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Editorial

Cloud Computing: What is on the Horizon?

September 27, 2013

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Cloud computing has built its foundations on decades of research in virtualisation, distributed computing, utility computing, networking and more recently web and software services. It represents a shift to computing as a service (hardware and software) that is delivered to users over the internet via large scale data centres. Indeed it facilitates a fundamental change in how information technology is provisioned in that it enables computing facilities such as storage compute power, network infrastructure and applications to be delivered as a metred service like a utility. Information technology research and advisory company Gartner has forecasted the public cloud services market to grow 18.5% in 2013 to a global \$131 billion.

The forthcoming years will be a crucial period for the development of cloud computing. Recently, cloud computing has become a strategic direction for the Irish government and its associated agencies. In November 2011, the Irish government launched the Public Service Reform Plans, which contained commitments to cloud computing and shared services. Specifically the reform plans outlined a commitment to maximise new and innovative service delivery channels through: piloting the use of cloud computing in 2012 and evaluation of a roll-out across the public service. In February 2012, the Irish government unveiled its first cloud computing initiative Cloud4Gov.

However, while cloud computing is growing in global popularity at a phenomenal pace, academic research is lagging behind the rapid developments in the field. Given the rapidly evolving nature of this nascent paradigm, the role of Information System (IS) researchers is crucial. In order for organisations to leverage the propitious capabilities associated with cloud computing, it is imperative from the outset that IS researchers are proactively involved in every discussion regarding the paradigm. To that extent the 1st IAIS Workshop on Cloud Computing Research will provide a current snapshot of emerging research in cloud computing, capturing both national and international submissions. The workshop is supported by the Irish chapter of the Association for Information Systems (IAIS), the Irish Software Engineering Research Centre (Lero) and NUI Galway's Whitaker Institute, and is being jointly delivered by the Business Information Systems discipline and Lero at

NUI Galway, and the Cloud Computing Services Innovation Centre at Hewlett-Packard.

We are really excited and encouraged to see the emergent research evident in submissions for this workshop. Such research in cloud computing has identified aspects situated more on the strategic end of the IS spectrum, in addition to some topics residing within a more implementation-based position on the spectrum. The topics shed light on different features of the cloud landscape and take us into fields previously unknown. Such topics that feature for presentation and discussion include:

Business value, models and value capture: Trevor Clohessy writes about the application of business model concepts for cloud provision while Peter O'Sullivan discusses return on investment (ROI) from strategic cloud sourcing. Barry Reddan talks about measuring business value with the cloud technology stack, whereas Christina Thorpe, Thomas Cerqueus & Anthony Ventresque present new research on a proposed open standard for performance monitoring to overcome the heterogeneity of the stack. *Cloud adoption* is prominent, with Niamh O'Riordan discussing adoption in firms, Enda Dempsey and Martin Hughes discussing the impact of cloud computing on value chains; Peter Votisky presenting a study on governance and adoption; Seán Browne and Michael Lang outlining work on security concerns for adopters; and Robert Rockmann outlining the impact of adoption on business models.

Cloud implementations and provisioning represent another emergent issue: Pooyan Jamshidi, Aakash Ahmad & Claus Pahl discuss resource scalability for elastic provisioning, while Vikas Sahni and Sruthi Nallapu outline work examining the effects of nested virtualisation on the performance of virtual machines. Anthony Ventresque, Christina Thorpe, Thomas Cerqueus and Xi Li present a study on service placement, and Fiona O'Riordan outlines a case-based study of cloud bursting in the Irish Central Statistics Office.

Also emerging is research on a more *holistic approach to situating cloud computing*: Roger Sweetman writes about a portfolio approach to cloud computing; Eoin Cullina and Trevor Clohessy discuss the greater cloud computing business ecosphere; and Christina Thorpe, Thomas Cerqueus, Adrien Thiery and Gerson Sunyé present research on a holistic approach to cloud deployment independent of vendors.

Finally, *mobility in the cloud* is represented by research on smartphones for data entry by Mark Griffin, and also by Louise Willemse's work on mobile access to cloud-based enterprise services.

Finally, we want to thank everyone for all the hard work, effort and contributions to the workshop.

1st IAIS Workshop on Cloud Computing Research

Research and Practice in the Cloud: What is on the Horizon?

National University of Ireland, Galway is proud to host the first IAIS Workshop on Cloud Computing Research (IWCCR) on Sep 27, 2013. The workshop is supported by the Irish chapter of the Association for Information Systems (IAIS), the Irish Software Engineering Research Centre (Lero) and NUI Galway's Whitaker Institute, and is being jointly delivered by the Business Information Systems discipline and Lero at NUI Galway, and the Cloud Computing Services Innovation Centre at Hewlett-Packard.

The IWCCR builds upon NUI Galway, Lero and Hewlett-Packard's strengths in cloud computing. NUI Galway's Masters degree in Cloud Computing Research began in Sep 2012, and is already helping to shape the national agenda. This new degree provides a dedicated programme of advanced research on high-value, business-focused aspects of cloud computing. In the current year, students from Hewlett-Packard, Cisco, Eircom and elsewhere, are covering a number of important issues for businesses, including a study on business success factors for cloud services, a model for return-on-investment for strategic cloudsourcing, user interaction for mobile cloud business applications, Irish legal considerations for cloud strategies, user benefits of cloud services, in addition to other topics of importance to both large businesses and small SMEs. The university's research on cloud computing has been published in international outlets, and cloud computing has become a core part of a large SFI-funded research team.

Workshop Chairs



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Dr. Lorraine Morgan



Dr. Chris Coughlan

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Workshop Schedule

Time	Activity	Description
09:00 AM – 09:30 AM	Registration	Cairnes Reception Desk. Location: Cairnes building, NUI Galway
09:30 AM – 09:45 AM	Introduction	Opening by Head of School & Introduction by workshop chairs. Location: CA118, Cairnes building
09:45 AM – 11:00 AM	Roundtable session 1	3 x roundtables, 3 papers per table. Location: 1st Floor Cairnes building open space
11:00 AM – 11:15 AM	Coffee	Location: 1st Floor Cairnes open space
11:15 AM – 12:30 PM	Roundtable session 2	3 x roundtables, 3 papers per table. Location: 1st Floor Cairnes open space
12:30 PM – 13:45 PM	Lunch	Location: Friars Restaurant, Cairnes building
13:45 PM – 15:15 PM	Panel Discussion: Cloud Horizons	Vikas Sanhi (Version 1), Emmet Donnelly (SourceDogg), Gary Ramsay (Dimension Data), David Waldron (CloudStrong), Brian Lee (Athlone IT). Chair: Chris Coughlan (Hewlett-Packard). Location: CA118
15:15 PM – 15:45 PM	Plenary session & wrap-up	Workshop chairs discussing the emerging research from the event. Location: CA118

Parallel Research Roundtable Tracks

Session 1: **9.45 AM – 11:00 AM**

Venue: **1st Floor Cairnes Building Open Space**

Green Roundtable Chair: Lorraine Morgan

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Trevor Clohessy, Lero at NUI Galway

Toward a model of ROI from Strategic Cloudsourcing p12

Peter O'Sullivan, Eircom, Galway

How Does the Adoption of Cloud Computing Affect the Company's Business Model? p15

Robert Rockmann, University of Applied Sciences Neu-Ulm, Germany

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IT Governance Aspects and Impacts of Adopting Cloud Computing in the Financial Sector p18

