summary of some data analysis agreed and supported by Corporate Planning.

Table 3: User satisfaction data between 2010 and 2011, by Corporate Planning, University of Southampton

a. I have adequate access to the equipment necessary for my research. Service rating: 5 is the highest and 1 is the lowest score. Accessibility (3 out of 5 and above): 93.32%	1	2	3	4	5	NA
Percent	1.64%	5.03%	13.58%	37.68%	38.23%	3.83%
Number of respondents	15	46	124	344	349	35
b There is appropriate financial support for research activities Enough financial support (3 out of 5 and above): 75.88%						
Percent	6.50%	10.13%	15.64%	29.62%	30.62%	7.49%
Number of respondents	59	92	142	269	278	68

c There is adequate provision of computing resources and facilities Availability (3 out of 5 and above): 89.11%						
Percent	1.43%	6.59%	11.98%	32.08%	45.05%	2.86%
Number of respondents	13	60	109	292	410	26
d I have the technical support I need Sufficient support (3 out of 5 and above): 89.53%						
Percent	1.54%	4.96%	16.52%	37.00%	36.01%	3.96%
Number of respondents	14	45	150	336	327	36

Table 3 refers to the user satisfaction rating between Year 2010 and 2011, and there are four areas of focus. The first area is accessibility, which 93.32% of all users have rated a score of 3 and above (scale of 1 to 5). There is also enough financial support for Cloud or computing related research events, where 75.88% of respondents have rated a score of 3 and above. Availability is the third focus, where 89.11% of them, with score of 3 and above, feel there is always adequate provision of computing resources and facilities. Support is the fourth focus, where 89.53% of respondents, with a score of 3 and above, are satisfied with services they have received.

4.3 Statistical Computational Analysis

Organisational Sustainability Modelling (OSM) helps large scale data analysis and presentation of complex data in the form of statistical computation and 3D Visualisation, the later of which simplifies the process of analysis. In addition, no hidden area can be missed in visualisation and all the key data can be found and analysed in the 3D domain. Our 3D Visualisation also supports 360 degrees rotation so it assists in any aspects of analysis and further investigation. The data from i-Solution is for 2009-2010 data and the data from Corporate Planning is for 2010-2011 data. These datasets are complementary to each other, since they are to measure how Cloud Computing services are used and rated by users. The objective is to extract and present data, which is not directly and explicitly interpreted from the survey. Therefore, both datasets are jointly used for statistical analysis, where the key data is computed by 3D Visualisation. User satisfaction is a core strategy and a crucial factor for the University of Southampton to succeed with Cloud and IT projects. See Table 5 for details.

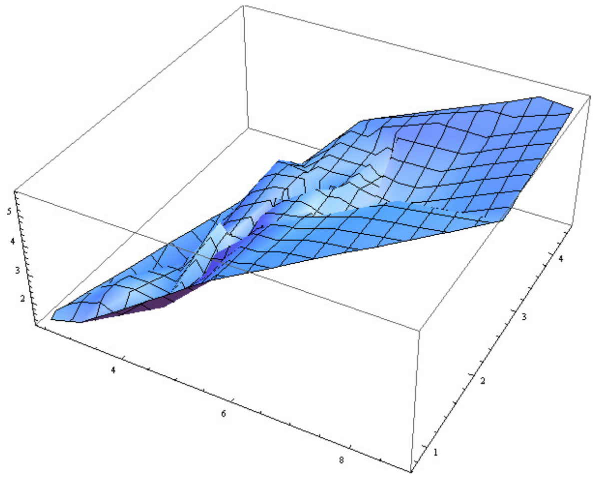
Table 5: Regression summary of Southampton University user satisfaction.

```
Southampton User Confidence and service improvement CAPM        The AUTOREG Procedure
Dependent Variable        r_sotonuser
                          Risk Premium for user confidence and service improvement

        Ordinary Least Squares Estimates

    SSE                 15.0740045        DFE                 55
    MSE                 0.27407           Root MSE            0.52352
    SBC                 94.0305602        AIC                 89.9444577
    Regress R-Square    0.5500            Total R-Square      0.5500
    Durbin-Watson       1.3394            Pr < DW             0.0040
    Pr > DW             0.9960
NOTE: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative
autocorrelation.
                          Standard          Approx
    Variable    DF   Estimate    Error   t Value  Pr > |t|  Variable Label
    Intercept    1   -0.8571     0.2017   -4.25    <.0001
    r_mkt        1    0.5535     0.0675    8.20    <.0001   Southampton Risk Premium for Market
```