Peter Votisky, MSc in Cloud Computing Research, NUI Galway

Investigating the Impact of Cloud Adoption in Firms p20

Niamh O'Riordan, Business Information Systems, NUI Galway

A Portfolio Approach to Cloud Computing p23

Roger Sweetman, Lero at NUI Galway

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Security Assessment: A Prerequisite for Cloud Adoption in SMEs p26

Seán Browne & Michael Lang, Business Information Systems, NUI Galway

The Impact of Nested Virtualization on the Performance of Virtual Machines p30

Vikas Sahni & Sruthi Nallapu, Version 1 & National College of Ireland

Towards The Deployment of Cloud Applications Using a DSL p33

Christina Thorpe, Thomas Cerqueus, Adrien Thiery & Gerson Sunyé, Lero & University of Nantes, France

Session 2: 11.15 AM – 12:30 PM

Venue: 1st Floor Cairnes Building Open Space

Green Roundtable Chair: Maciej Dabrowski

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Fiona O’Riordan, Central Statistics Office, Ireland

Monitoring the Cloud – CloudMon p38

Christina Thorpe, Thomas Cerqueus & Anthony Ventresque, Lero Performance Engineering Lab, University College Dublin

Service Placement in the Cloud p42

Anthony Ventresque, Christina Thorpe, Thomas Cerqueus & Xi Li, Lero Performance Engineering Lab, University College Dublin

White Roundtable Chair: Tom Acton

Towards a Greater Understanding of the Cloud Computing Business Ecosystem p45

Eoin Cullina & Trevor Clohessy, Lero at NUI Galway

Measuring Business Value within the Cloud Technology Stack: An Exploratory Study p48

Barry Reddan, Lero & Hewlett-Packard, Galway

An investigation into the Impact of Cloud Computing on the Value Chain of Irish SME’s p51

Enda Dempsey & Martin Hughes, Business Information Systems, NUI Galway

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Self-Adaptive Resource Scalability for Elastic Service Provisioning in Cloud Architectures p54

Pooyan Jamshidi, Aakash Ahmad & Claus Pahl, Lero & School of Computing, Dublin City University

Mobile Cloud Computing: The Impact of Location-Based Services and Context-Awareness on Enterprise Services p58

Louise Willemse, Hewlett-Packard, Galway

Using Smartphones for Data Entry p61

Mark Griffin, MSc in Cloud Computing Research, NUI Galway

Demystifying the Nebulous Cloud Computing Business Model Concept

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Research Motivation

Despite the recent emergence of research pertaining to the significance of the business model in ensuring the long-term viability of the cloud computing paradigm (Chang, Walters, & Wills, 2013; Morgan & Conboy, 2013), research relating to understanding the interrelated dynamics of strategy, the business model and business processes is non-existent. We attempt to address this research gap by proposing a holistic multi-level cloud computing business framework that derives from a comprehensive review of the cloud computing, business model and strategy literature.

Literature Review

Despite business model lineage dating back to an era where barter exchanges were commonplace, its meteoric rise to prominence, in business and academic spheres, has only manifested in the last decade (Teece, 2009). Driving factors such as the emerging knowledge economy, consumerization of ICT, the restructuring of global financial services, increased outsourcing and offshoring of business processes and advancements in ICT have catapulted the business model concept into the public arena. In modern society, as organisations integrate information communication technology (ICT) and associated nascent platform technologies into their everyday business processes, they are concurrently enabling a shift from traditional business models to “combined physical and virtual models” (Weill & Vitale, 2002). This business model metamorphosis, if not managed solicitously, is strewn with many abrogating repercussions (Weill & Vitale, 2001). In order for organisations to enhance their competitive positioning, they must be capable of responding rapidly to fluctuating environmental changes, a process may be facilitated with superior business decisions which are buttressed by suitable cogent business models and

strategy. A recent study by Zott, Amit, and Massa (2011) highlights how the business model concept has received substantial attention from academics and practitioners, where between 1995 and 2011 there were roughly 1,177 articles published pertaining to the topic. The authors argue that even though the business model concept has been rigorously put under the microscope in recent years, there is still no general consensus on “a common and widely accepted language that would allow researchers and practitioners, who examine the business model construct through different lenses, to draw effectively on each other’s work...the business model literature is “developing in silos according to the phenomena of interest to the respective researcher”. It has been argued that cloud computing has the potential to “revolutionize the mode of computing resource and application deployment breaking up traditional value chains and making room for new business models” (Leimeister, Böhm, Riedl, & Krcmar, 2010). The cloud computing paradigm constitutes a propitious and nebulous phenomenon where hardware and software computing resources are provided as a service over a network from large scale data centres. While some research has investigated how organizations can reap the benefits associated with cloud computing e.g. (Armbrust et al., 2010; Brynjolfsson, Hofmann, & Jordan, 2010; Buyya, Yeo, Venugopal, Broberg, & Brandic, 2009; Clohessy & Acton, 2013; Clohessy, Acton, & Coughlin, 2013), There is a “paucity” of academic and practitioner literature pertaining to the role of effective business models in innovative technology, business performance, strategy and information systems (IS) (Teece, 2009; Zott et al., 2011). The coupling of these arguments in conjunction with the current fuzzy fragmented knowledge pertaining to the business model concept and the cloud computing paradigm create a robust foundation for examining the business model concept with cloud computing. Thus, the aim of this research in progress is to coalesce the disparate work on business models, and propose a framework which is appropriate for cloud computing.

Methodology

As a first step towards the refinement and validation of our framework, we intend to run a series of focus groups comprising leading cloud service providers and partnering cloud service users followed by a series of case studies.

Contribution

We envisage that the following research can make contributions e.g. present implementation scenarios, which are relevant to decision makers not only in software firms provisioning cloud services but also to organizations who are new to the cloud

computing landscape and organisations striving to be vanguard in the cloud technological development.

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Toward a model of ROI from Strategic Cloudsourcing

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Motivation

There is currently a gap in academic research literature on the topic of Return on Investment (ROI) for enterprise Cloud Computing (CC) adoption (Khajeh-Hosseini et al., 2011). Significant firm investments are placed behind strategic IT outsourcing decisions with a view to achieving their business objectives (Lacity & Willcocks, 1998; Paisittanand & Olson, 2006). To date, a long term strategic approach to the consumption of new IT solutions by the firm has not been evident (Butler and Murphy, 2007). This lack of central strategy causes IT dysfunctionality between departments of the firm and works away from a collaborative organisation (Papastathopoulou et al., 2007). The CC model broadens the scope beyond the technological reality of traditional IT outsourcing, thus demanding the wider viewpoint aligned with the strategic objectives of the organisation. There are gaps between the promises of the return of the cloud and thus a need for effective methods and tools to properly assess the ROI of the enterprise cloud project. The objective of this study is to examine how firms can make investment decisions and come closer to realising the return on investment from cloud computing. The following research questions are proposed:

1. How does the firm select the factors for value and cost?
2. How can stakeholder consultation reveal reliable benefit and cost measurements for enterprise cloud ROI calculations?

Literature Review

This study will examine the ROI from SAAS by the adopting firm. The ROI metric is effective in supporting strategic IT investment decisions by gauging the Return on Money (ROM) invested by the firm (van Solingen, 2004; Misra & Mondal, 2011). Developed by the DuPont Company in 1919, the original model was intended to measure profit related to an investment (Clarke, 2007; Hoque, 2004) and was expressed as follows:

$$\text{ROI} = \frac{\text{Sales} \times \text{Profit}}{\text{Investment Sales}} \quad (\text{Hoque, 2004})$$

Investment Sales

For a more contemporary financial model we see Moyer et al. (2012) expressing ROI as:

$$\text{ROI} = \frac{\text{Earnings after taxes (EAT)}}{\text{Total assets}} \quad (\text{Moyer et al., 2012})$$

Total assets

In this accounting-centred model the aim is to measure a firm's net income to the total asset investment. These and related financial models are specifically fiscal and possibly too rigid for measuring the firm's return from a cloud computing project. Our search for an appropriate and more open ROI model brought us to the widely accepted ROI marketing models, adapted to offer an approach with the scope to involve a wider range of costs and benefits that might surround an investment:

$$\text{ROI} = \frac{\text{gains from investment} - \text{costs of investment}}{\text{Cost of Investment}}$$

Cost of Investment

Methodology

The study will employ a number of case studies to better examine the factors affecting ROI of enterprise cloud computing for SAAS deployments. This approach suites exploratory IS studies that are at the early stage of theory development (Benbasat et al., 1987).

Contribution

The principal contribution from this study is the identification of appropriate cost and benefit factors that should be included when measuring the ROI of enterprise CC to the consuming firm when adopting SAAS. The study also suggests an approach using stakeholder engagement to draw out the monetary value from initially intangible CC costs and benefits. These values are then incorporated into a specific ROI calculation for measuring the financial effect that strategic cloud sourcing will have on the firm.

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How Does the Adoption of Cloud Computing Affect the Company's Business Model?

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Research Motivation

When looking at how companies adopt cloud computing, the example of Netflix Inc. is one of the most prominent ones. Netflix moved from a DVD-by-mail rental service to a streaming-only service. But instead of investing in own data capacities, they decided to migrate on Amazon's cloud environment allowing them to scale their business among the rapid growth of users with lowered risks and efforts (Webb, 2011). However, several authors (e.g. Teece, 2010) are of the opinion that Netflix not succeeded because of their technology usage, but because of their business model adaption. In line with this, several authors (Teece, 2010; Zott et al., 2011) state that future competitive advantage will not be achieved through technology, but rather through business models in which technology plays an enabling role.

A business model reflects the link between strategy, business processes, and information systems. It is an abstract description of a company's business purpose and provides an aerial view on business elements and their relationships, such as value propositions, target customers, revenues stream, key resources and processes (Timmers, 1998; Chesbrough and Rosenbloom, 2000; Osterwalder et al., 2005). In that respect, the adaption of cloud computing as an enabling technology might affect a company's business model on several elements. Cloud Computing allows for example optimized cost structures, new applications and broad network access to all stakeholders (Armbrust et al., 2009; Mell and Grance, 2011). However, companies show different levels of cloud adaption, which leads to the research question:

How does the adoption of cloud computing affect the company's business model?

Literature Review

A literature review on business-related adoption of cloud computing revealed that current research deals primarily with economic-benefits for the cloud-user, adoption-decision-making tools or adoption-benefits and -risks in general (Yang and Tate, 2012). In terms of adoption outcomes, there is little research on how the degree of

adoption affects a company's business model. With regard to this, Brook et al. (2012) made a first contribution. The authors show that the adoption of cloud services leads to changes on certain elements of the companies' existing business models.

Methodology

Building on these insights, this research aims to analyze the correlation between the degree of cloud computing adoption and the distinctive adaption of business model elements. For this purpose, the research framework will use the degree of adaption as independent variable. A stage maturity model seems to be an applicable measurement framework. The cloud maturity models of Weiss et al. (2013) and Verma et al. (2011) will serve as a basis for further extensions of certain adoption measurement criteria (e.g. business goals, applications, scope). The affected business model elements as dependent variables will be based on the ontology of Osterwalder (2004), as it allows for a detailed analysis of the impacted business model elements. The proposed framework enables to analyze the impact a company's cloud computing maturity level has on its business model elements. The research methodology will stand on case studies, whereby cases in three to five companies will be conducted per maturity level. Initially, the research will be limited to only one industry in order to contain variations of the results. Further research will then be conducted across various industries.

Contribution

The expected outcome is two-fold: As a contribution to IS theory the research will provide a linkage on how cloud computing usage can be transformed into business value. As practical implication the research will guide decision makers to govern their investments in cloud computing.

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IT Governance Aspects and Impacts of Adopting Cloud Computing in the Financial Sector

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Research Motivation

Cloud computing proves to be an increasingly applied methodology and environment; there is a growing number of solutions used in various industries. As published by the IEEE Computer Society four years ago, “Cloud computing has become a significant technology trend, and many experts expect it to reshape information-technology processes and the IT marketplace during the next five years” (Leavitt, 2009). Emerging of the technology still keeps going however. As of a definition, the (US) National Institute of Standards and Technology stated that “Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction” (Mell & Grance, 2010). The financial industry shows interest in cloud-based services as a means of cost-efficiency and manageability to take advantage of decreasing necessary effort. At the same time, in order for financial institutions to maintain a safe IT environment that provides their customers with a high level of privacy and data security, numerous regulations have to be complied with; and business-driven developments also need to be supported by continuously improvable solutions to meet strategic goals. All these aspects have to be covered by well-defined procedures and roles assigned to responsibilities, to ensure that the environment is regulated and controlled properly. Market players of the financial sector are therefore facing complex challenges in information technology; in addition, cloud computing means new aspects to be aware of. The research aims at revealing difficulties, best practices and benefits in cloud adoption from the perspective of IT governance.

Literature Review

As cloud computing – however it’s not a new-born term – has become popular recently, and its relationship with the other aspects of the proposed research makes the research questions specific, therefore there is a only a limited amount of existing literature that can be discovered. However, drilling down to the components of the

research topic along a relevance tree we're getting to the actual research terms; these terms allows finding relevant sources. Apparently it's not possible to observe all the aspects at the same time, but studying essentials and certain pairs of the elements reveals already published information. When writing about changes driven by cloud computing to be considered, and how to utilise COBIT, a widely applied IT governance framework, Vael suggests (2012): "As cloud computing evolves in importance worldwide, it is important that enterprises understand how to handle the paradigm change in business operations that the cloud presents in an effective and efficient manner. This level of understanding will enable enterprises to maximize the benefits and opportunities that cloud computing offers, while simultaneously addressing its unique and emerging threats and vulnerabilities in an intelligent manner". We can find already implemented cloud-based solutions in various financial institutions, although with limited occurrence for the time being, and providing complementary rather than core services. "Even with the potential for cost savings and greater efficiencies, most community banks are approaching cloud computing with caution" – Motley highlights (2012) in the ICBA Independent Banker journal.

Methodology

The research has developed its objectives around the following aspects: applicability of IT governance models on cloud-based services and solutions in the financial sector; IT governmental impacts and risks; and the potential benefits to be revealed. Given the nature of the objectives and the population targeted, the research is qualitative and exploratory at the same time. Utilising a preliminary survey and semi-structured interviews, the research will try to predict best practices and to publish already resolved concerns in the form of case studies; besides that it is also planned to reveal analysis of the identified factors.

Contribution

The purpose is to make analytical and predictive conclusions, therefore to provide re-useable contributions both for the industry and for future researches from an academic perspective as well.