The next step is to identify the level of service improvement, which provides useful feedback to organisations adopting and providing IT services such as Helpdesk (Office of Government Commerce, 2007; Hanna et al., 2009). Understanding the extent of improvement is essential for continuous service improvement and is a good indication for cloud business performance measurement, the second key area in the CCBF. Some of data are from Table 5. Data has been carefully examined and analysed. They are computed in Mathematica to present the result as 3D Visualisation. Based on our data, user satisfaction is largely dependent on user confidence and service improvement, which is a key indicator in our analysis. Modelling based on CAPM is often used as actual return versus expected return along with the risk-free rate. Figure 3 shows the 3D analysis and Figure 4 shows its 90 degrees rotation. The x-axis reflects actual rate of return, user confidence and service improvement between 3.4% and 8.4%. The y-axis reflects expected rate of return, user confidence and service improvement between 1.2% and 5.8%. The z-axis shows risk-free rate between 0.8% and 4.4%. In this case, risk free rate refers to the areas of services that the University will always receive highest rating, and often this refers to response time to incidents or requests within the time frame defined in the service level agreement.



x-axis: Actual Rate of Return - User confidence and service improvement (3.4% - 8.4%)
y-axis: Expected Rate of Return - User confidence and service improvement (1.2% - 5.8%)
z-axis: Risk-free rate (0.8% - 4.4%)

Figure 3: 3D Visualisation for user confidence and service improvement

90 degrees rotation

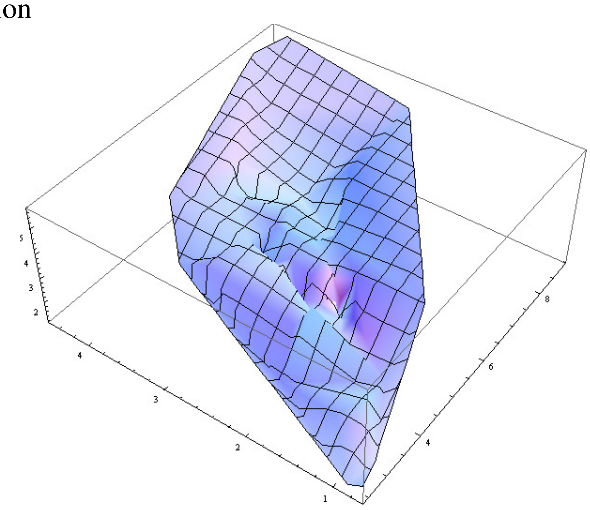


Figure 4: 3D Visualisation for user confidence and service improvement, 90 degrees rotation

The extent of service improvement is a straight line with an upward movement. This shows the level for service improvement is continuously progressive and heading upwards. Explanations are likely due to two reasons. Firstly, services offered by Cloud is challenging for operational and service management. The incremental improvement already suggests good progress has made. Secondly, some users may feel positive experience about Cloud services, infrastructure and platform, and they have increased their user confidence level, which includes reduction in time and resources spent on the University IT and Cloud services.

5. Discussions

There are also seven interesting discussions. The first discussion asserts there is difference between technical and user perspective towards availability. Users may still find if they are uncertain about the procedures, they need prompt consultation, and do not feel this service is available for them to complete their tasks. The response times to deal with user requests and complete tasks are thus important. The second discussion confirms the positive ROI for the University of Southampton and a popular Cloud adoption in Education. The third discussion presents a structured QA process for data analysis and is supported by Continuous Assurance that offers additional benefits. The fourth discussion introduces Business Integration as a Service (BIaaS), which links different processes and functions together into an integrated platform, with the end result of one process used as the input of another. The fifth discussion addresses the greater role of Green Cloud Computing for Education. The sixth discussion summarises case studies and contributions offered by OSM of CCBF. The final discussion is the comparison between OSM/CCBF and other methods and approaches, where OSM and CCBF can provide more added values.

5.1 Availability defined by SLA versus availability perceived by users

Many papers assert that availability is defined as the up time for services, and should stay close to 100% (Ambrust et al., 2009; Buyya et al., 2009, 2010; Brandic et al., 2009). This is true for the service provider's perspective and all services are available at all times and are accessible by different means. Our data suggests there is only 89.11% availability from users' perspective, and this is considered a good result based on users' feedback. However, the discrepancy between the ideal and users' availability is about how services are handled and managed. Service providers assume a near 100% up time for different types of services. In users' perspective and based on our data, they count the number of incidents that they need further enquiries and support from services. Although numerous services have the ability for automation or features with self-service, a large percentage of users still prefer to consult for help when problems arise, or they have difficulty using self-services. In this case, the response time for each incident or request is important. The University of Southampton is considered above average compared with most of Universities because if the problems happen outside normal office hours, they can respond to the issues and keep users up-to-date. Our data analysis suggests there is a different perception of service availability between technical and users perspectives, and fast response time within acceptable hours to complete the tasks are crucial to retain user satisfaction.