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Investigating the Impact of Cloud Adoption in Firms

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Research Motivation

Cloud computing combines elements of grid computing, utility computing and autonomic computing in an innovative deployment architecture (Zissis & Lekkass, 2012). More specifically, the US National Institute of Standards and Technology (NIST) define it in terms of *five characteristics* (on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service), *four deployment models* (private, community, public and hybrid clouds), and *three service models* (Software as a Service, Platform as a Service, and Infrastructure as a Service) (cf. Mell & Grance, 2011). The potential impact of cloud computing has sparked significant interest in the IS and IT industry. Cloud computing services, which are effectively based on a pay-as-you-go model (Armbrust *et al.*, 2010), result in immediate savings on hardware and software (Morgan and Conboy, 2013) and can also lead to time savings by supporting process transparency and auditability and also by facilitating better communication within the firm and (Conboy & Morgan, 2012). However, empirical research on cloud computing is limited, focusing on the technical rather than business aspects (Leimeister *et al.*, 2010) and on the barriers to adoption rather than the value implications of use (Conboy and Morgan, 2012; Clohessy & Acton, 2013). In particular, very little is known about the implications of cloud solutions on the use of time in firms – even though time use is recognised as a fundamental business performance indicator (Ciborra, 1999). This study therefore systematically investigates the business implications of the cloud adoption within the client firm using a temporal perspective.

Literature Review

Increased responsiveness at shorter notice: Cloud solutions affect firm agility (the capacity of firms to make significant changes at short notice in response to environmental changes). For the first time, firms can avail of dev/test environments on demand which can facilitate exploratory and innovative work within the firm. At the same time, cloud solutions are easy to install (Conboy & Morgan, 2012) and highly scalable

(Armbrust *et al.*, 2010) which increases firms' capacity to rapidly respond to change by varying their own demand for particular services (*ibid.*). In addition, cloud solutions can increase firms' capacity to run complex queries on large distributed data sets in near real time and these results can be used to trigger responses to environmental and market changes. However, increased firm agility leads to greater industry turbulence. As such, cloud solutions may enable individual firms to quickly adapt to change but firms are more likely to encounter such change going forward. *Better synchronisation and improved access to data:* Cloud solutions improve the availability and accessibility of data (Yu *et al.*, 2010), the capacity to synchronise data across multiple locations and across multiple devices (Agrawal *et al.*, 2010), and provide greater opportunities for individuals and teams to collaborate at work (Marston *et al.*, 2011). But to take full advantage of these benefits, individuals and teams need to develop new ways of timing and coordinating work, new techniques to cope with the costs of switching from one task to another and new mechanisms to support concurrent work practices. *Increased velocity leading to greater time pressure:* Cloud solutions result in significant process improvements (Conboy & Morgan, 2012). However, the resulting time savings can, in turn, lead to time compression (Kumar, 1995) and increased time pressure across industries (O Riordan *et al.*, 2012a). Indeed, most network-enabled firms are increasingly expected to be able to operate in real time (Orlikowski & Yates, 2002). As such, cloud solutions may enable individual firms to make time savings but ultimately, firms will have to work hard to derive sustainable competitive advantages from these savings because of the increased time pressure that these technologies also induce at the industry level.

Methodology

This study leverages an existing theoretical framework on temporality in firms to systematically investigate the direct and indirect consequences of adopting cloud solutions in three technology-intensive firms. Given the exploratory nature of the topic, the data will be collected and analysed using qualitative techniques. This research addresses a fundamental gap in our current understanding of the business implications of adopting cloud solutions in firms. Given the impact that cloud technologies are currently having, the research is of strong industry relevance.

Contribution

From a theoretical perspective, its core contribution is to on-going efforts to develop new ways of investigating temporality and its relationship with technology in organisational settings (cf. O Riordan *et al.*, 2012b).

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A Portfolio Approach to Cloud Computing

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Research Motivation

Cloud Computing can make software as a service more attractive and shape the way IT hardware is designed and purchased (Armbrust et al. 2010). It is seen as a panacea by many organisations. These organisations are under massive pressure to maintain profits and deliver operational excellence. However as Michael Porter (1996) wrote, “operational excellence is not strategy”. Strategy is the basis on which organisations battle to maintain competitive advantage. Strategic goals are realised by aligning IT projects with business goals and grouping them into portfolios (De Reyck 2005). IT project portfolios are the subject of a growing body of literature, however there has been no focus on the specific challenges of cloud computing.

Literature Review

Existing project selection criteria often focuses on return on investment and discounted cash flows. These criteria ignore the flexibility inherent in complex dynamic systems and systematically undervalue them (Benaroch and Kauffman 1999). They also fail to measure the alignment between projects and business strategy. Proper alignment requires companies to take a portfolio approach to its adoption of Cloud Computing. Practitioners will seek to avoid some of the previous mistakes that have haunted IT. Software development suffered from a crisis of budget overruns, late delivery and issues with functionality (Naur and Randell 1969). McFarlan (1981) introduced IT project portfolio management (PPM) as a response to the software crisis. He grouped projects into portfolios in order to minimise project risk. Market risk can be transferred to vendors through cloud technologies (Armbrust et al. 2010). Market risk has become a big problem for IT organisations. They exist in a dynamic environment with rapid change. This can result in “big bang disruption” where markets are wiped out overnight. (Downes and Nunes 2013). The threat of big bang disruption forces organisations to embrace business agility. Agile organisations have to be prepared to enter and exit markets quickly. This can result in them losing alignment with their intended strategy. Minzberg’s use of the term “strategy formation

in an adhocracy” (1985) is applicable to IT in complex environments (Harris et al. 2009). A change in strategy requires a review of the alignment of business goals with operational projects (PMI 2009). Conversely, the adoption of emergent technologies should trigger a review of strategy at the portfolio level. Ensuring strategic alignment is a key output of PPM (PMI 2009). But PPM does not have the appropriate tools for this (Jeffery and Leliveld 2004). There are no accepted metrics to measure the alignment of Cloud Computing projects to overall strategy. PPM has focussed almost exclusively on portfolio selection (Frey et al. 2013). However there is a significant body of research in financial portfolio literature that looks at performance measurement, style (e.g. Sharpe 1992) and drift (e.g. Idzorek and Bertsch 2004). The trans-disciplinary nature of business research has gained considerable support (Saunders et al. 2012).

Methodology

How can we measure strategic alignment in a portfolio of cloud based projects? This requires us to: Identify the appropriate data available to measure strategic alignment in project portfolios (RQ1). Identify and adapt an appropriate financial portfolio framework to measure project portfolio alignment (RQ2). Validate the framework for cloud portfolios (RQ3). The study will be informed by explorative case studies. Interviews and archival research will compare the metrics required by portfolio managers with those available. A Survey will generate insight into the flow of information both between teams and portfolio managers. Case studies will be used to validate the framework to measure alignment in project portfolios.

Contribution

Emerging IT trends are often practitioner led. Cloud Computing is no different. This research will make a contribution by providing a rigorous framework to measure strategic alignment in Cloud Computing portfolios. It will also help formalise some of the best practices already in use by practitioners.

Acknowledgment

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Security Assessment: A Prerequisite for Cloud Adoption in SMEs

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Research Motivation

This research is motivated in equal parts by (a) the belief that cloud computing is a phenomenon driven by economic factors that are both logical and inexorable (Marston et al., 2011), and (b) that the SME sector is a critically significant domain of study for reasons of global economic relevance, current adoption behaviour and vulnerability to cyber attack. In America, for example the SME sector comprises the vast majority of firms (USITC, 2010), and the sector's importance in Europe is equally pronounced, at 99% of all firms, contributing more than half of the total value-added by business, and providing two thirds of private sector jobs, 90% of which are in micro firms of 10 employees or less (ECORYS, 2012). In the cloud-computing context, with SaaS as the dominant delivery model for meeting enterprise needs, SME companies heretofore have the highest adoption rates (Subashini and Kavitha, 2011). Coupled with data from recent reports highlighting that cybercriminals are now automating and streamlining high-volume, low-risk attacks against weaker targets (Verizon, 2012, PWC, 2013), it seems both sensible and necessary to separately examine security factors as they specifically relate to cloud adoption in SMEs. Cloud computing is not a panacea (Zissis and Lekkas, 2012), and consequently a security-centric adoption approach is pragmatic.

Literature Review

Security and privacy issues are often the most cited objections to cloud adoption, (Armbrust et al., 2010, Takabi et al., 2010), with threats coming from both inside and outside the cloud. However, what is more worrying, is the fact that many companies believe that with SaaS, they are simplifying security issues by effectively 'outsourcing' them to another party (Anthes, 2010) or as Kaufman (2009) suggests that small companies or start-up companies, because of limited resources, often turn to the cloud to deflect cybersecurity concerns.

Much of the extant literature in this area refers to technical matters such as the inherent vulnerabilities from multi-tenancy and the consequent possibility of ‘insider’ attack, (Subashini and Kavitha, 2011), difficulties of data ownership and location (Hayes, 2008), responses to security incidences, disaster recovery and provider’s economic stability (Takabi et al., 2010). Many of the accompanying solutions are in effect acknowledging the fact that the vulnerability of the cloud is similar to the vulnerability of all web applications, and bypass the fact that information security is now seen as a socio-technical problem that requires a thorough understanding of the weakest link in the defence against security threats: human behaviour (Dinev and Hu, 2007).

Methodology

This research seeks to examine cloud security adoption through the lens of a variant of Technology Threat Avoidance Theory (Liang and Xue, 2009, 2010) specifically adapted for this study. Initially conceived to predict threat avoidance behaviour, the adapted framework uses constructs of perceived likelihood and severity (Rogers, 1975) to determine SMEs assessment of perceived threat of attack pursuant to SaaS adoption. Interacting with this threat perception are measures of coping, both problem-focussed and emotion-focussed (Lazarus, 1993). Because this framework aims to predict (or at least elucidate the reasons behind) adoption rather than avoidance behaviour, variables such as self-efficacy (Ajzen, 2002, Bandura, 1977, Bandura and Cervone, 1983), controllability (Bandura and Wood, 1989, Rotter, 1975) and normative beliefs (Schwartz and Tessler, 1972) have been added to the research model (See Fig 1). The empirical segment of this research will begin with a series of personal face-to-face interviews including the use of a number of vignettes, designed to control for the non-security related motivations for adoption, such as economic and technical benefits.

Contribution

The contributions from this research will be twofold - as a predictor of behaviour in relation to cloud adoption in SMEs and as a prescriptive security model of steps to be undertaken by SMEs prior to cloud adoption.

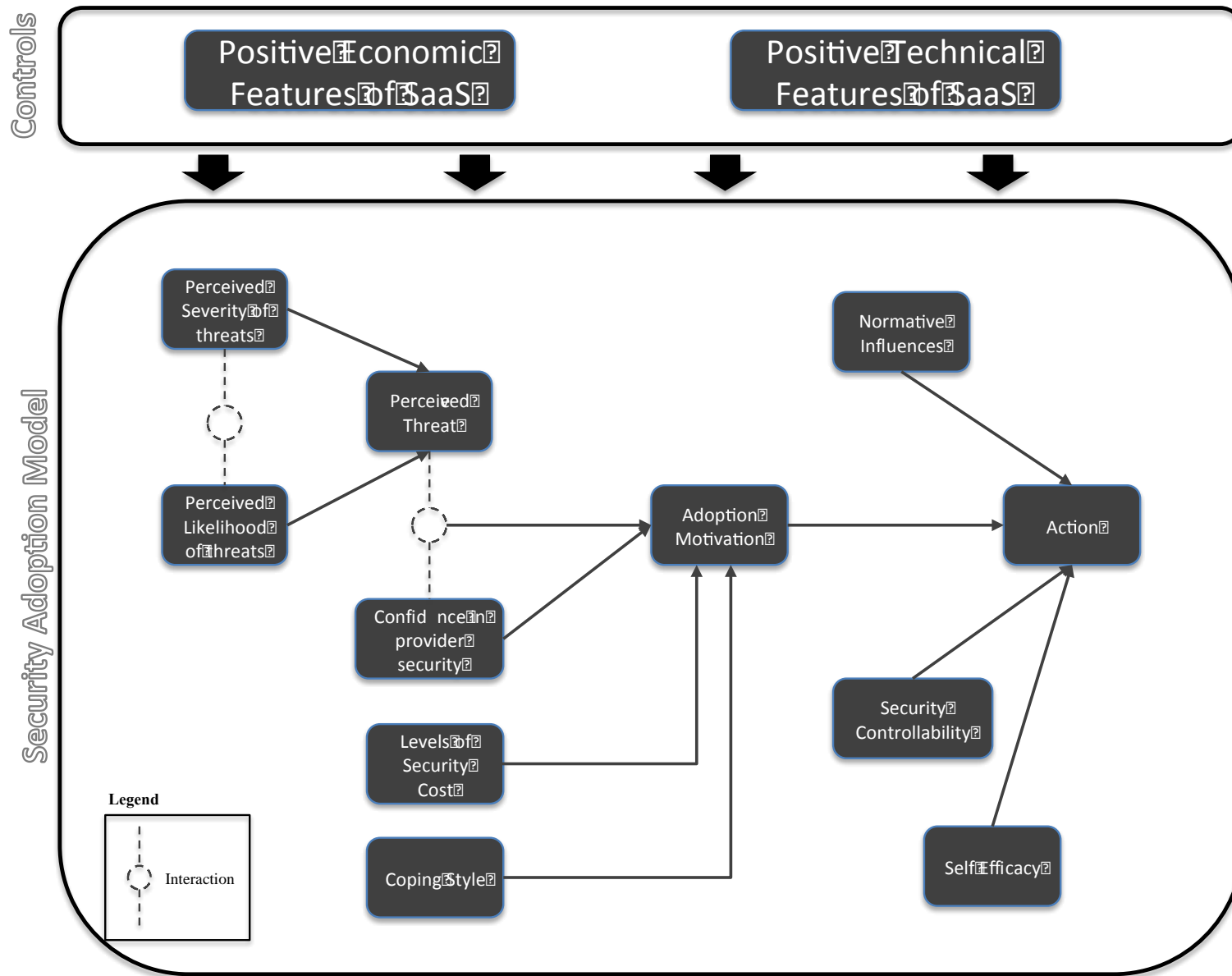


Figure 1 Proposed Research Model

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The Impact of Nested Virtualization on the Performance of Virtual Machines

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Research Motivation

Nested virtualization is increasingly being used for testing, teaching and training purposes to provision different environments on demand. Very little work has been published till date about the quantitative impact of nested virtualization. This research is important so that users who want to use nested virtualization have quantitative data about the impact of nested virtualization on the performance of client virtual machines. This will enable them to make informed decisions about using nested virtualisation, and if yes, then which combination of hypervisors.

Literature review

Nested virtualization is the implementation of a second level of virtualization on the top of first level virtualization. It is implemented by installing a hypervisor within a host hypervisor (Pan, et al., 2011). There is a published work about using nested virtualization to reduce the cost of testing (Casey & Santiago, 2009). The focus of this work is on cost, the impact on performance has not been considered. (Ben-Yehuda, et al., 2010) worked on the Turtles project to test the performance of guest hypervisors and guest virtual machines of nested virtualization. They used only KVM as the host hypervisor. We are extending their work by testing on both VMware and KVM as host hypervisors and using different benchmark tools. Hypervisors that participate in nested virtualization are called nested hypervisors (Wing-Chi & Aloysius, 2012). Some of the hypervisors that support nested virtualization are VMware, KVM and Xen. The biggest drawback of nested virtualization is the performance (Masakuni, et al., 2013). Among these hypervisors, it is difficult to decide which one performs well. Therefore, the motivation for this research is to get quantitative performance data.