5.2 Cloud migration and services for Education

JISC UK has announced Cloud Computing is increasingly attractive for research and education, and they state there are five reasons for University adoption (JISC, 2011). The use of Cloud adoption offers a greater Return on Investment (ROI), where Chang et al. (2011 a, 2011 b, 2011 c) have demonstrated how Cloud Computing and the use of CCBF helps organisations to obtain a good rate of ROI. This helps more Cloud migration and adoption in Education. The University of Southampton, King's College London (KCL) and the University of Greenwich have followed CCBF for Cloud design, deployment, migration and services. Two Southampton case studies have been used for this paper where 21% -22% of cost-saving is achieved by ECS, and also 1.2-5.8% increase in user confidence and service improvement is experienced by i-Solution and Corporate Planning, which represent encouraging rate of satisfaction and additional values experienced by students and members of staff. 3D Visualisation also confirms there is a progressive improvement in user confidence and service throughout 2009 and 2011, so that investment in user support and service improvement should be maintained.

Other case studies in educational Cloud adoption are as follows.

- Storage Cloud and self-serviced infrastructure have helped KCL and National Health Service (NHS) UK to improve efficiency and streamline a good process for IT services (Chang 2009, Chang et al., 2011 b).
- University of Greenwich has three projects that use Cloud resources for development, and this includes Sharepoint development and migration, media server and e-learning development and e-procurement and e-supply chain. These three projects are still in further development with a good progress reported (Chang et al., 2011 d; 2011 e).
- The National Grid Services (NGS) UK has deployed Cloud infrastructure and is ready to provide Cloud-related services for scientists and researchers across the UK (Chen et al., 2010).

5.3 The Quality Assurance process and Continuous Assurance for business

Data quality is an important aspect because it checks for data structure and consistency, and rectifies any errors, thus quality of data is improved on an ongoing basis. It ensures statistical analysis, whether in computational or visualisation format, is at a high quality of research output (Chang et al., 2011 b). QA process must be improved and made as efficient as possible. This means time reduction to deliver the same level of services using a tool, and/or automation. Our data (that correlates to 3D Visualisation) have undergone a structured process, and all data are thoroughly tested with STATA 11 and selected regression techniques to ensure a high quality of data analysis. Chang et al. (2011 b) streamline and demonstrate a good process for their QA, which include

- Review all the data generated by SAS, and determine what need to be further analysed;
- If we are uncertain what needs to be further analysed, then use STATA for testing regression to double check;
- Determine what needs to be further analysed, and make them into a format readable by Mathematica;
- Use Mathematica to compute dynamic 3D Visualisation
- Use STATA to double check the validity of 3D Visualisation.

Continuous Assurance applies quality assurance across strategy and operations of management and service delivery. Continuous Assurance is critical to Cloud Computing, Services and Operations in the Enterprise environments, where ISACA (2009), a consulting firm working for an EU project, define the following benefits of adopting it:

- Transparency - Effective and robust security controls are in place, assuring customers that their information is properly secured against unauthorized access, change and destruction.
- Privacy - Privacy controls are in place and demonstrate their ability to prevent, detect and react to breaches in a timely manner.
- Compliance - Organisations must comply with a litany of laws, regulations and standards, in particular to data protection.
- Trans-border information flow - Data in the Cloud can be anywhere. Physical location dictates jurisdiction and legal obligation.
- Certification - Independent assurance from third-party audits and/or service auditor reports should be a vital part of any assurance program.

Our CCBF can offer both QA and Continuous Assurance for participating organisations, which the University of Southampton that has obtained those benefits.

5.4 Linking all different processes, functions and departments together

Three different departments from the University of Southampton have their Cloud projects and services in place. Each department's work is independent from the others, except i-Solutions and Corporate Planning have the same focus. Even so, it takes some time for communications and establishment of a mutual goal. But an interesting research challenge has surfaced: whether the activities and results from one department can be used for the other department, and whether the end processes of department A can be the used as the input for the processes of department B. This leads to a new and innovative area known as Business Integration as a Service (BIaS), where Chang et al. (2011 d, 2011 e) have demonstrated how to link different processes and functions together in an integrated platform, and the end result of one process can be used as the input for another process without further translation. BIaS will be useful for universities and enterprises to synchronise all their Cloud services and activities, and can improve the efficiencies without manual work being carried out in each department, and spending much time in communications and getting consensus between different departments.