Methodology

To execute the research, a hypervisor called the host hypervisor will be implemented as a first layer of virtualization on the physical hardware. On the top of the host hypervisor, a second hypervisor called the guest hypervisor will be implemented as a second nested layer of virtualization. In order to measure the performance of virtual machines in the nested hypervisors, the performance of hardware resources like CPU, Memory, Disk I/O and Network will be measured. Windows and Linux operating systems will be installed on virtual machines of the base hypervisor. Then tests will be performed on the two different operating systems running in the guest virtual machines so as to see if performance varies from one operating system to other.

On both VMware hypervisor and KVM, again VMware and KVM hypervisors are proposed to be installed. Virtual machines will be created in each nested hypervisor, and Windows and Linux operating systems installed as guest operating systems. Then the tests will be repeated in the two nested virtualized environments. Performance of hardware resources like CPU, Memory, Disk and Network will be measured using different benchmark tools. CPU performance will be measured using LINPACK, memory performance using STREAM, Disk I/O performance with IOzone and Network performance by using Iperf. These tools will be installed and executed on the third level VMs running Windows and Linux operating systems. The performance measurements can then be recorded and the combinations compared and analysed to quantify the impact of nested virtualisation.

Contribution

This work will provide a template and an example of how performance variation from single level of virtualization to second level of nested virtualization can be measured. We expect that there will be differences because requests are to be processed in two levels in case of nested virtualization that are virtual-to-virtual in the second level and virtual-to-physical in first level whereas in single level of virtualization, only virtual-to-physical instructions are executed. Design of hypervisors also varies from one vendor to another, which may result in performance variation. In this work we propose to compare VMware and KVM. Therefore, the result of this work will tell us about the performance overhead of nested virtualization and single level virtualization and differences due to VMware and KVM.

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Towards The Deployment of Cloud Applications Using a DSL

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Research Motivation

Cloud infrastructures offer facilities to develop and deploy large-scale applications. Nevertheless, testing Cloud applications is an intricate task because applications themselves are very complex, infrastructures are highly distributed and heterogeneous, the amounts of data are massive, and the interconnections between services/components are sophisticated. From a business point of view, testing is generally not seen as an interesting phase of software development because, unlike the development of new features, it does not offer a direct return on investment. We think that providing accurate methodologies and tools to test Cloud applications will allow companies to speed up testing (and thus save time and money), and produce better software (and thus increase their competitiveness). In this research, we aim to ease the deployment of Cloud applications. This task is painful in the context of Cloud applications because testers have to write different scripts to test their applications with different Cloud vendors (e.g. Amazon EC2¹, Google Compute Engine²). Our objective is to define a generic language that allows writing deployment scripts disregarding Cloud vendors.

Literature Review - State of the Art

Many different configuration management tools have been developed to maintain applications across multiple hosts in a distributed environment e.g., Cfengine (Burgess, 1995), Puppet (Kanies, 2006), and Chef³. A similar tool described by Juve et. al. (2011),

¹ <http://aws.amazon.com/ec2/>

² <https://cloud.google.com/products/compute-engine>

³ <http://www.opscode.com/chef>

Wrangler, enables users to define application's layout using a declarative language, and provides a robust service to automatically provision, configure and manage the application. Such configuration tools are often heavy weight and involve a complex architecture, including: clients, servers, repositories, etc. The set-up alone can consume a significant amount of time and require expert knowledge. A review of the literature shows that DSLs are a popular approach to application deployment in Cloud environments. However, many of the existing solutions target just one Cloud vendor and cannot support multiple or federated Clouds (commonly used to avoid vendor lock-in [6]). Sledziewski et. al. (2010) propose a DSL to ease the design of high-level models and specifications, enabling a non-expert to understand and develop the system. Kirschnick et. al. (2010) describe an architecture that uses DSLs to automatically deploy and manage VM instances, and applications in the Cloud. DSLs are used to describe the desired state of the virtual infrastructure and components, and how they should be installed, configured and managed to achieve it.

This abstract proposes a DSL to provide a lightweight, platform-independent solution for application deployment in the Cloud with support for multiple vendors.

Contribution

The objective of our research is to propose a generic language that allows writing deployment scripts independent of Cloud vendors. In order to achieve this objective, we plan to define a Domain Specific Language (DSL). Testers will then be able to write deployment scripts in the proposed DSL. To apply the script to a specific Cloud vendor, a transformation must be defined between the DSL and the language used by the vendor. Each vendor may have its own deployment language, which is likely to present some specifics (e.g. use of a specific library, specific ordering of instructions). In order to deploy an application on N vendors platforms, a script must be written in the DSL. It is then translated into vendors' specific scripts: N scripts are automatically generated from the initial script. This approach offers the following advantages: (i) only one script needs to be written for each application (rather than one for each Cloud vendor), (ii) if a Cloud vendor changes the way to deploy applications, testers don't have to modify their deployment scripts: they just have to modify the transformations accordingly, and (iii) the introduction of a new Cloud vendor just requires a new transformation to be written (no need to write new deployment scripts). This work is still at a preliminary stage.

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Cloud Bursting in the CSO

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Research Motivation

The Department of Public Enterprise and Reform published a Cloud Strategy in June 2012 (Department of Public Expenditure and Reform – Cloud Computing Strategy), it sets out the importance of Cloud Computing in the Government Sector. It encourages the use of the Cloud and has both a 5 year and 10 year strategy as it envisages that both public and G Cloud (Government Cloud) will be available. The Central Statistics Office was established in 1949 as Ireland’s national statistical office. Its status was formalised in legislation with the enactment of the Statistics Act, 1993. The mandate of the CSO, as set out in the act, is the “collection, compilation, extraction and dissemination for statistical purposes of information relating to economic, social and general activities and conditions in the state” (Central Statistics Office).

The demand for more timely statistics has meant the CSO has collected data via different methods over the last number of years so as to increase the time from collection, in the example of household statistics, to publication. The Office is currently exploring extending their collection of statistics to include ‘Big Data’, issues such as data storage, processing and data protection are considerations for its usage. (Dunne, 2013). The availability of big data would increase available statistics, data from social media, mobile telephones and credit cards have obvious benefits for official statistics.

I have embarked on a research project to measure processing requirements for the CSO, how much hardware/processing power is required to achieve it and how we can provide more to ensure that i.) the current processing is achieved in a more cost effective manner and ii) assess the provision of an environment where the ability to process more data in a timely fashion without investing in costly infrastructure.

This research is based on a 5 year cycle; this time frame is set to include the Census which has a large impact on requirements due to the high level of processing it requires.

Methodology

My research must measure the output, measure the data, the variables, the time allocated between raw data and publication. CSO statisticians must be surveyed to try and discern their attitude, practices and perceptions of data processing. This data will form the basis of a model. The model will measure the level required, forecast data growth based on historical information and provide measures of what would be required when volumes of data increase. If at times, the data was to exceed the perceived parameters of the current infrastructure, a burst to the Cloud will be considered as a solution. The 'cloud' will have to be defined within the scope of this project i.e. a hybrid cloud, the G Cloud (Government Cloud). How will this model be used? This model is designed to measure the requirements, it will be used by Infrastructure architects to ensure availability and give them a mechanism to measure the reality of the processing of more data without large capital investment. The research will demonstrate how it would be possible to use other resources for peak times of processing.

Summary and Recommendations

The summary should detail the research methodology and how the model was created. It should allude to the testing and verification methods. The recommendations should be based on the CSO register of data processing over a 5 year cycle. They should compare the benefits of further capital expenditure to a Cloud model. The possible use of big data should be detailed in the recommendations and how it could be incorporated into the proposed solution.

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Monitoring the Cloud - CloudMon

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Research Motivation

The Cloud is a complex, heterogeneous environment consisting of many layered components with complicated interconnections and relationships. Monitoring the Cloud is vital in providing service assurance and upholding SLAs. Failure to do either would result in a negative impact to customer satisfaction, potentially resulting in a loss of revenue. While the Cloud offers many advantages and interesting features (easy deployment of applications, resiliency, security, performance, scalability, elasticity, etc.), there are many challenges involved in monitoring such complex systems (Adinarayan, 2012; Aceto, 2012). Some of the main issues for monitoring the Cloud include: heterogeneity of hardware/software, scalability, aggregating and analyzing data.

Data centers, at the crux of the Cloud paradigm, are often very large buildings that house many thousands of different hardware devices. Additionally, the virtual machines that form a layer in the Cloud stack may have a wide range of operating system software, introducing yet another layer of complex heterogeneity. The different hardware/software results in a plethora of metrics and formats, leading to a significant challenge in monitoring the Cloud – aggregation of monitoring data. Cloud monitoring data is ‘big data’, with many different types of metrics calculated and recorded at frequent intervals. An important question is then, how can this information be aggregated, correlated, and analysed in an efficient and intelligent way, to make smart reconfiguration decisions? The scalability of such a solution also poses significant challenges. Given the vast number of machines (physical and virtual) and applications involved, and the many performance metrics of interest, it is vital that the information is collected and processed in a scalable way.

Literature Review

There is quite a number of monitoring tools in the Cloud arena, however, many of them don't support reconfiguration or consider scalability. The work in (Anand, 2012) presents a scalable framework for monitoring Cloud applications, with support for cluster node monitoring. Mohamed et. al. (Mohamed 2013) propose a framework that adds monitoring and reconfiguration facilities to services of a service-based application and deploys them in the Cloud using a scalable micro-container (Yangui, 2011). The article in (de Chaves, 2011) describes the authors' experience with a private cloud, and discusses the design and implementation of a private cloud monitoring system (PCMONS). The authors claim that main factor impacting the success of Cloud monitoring tools is the lack of open source tools; this one of the limitations addressed by CloudMon.

Methodology

CloudMon will be initially implemented on a small-scale testbed to validate the fundamental idea, Key Performance Indicators (KPIs), aggregation method, and scalability algorithm. The CloudMon controller (Fig 2) will support the (re)configuration of the Cloud monitoring service. It will have a web interface, where users can view the entire CloudMon network (consisting of all CloudMon enabled devices). Metrics can be enabled/disabled, and thresholds configured for each layer; and values can be viewed in the results display. The controller can be extended with logic to make intelligent VM migration decisions based on customer-defined requirements (e.g. economic, legislative, data protection). Platform independent, lightweight, software agents can be deployed on each sensor in the system. Their responsibilities include collecting, filtering, calculating new metrics, formatting and transmitting reports to the CloudMon controller.

Contribution

CloudMon is a proposed open standard for performance monitoring to overcome the heterogeneity of the Cloud stack. It has a hierarchical architecture consisting of a centralized controller and platform independent software agents (installed on every monitoring node - Fig 1). A standard set of messages is provided for metric request and reply functions to facilitate communication between the controller and agents. The standard will be extensible, and include a framework that can be used for adding new

metrics e.g., new service-specific Key Performance Indicators (KPIs) can be developed to provide a better view of system performance for individual services. New scalability algorithms are needed to determine the necessary frequency of metrics and density of sensor nodes (that provide a representative sample set), given the size of the system and the required accuracy (defined in the SLA).

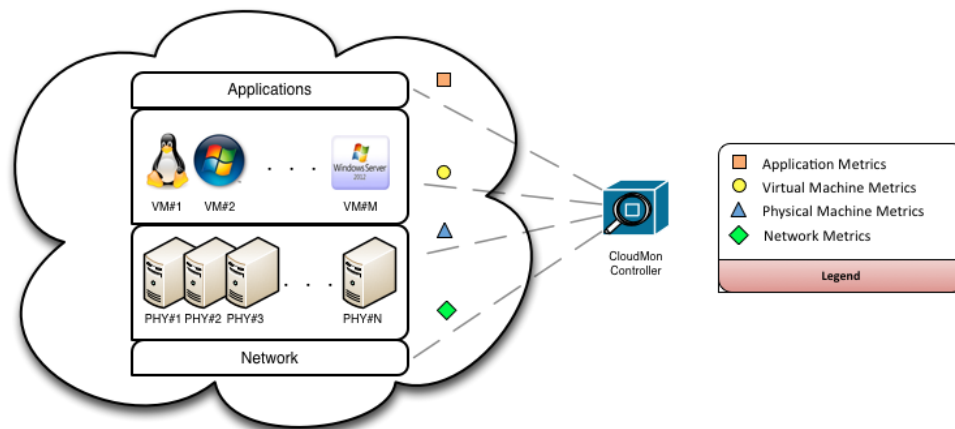


Figure 2. CloudMon Reporting Architecture

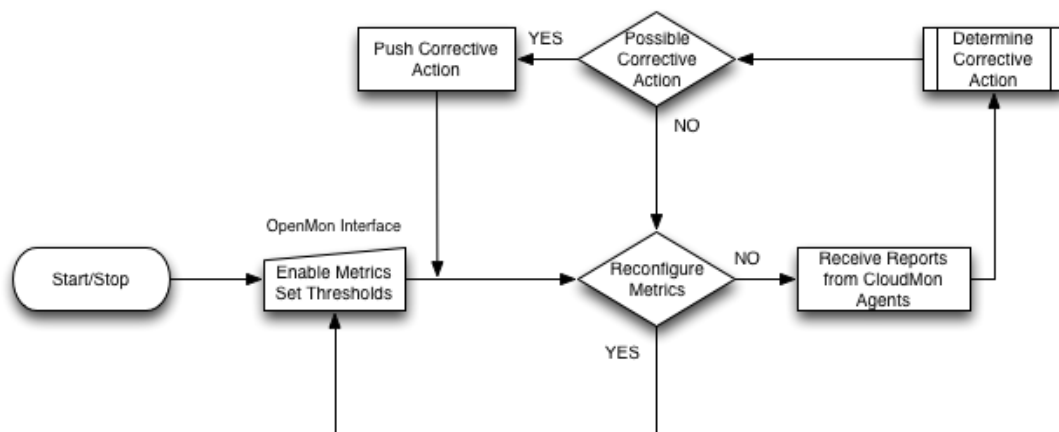


Figure 2. CloudMon Controller Flow Chart

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Service Placement in the Cloud