5.5 The role of Green IT for Education

Garg and Buyya (2010) demonstrate how Cloud Computing can help organisations to achieve Green IT, and how advanced techniques and technologies can make Green IT ready for enterprise solutions. Case studies from the University of Southampton demonstrate Green Cloud Computing helps the University fulfil two major goals: (i) cost-saving and (ii) improved user satisfaction. Green Cloud

Computing has also been adopted by the University of Greenwich, where the Business School has received a Sustainability Award. The Business School at the University of Greenwich has a policy to reduce carbon emissions and procurement of environmental-friendly equipment. There are policies and tools working together to deliver benefits such as cost-saving, integration of services, service improvement and user confidence growth offered by Cloud Computing. Current Plan include

- Streamline departmental printing process and improve recycling rate.
- Digitalise student coursework into electronic format, and improve online marking rate through the use of technologies and policies.
- Collect useful metrics for IT Services and project delivery.
- Collect useful metrics for energy, operational and procurement costs, and analyse data using the use of Organisational Sustainability Modelling (OSM).

Detailed metrics are in the process of collection and analysis. In addition, KCL and National Health Service (NHS) UK have implemented environmental friendly Cloud Storage that not only provides automation and self-services, but also reduces carbon emission with the use of advanced technologies (Chang, 2009). Similarly, the University of Oxford has e-Research projects in collaboration with NGS UK addressing Green Cloud Computing. The role of Green IT has significantly improved and has become more influential for Education, as there are initiatives and pilot projects investigating the use of Green Cloud resources and strategies (Buyya et al., 2010).

5.6 Summary of case studies and contributions offered by Organisational Sustainability Modelling (OSM) of CCBF

The CCBF has helped several organisations to measure its Cloud business performance including Green IT adoption, and selective results have been presented in several journals, as summarised in Table 6.

Table 6: Summary of case studies and contributions offered by OSM, part of CCBF

Organisations	Summary of 3D analysis	Contributions
OMII-UK (Chang et al., 2010 b)	x-axis: The return for OMII-UK (1 and 5%) y-axis: Risk premium for the market (-0.3 and 0.5%) z-axis: Risk-free rate of OMII-UK (0 to 50%)	OMII-UK was a start-up in Cloud services, and experienced a volatile period with uncertainty and competitions. It survived till the end of 2010. OMII-UK is a good case study for start-up's lessons learned.
SAP (Chang et al., 2011 c)	x-axis: The return for SAP (-1 and 1%) y-axis: Risk premium for the market (-1 and 1%) z-axis: Risk-free rate of the market (0.7 to 0.715%)	(i) SME use SAP as a cautious cloud tactics (ii) SME prefer to use more predictable or familiar ways to maintain their cloud business sustainability.
Vodafone/Apple (Chang et al., 2011 c)	x-axis: Vodafone's return (21-24%) y-axis: Risk premium of the market return (22-26%) z-axis: Risk-free rate in market (2.0-4.0%)	Their iPhone and iPad strategy has vastly improved profits and business performance.
NHS UK Infrastructure (Chang et al., 2011 b)	x-axis: The return of NHS Infrastructure (6% - 7.2%) y-axis: Risk premium for the market (4.3% - 6%) z-axis: Risk-free rate of the market (3% - 5%)	The use of Cloud infrastructures can improve efficiency. It also results in raising benchmark, the minimum acceptance level to complete concurrent tasks.
NHS UK Bioinformatics (Chang et al., 2011 b)	x-axis: The return of NHS Bioinformatics (1.2% - 7.2%) y-axis: Risk premium for the market (0.2% - 4%) z-axis: Risk-free rate of the market (0.1% - 4.8%)	There are incremental improvements to an NHS Bioinformatics project. The low risk-free rate may imply code development allows reduced time to complete, and objective is clearly met and project delivery is straightforward.
A SME (requests not to reveal identity) in broadband service (Chang et al., 2011	x-axis: The return of SME cost-saving (20% - 23%) y-axis: Risk premium for the market (7.5% - 8.5%)	CCBF helps them to upgrade their services from IaaS to PaaS. Cost-saving (electricity and operational costs) is achieved with the use of

d)	z-axis: Risk-free rate of the market (5% - 5.8%)	Cloud and Green IT.
ECS, University of Southampton (this paper)	x-axis: Expected return of cost-saving (22.5% - 26%) y-axis: Actual return of cost-saving (21.0% - 22.0%) z-axis: Risk-free rate (4.0% - 4.8%)	Cost-saving (electricity and operational costs) is achieved with the use of Cloud and Green IT.
i-Solution Group and Corporate Planning, University of Southampton (this paper)	x-axis: Actual Rate of Return - User confidence and service improvement (3.4% - 8.4%) y-axis: Expected Rate of Return - User confidence and service improvement (1.2% - 5.8%) z-axis: Risk-free rate (0.8% - 4.4%)	The level for service improvement is continuously progressive and heading upwards. Some users feel positive experience about services, infrastructure and platform, and they have increased their user confidence level.

Each case study is unique and has either technical, cost or user focus. While leading papers (Amburst et al., 2009; Brandic et al., 2010; Buyya et al., 2009; 2010) explain the technical added values offered by SLA aspects of Cloud Computing, none of them can address user satisfaction and its methodology for measurement and presentation. We would like to emphasise user satisfaction is an important aspect for Cloud ROI measurement and should be managed and monitored by organisations adopting Cloud deployment.

5.7 Comparisons with other methods and approaches

Before discussing added values offered by OSM and CCBF, other approaches to define and review business framework or business performance are reviewed. Chang et al. (2011 c) have investigated a number of selected frameworks, and compare their strengths and weaknesses with OSM and CCBF, where Table 7 is the summary of all reviews.

Types of framework	CCBF (Chang et al., 2010 b, c ; 2011 a, b , c, d, e, f)	VBSPN (Zirpins and Emmerich 2008)	DSGE (Etro, 2008)	CBM (Klems, Nimis and Tsai, 2009)	SLA-based (Assuncao, Costanzo, Buyya, 2010; Buyya et al., 2009)	Miscellaneous (Lobo and Arthur, 2005)
Qualitative	Yes. There are proposed business model classification and the use of hexagon model.	Yes. They have a solid qualitative and theoretical framework.	Yes. But only in the EU and make several assumptions.	Yes. They have great descriptions about this.	Might be possible, but take certain assumption on service providers and usage scenarios.	Yes. They provide a series of best practices for framework.
Quantitative	Yes. The use of modelling and simulations to validate.	No, despite they use UML to support theoretical framework.	Yes. He has solid econometrics insights to explain this.	Yes, but not yet done.	Yes. They have numerous ways to measure cloud billing models quantitatively.	Potentially yes, but further work needs to be done.
Linkage (qualitative-quantitative)	Yes. It demonstrates Business Integration as a Service (BIaaS).	No	Yes. But in an early stage. Weak in linkage.	Yes, but not yet done.	No, at least not yet.	No, before they can propose quantitative area.
Cloud Business Performance	Yes. Use Organisational Sustainability Modelling with statistical computing and 3D visualisation. Can offer accurate measurement.	No. This is a generic framework, and is likely to work in their own environment only.	Not yet, although he is working towards it for the EU.	Yes. Use their conceptual framework.	Yes. They are one of pioneers in pay-as-you-go and billing models.	No. Their framework is not designed for cloud, but for generic uses and risk analysis.
Service Level	Yes. Deal with selective IaaS, PaaS and SaaS.	Potentially yes, but in their own setting only.	Potentially yes, but only for the EU.	Yes. Similar to ours, but use a different way to present.	Yes. They have a few papers about this.	Possible, but more work needs to be done.
Orientation of framework	Conceptual and architectural.	Conceptual only	Mathematical Conceptual	Conceptual only	Architectural	Conceptual
Ways to validate	Modelling, simulations, and experiments for quantitative. Hexagon Model, case studies, and interviews for qualitative.	UML and complex business object modelling.	Econometrics and financial modelling based on the data he collects.	Case studies and theoretical hypothesis.	Simulations and calculations.	Theoretical hypothesis and case studies.
What needs to be improved	In progress. More validations and improvements will be presented.	Framework update is required.	Framework update is required.	Need to consider more on quantitative aspects.	Should deal with more strategic levels rather than operational.	Framework update is not published for nearly 5 years.

Table 7 Review and comparisons between selective frameworks for defining and measuring cloud business and ROI (Chang et al. 2011 c)

6. Conclusion and Future Work

The CCBF is a relatively new area, and finding the right methods to review business performance can enhance organisational sustainability. Cost-saving is particularly important at times of economic downturn, and this is a reason why more organisations are using CC to minimise and control costs. We have demonstrated the case study of the ECS, University of Southampton for cost-saving, and i-Solution and Corporate Planning of the University of Southampton for user confidence and service improvement. These three case studies offer added values. This involves using a highly structured and organised process to review and evaluate. There are three stages and highly structured process involved for data analysis, which have been explained in detail.

Our ROI method introduced by OSM and CCBF provides additional value. Firstly, it includes the use of the CAPM statistics to compute analysis. Secondly, it involves conversion to 3D Visualisation to present cloud business performance. Thirdly, it involves a series of QA tests to ensure the quality of 3D Visualisation is of a high standard. Of the Cloud ROI methods available, ours is the only one demonstrating QA and high quality of analysis among others. The challenge for the UK universities is to improve confidence, particularly in Consumers, which means staff and students can feel the positive impacts of cost-saving offered by CC, which is useful in the economic downturn.

OSM offers the following two advantages: (i) it allows performance reviews at any time; and (ii) it provides strategic directions and added-values for adopting the right types of cloud business for sustainability. The ECS, i-Solution and Corporate Planning case studies strongly support the use of Green IT that provides cost-saving benefit and added values for users. 21-22% of cost-saving and 1.2-5.5% increase (on top of high user rating) in user confidence level and service improvement has justified Cloud migration and these services provide a valuable ROI for staff and students. This also fits well into the University of Southampton strategy for cost-saving and user satisfaction and our continued collaboration with the University will ensure our work benefits others in addition to the University of Southampton.

There are topics of discussions, among which two topics are worth for further elaboration. The second discussion topic confirms the positive ROI for the University of Southampton and a popular Cloud adoption in Education. This is supported by high percentages of satisfactory survey results (3 out of 5 and above), such as 93.32% for accessibility, 75.88% for enough financial support, 89.11% for availability and 89.53% for sufficient support for all users involved. User confidence and service improvement have further improved between 3.4% and 8.4%, which are considered satisfactory by users and IT staff. Full support received from the University is also a factor for maintaining good percentages of satisfaction. The sixth discussion topic sums up all 3D analysis and contributions for all collaborators, which include OMII-UK, SAP, Vodafone/Apple, NHS, a broadband SME and University of Southampton (three departments). Those results and analysis have helped collaborators to understand their Cloud business performance, and make the right decisions based on such analysis, which supports that OSM is a unique ROI method with extensive case studies.

CCBF has been extensively used in several organisations such as NHS UK, KCL, Universities of Greenwich, Southampton, Oxford, VMware, Vodafone/Apple, Salesforce, IBM, Commonwealth Bank Australia (CBA) and so on. Some collaborators find it useful for their organisations and contributions from CCBF can positively impact e-Research, Cloud, Grid, Health, Finance and Education Communities.

7. References

Armbrust, M., Fox, A., Griffith, R., Jseph, A. D., Katz, R. H., Kownwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica, I., Zaharia, M., “Above the Clouds: A Berkeley View of Cloud computing”. Technical Report, No. UCB/EECS-2009-28, UC Berkeley, Feb 2009.

Assuncao M D d, Costanzo A d and Buyya R, "A cost-benefit analysis of using cloud computing to extend the capacity of clusters", Journal of Cluster Compute, 13: 335–347, April 2010.

Bechini, A., Cimino, M. G.C.A., Marcelloni, F., and Tomasi, A., "Patterns and technologies for enabling supply chain traceability through collaborative e-business", Information and Software Technology Journal, Issue 50, 342–359, 2008.

Brandic, I., Music, D., Leitner, P. and Dustdar, S., "VieSLAF Framework: Enabling Adaptive and Versatile SLA-Management.", the 6th International Workshop on Grid Economics and Business Models 2009 (Gecon09), 25- 28 August 2009, Delft, The Netherlands.

Briscoe, G. and Marinos, A., "Digital ecosystems in the clouds: towards community cloud computing". In: IEEE 2009 the 3rd IEEE International Conference on Digital Ecosystems and Technologies (DEST 2009), New York, USA, pp. 103-108.

Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J. and Brandic, I., "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility", Journal of Future Generation Computer Systems, Volume 25, Issue 6, June 2009, Pages 559-616.

Buyya, R., Ranjan, R. and Calheiros, R. N., "InterCloud: Utility-Oriented Federation of Cloud Computing Environments for Scaling of Application Services", Algorithm and Architectures for Parallel Processing, Lecture Notes in Computer Science, 2010, Volume 6081/2010, 13-31.

Butler, T., "Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS", Journal of Strategic Information Systems, 20 (2011), 6-26.

Celik, A., Holliday, J. and Hurst, Z., "Data Dissemination to a Large Mobile Network: Simulation of Broadcast Clouds", the 7th International Conference on Mobile Data Management (MDM) 2006, 10-12 May 2006, Santa Clara University, USA.

Chang, V., Mills, H. and Newhouse, S., "From Open Source to long-term sustainability: Review of Business Models and Case studies". In: UK e-Science All Hands Meeting, September 2007, Nottingham, UK.

Chang, V. (2009), "Cloud Storage Framework – An Integrated Technical Approach and Prototype for Breast Cancer". In: All Hands Meeting 2009, 7-9 December, 2009, Oxford.

Chang, V., Bacigalupo, D., Wills, G., De Roure, D., "A Categorisation of Cloud Computing Business Models", CCGrid 2010 IEEE conference, Melbourne, Australia, May 2010 (Chang 2010 a).

Chang, V., Wills, G. and De Roure, D., "A Review of Cloud Business Models and Sustainability", IEEE Cloud 2010, the third International Conference on Cloud Computing, 5-10 July 2010, Miami, Florida, USA (Chang 2010 b).

Chang, V., Wills, G. and De Roure, D. (2010) Cloud Business Models and Sustainability: Impacts for businesses and e-Research. In: *UK e*-Science All Hands Meeting 2010, Software Sustainability Workshop, 13-16th September, 2010, Cardiff (2010 c).

Chang, V., Li, C. S., De Roure, D., Wills, G., Walters, R. and Chee, C. (2011) The Financial Clouds Review. International Journal of Cloud Applications and Computing, 1 (2). pp. 41-63. ISSN 2156-1834, eISSN 2156-1826 (Chang et al., 2011 a)

Chang, V., De Roure, D., Wills, G., Walters, R. and Barry, T. (2011) Organisational Sustainability Modelling for Return on Investment: Case Studies presented by a National Health Service (NHS) Trust UK. Journal of Computing and Information Technology, 19 (2). ISSN Print ISSN 1330-1136 | Online ISSN 1846-3908 (In Press) (Chang et al., 2011 b)

Chang, V., De Roure, D., Wills, G. and Walters, R. (2011) Case Studies and Organisational Sustainability Modelling presented by Cloud Computing Business Framework, International Journal of Web Services Research. ISSN 1545-7362 (In Press) (Chang et al., 2011 c)

Cha Chang, V., De Roure, D., Wills, G., Walters, R., Li, C. S., Barry, T. and Currie, W. (2011) The development that leads to the Cloud Computing Business Framework, submitted to Information and Management, 2011 (Chang et al., 2011 d)

Chang, V., Wills, G. and Walters, R. (2011) Towards Business Integration as a Service 2.0 (BIaaS 2.0), In: IEEE International Conference on e-Business Engineering, The 3rd International Workshop on Cloud Services - Platform Accelerating e-Business, 19-21 October, 2011, Beijing, China. (Chang et al., 2011 e)

Chen, X., Wills, G. B., Gilbert, L., Bacigalupo, D. (2010), “Using Cloud for Research: A Technical Review”, TesciRes Report for JISC, June 2010, available on http://eprints.ecs.soton.ac.uk/21273/.

Chowhan, S. S. and Saxena, R., "Customer Relationship Management from the Business Strategy Perspective with the Application of Cloud Computing", The Proceedings of DYNAA 2011, Vol. 2, No. 1.

Croson, R. and Donohue, K., “Impact of POS data sharing on supply chain management: an experimental study”, Production and Operations Management 12 (1), 1–11, 2003.

Creeger M, “CTO Roundtable: Cloud Computing”, special article, Communications on the ACM, Vol. 52, No 8, August 2009.

Dietmann, A., Helbok, R., Lackner, .P, Fischer, M., Reindl, M., Lell, B., Issifou, S., Kremsner, P. and Schmutzhard, E., “Pathophysiology and severe malaria – from basic knowledge to new therapeutic approaches”, Europena Journal of Tropical Medicine and International Health, Vol. 14, Issue 2, September 2009.

Dunn, T., “Identity Management: Cloud and Virtualisation”, keynote, European Identity Conference, Munich Cloud 2010, 4-7 May, 2010, Munich, Germany.

Etro F, “The Economic Impact of Cloud Computing on Business Creation, Employment and Output in Europe”, Journal of Review of Business and Economics, May 2009.

Garg, S. K. and Buyya, R., "Green Cloud computing and Environmental Sustainability", Working Paper, CLOUDS Laboratory, University of Melbourne, 2010.

Hanna, A, Windebank J, Adams S, Sowerby S, Rance S and Cartlidge A (2009), "ITIL V3 Foundation Handbook: Pocketbook from the Official Publisher of ITIL", Paperback Edition, June 2009, ISBN 9780113311989.

Hull, J.C., “Options, Futures, and Other Derivatives”, Seventh Edition, Pearson, Prentice Hall, 2009.

An ISACA White Paper, “Cloud Computing: Business Benefits With Security, Governance and Assurance Perspectives”, 2009.

JISC article and news, “Cloud computing increasingly attractive to universities, says JISC”, JISC, May 2011.

Khajeh-Hosseini A, Greenwood D and Sommerville I, “Cloud Migration: A Case Study of Migrating an Enterprise IT System to IaaS”, 3rd IEEE International conference on Cloud Computing, Cloud 2010, 5-10 July 2010; Miami, USA.

Klems, M., Nimis J and Tai S, “Do Cloud Compute? A Framework for Estimating the Value of Cloud Computing”, Cloud Computing and its Application CCA 08, Chicago, October, 2008.

Lobo L O and Arthur J D: “An Objectives-Driven Process for Selecting Methods to Support Requirements Engineering Activities”, 29th Annual IEEE / NASA Software Engineering Workshop (SEW-29 2005), 6-7 April 2005, Greenbelt, Maryland, USA.

Msanjila, S. S., Tewoldeberhan, T., Bockstael-Blok, W., Janssen, M., and Verbraeck, A., "E–Supply Chain Orchestration Using Web Service Technologies: A case using BPEL4WS", IRMA 2005 Conference, 2005, San Diego, USA.

Nick, J. M, Cohen, D., and Kaliski B. S., "Key Enabling Technologies for Virtual Private Clouds", Handbook of Cloud Computing 2010, Part 1, 47-63, DOI: 10.1007/978-1-4419-6524-0_3.

Office of Government Commerce (OGC), “Official ITIL Lifecycle Publication Suite (5 books)”, ISBN: 0113310501 / 9780113310500, TSO Publisher, May 2007.

An Oracle White Paper, “Platform-as-a-Service Private Cloud with Oracle Fusion Middleware”, September 2009.

An Oracle White Paper, “Oracle Cloud Computing”, May 2010.

Pajorova E and Hluchy L, "3D visualization the results of complicated Grid and Cloud-based applications", the 14th International Conference on Intelligent Engineering Systems (INES), 5-7 May 2010, Las Palmas, Spain.

Papazoglou, M.P., and Georgakopoulos, D., "Service Oriented Computing", Communications of the ACM, Vol. 46, No. 10, October 2003.

Rungtusanatham, M., Salvador, F., Forza, C. and Choi, T.Y., "Supply-chain linkages and operational performance: a resource-based perspective". International Journal of Operations and Production Management 23, 1084–1099, 2003.

Prechter, R.R. Jr and Parker, W.D., "The Financial and Economic Dichotomy in Social Behavioral Dynamics: the Socionomic Perspective", the Journal of Behavioural Finance, page 84-108, Vol. 8, No. 2, 2007.

Schubert, H., Jeffery, K. and Neidecker-Lutz, B., "The Future for Cloud Computing: Opportunities for European Cloud Computing Beyond 2010", Expert Group report, public version 1.0, January 2010.

Sharp, W.F., "Capital Asset Prices with and without Negative Holdings", Nobel-Prize Economics Lecture, December 7, 1990.

Sun Microsystems White Paper, "Introduction to Cloud Computing Architecture", 1st Edition, June 2009.

Weinhardt, C., Anandasivam, A., Blau, B. and StoBer, J. "Cloud Computing – A Classification, Business Models, and Research Directions", Journal of Business and Information Systems Engineering, 2009.

Zhang, H., Liu, L. and Li, T., "Designing IT systems according to environmental settings: A strategic analysis framework", Journal of Strategic Information Systems 20 (2011) 80–95.

Zirpins C and Emmerich W, "A reference model of virtual service production networks", International Journal on Service Oriented Computing and Applications, Vol 2, No. 2-3, page 145-166, Springer, 2008.

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