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Research Motivation

The Cloud is a complex and heterogeneous composition of physical machines and services. It is *heterogeneous* because capital allocators in companies do not buy new hardware every year and machines age, and the software on those machines are not always at the same version. It is *complex* because of the software stack on the machines: various kinds of operating systems, web/database/application servers, and because a large number of the services nowadays are multi-tier, i.e., are composed of separated services that can reside on different machines. Consider for instance a classical e-service with a web interface (e.g., a page in Javascript) residing on the machine of a datacentre d_1 , while the logic is situated remotely on another datacentre d_2 and the database in a PaaS provider (e.g., Google Datastore). The problem is now that there are potentially an infinite number of machines where to put processes or services, and that the *placement* of a service on a specific environment can have an impact on its performance. Capital Allocator in companies have the role of assessing the performance of assets, and making decisions such as: changing the performance grade of an asset, decommissioning and asset, buying some new assets. These decisions are made on a regular basis in the Enterprise, at the global level or at the level of a single datacentre. For them, grouping workloads in virtual machines (VM) make things easier as it hides the complexity of the internal software stack and allows to attach just few key indicators to a VM. The question of placement then becomes one of mapping VM to PM, and very often researchers understand it as a particular instance of the bin-packing problem. This problem is classical in computer science and consists in trying to optimise some utility function associated with the assignment of items to bins. It is unfortunately, as we will see in the rest of this section, very sensitive to the size of the instance and the resolution time. One major challenge is that, while the *size* of datacentres varies a lot, it is usually a very large problem. For instance, number of machines ranges from few machines (e.g., in a SME or a university), to hundreds of thousands of machines for

large datacentres (Miller, 2013). The number of processes or VM hosted on each machines is also large: from one VM per PM in non-virtualised environments, to more than a hundred of VM per PM on big servers. Another challenge concerns the *time* offered for the placement decision. In the Enterprise, like in most companies, the process is very iterative and distributed: placement plans need to be approved by CAs, and are not applied directly from the top. This means that a plan will be updated multiple times before reaching a state where all parties agreed, and the placement algorithms need to run quickly enough to incorporate the modifications given by the different CAs consulted.

Literature Review – Related Work

Most papers in the literature focus on operation research solutions for optimised placement (e.g., constraint programming, linear programming) (Hermenier, 2009; Feller, 2011). While their quality is usually very good, they are often extremely slow and fail at giving a ‘practical’ solution for the case we consider – multiple parties collaborating interactively in a company. Industry products also do not really address this specific case of server consolidation. They have usually two different objectives: load balancing in a subset of the datacentre or VM physical migration, while an automatic (and interactive) placement in the global context, i.e., in the Enterprise as a whole, is desirable.

A Different Approach: iVMp

(Li, 2013) have proposed recently a heuristic based placement taking into account individual permissions, obligations or special preferences. They call iVMp for interactive VM placement, and describe it as an *agile solution*, as CAs interact with plans made by the algorithm to iteratively find an adequate solution (see Figure 1). Among the different subsets of an enterprise IT infrastructure, each CA may have different placement objectives, such as what VM can run on which machine (e.g., specific country licensing may apply), or what load to put on what VM (e.g., for some energy efficiency purpose). In iVMp, the authors propose to let the CAs interact with the plans and find ‘together’ a solution. They compare their solution to IBM ILOG CPLEX, the best optimisation solution available, and to few heuristics (Lee, 2011). They show that iVMp provides a near optimal solution (very close to CPLEX) while the processing time is acceptable and better than CPLEX. In Figure 2 they increase the size of their problem (342 PM, number of VM on the x-axis) and while CPLEX does not scale, iVMp gives a solution in few seconds.

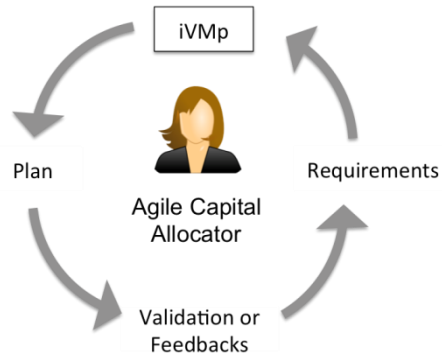


Figure 1. Overview of our Agile Capital Allocation System.

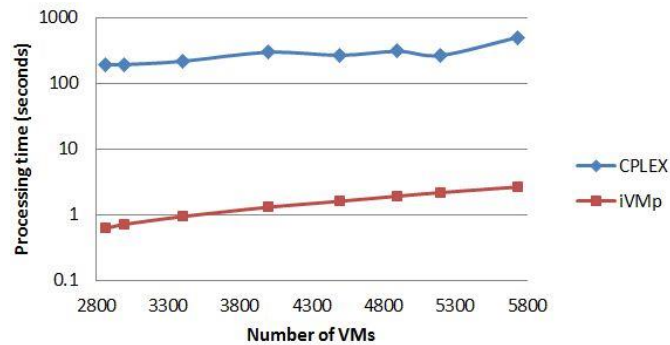


Figure 2. Scale-up, logarithmic scale: CPLEX and iVMp

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Towards a Greater Understanding of the Cloud Computing Business Ecosphere

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Research Motivation

Our understanding of the cloud ecosphere has evolved substantially in recent years. Definitions as to the architecture and composition of the cloud have also changed since the outset of the earliest theoretical concepts outlining the components and boundaries of the ecosphere. From the outset of cloud computing various attempts have been made to codify and outline the key aspects of the cloud to include the architecture layers, major service providers and indeed value models offered by the structure of the cloud. In attempting to delineate a map encompassing the core nodes of the cloud eco we see a complex series of inter-relationships at multiple layers that interlock to form the backbone of the present ecosphere. The main aims of this research in progress is to identify the current state of play with regards to the main entities and associated relationships encapsulated in a cloud computing vendor ecosphere and associated value network.

Literature Review

(a) Cloud Vendor Ecosphere

21st century ICT organisations operate and compete in ecospheres that comprise a set of entities such as rival organisations, infrastructure providers, complementors, development platform providers and so on (Iyer and Henderson, 2010; 2012). Iyer and Henderson (2010) identified, following the exploration of the cloud vendor ecosphere, five specific categories of cloud computing organisations which included: (1) infrastructure, (2) platform, (3) collaboration, (4) application, and (5) service provider. The authors also identified specific partnerships amongst the aforementioned categories and asserted the main cloud vendors engage in specific strategic partnerships with organisations to assist with the delivery of their value propositions.

Partnerships identified consisted of, strategic relationships, technical alliances, reseller relationships, independent software vendor arrangements and consortium membership. Recently, the American National Institute of Standards and Technology (NIST) proposed a conceptual cloud computing reference architecture, comprising of five main entities, their activities and functions in cloud computing (Liu et al., 2011). The conceptual architecture delineates five main entities: cloud provider, cloud consumer, cloud auditor, cloud broker and cloud carrier. A cloud provider and cloud consumer constitute the two main entities who share control of computational resources in a cloud computing environment. However, due to the rapidly evolving nature of the cloud computing vendor ecosphere, the paradigm is still maturing. This research will provide a revised perspective, utilising the methodology as prescribed by Iyer and Henderson (2010), on the main entities currently dominating the current stage of the cloud computing evolution.

(b) Cloud Value Networks

Modern day service industry organisations are facing substantial challenges in terms of rapidly changing markets, fluctuating customer demands, increased availability of low cost technology and complex networks of stakeholder relationships. The concept of value networks have emerged as a nonlinear platform where value is created through collaborative interactions and the exchange of resources in organisational networks. According to Leimeister, Böhm, Riedl, and Krcmar (2010), the service oriented and virtualised nature of the cloud computing paradigm coupled with “new opportunities to integrate individual component services to create value-added, complex services gave rise to a set of new roles that can be found in cloud computing”. The authors adopted a methodology, based on the e³-value ontology as proposed by Gordijn, Akkermans, and Van Vliet (2001), in order to identify a generic cloud computing value network which depicts actors, their role, interrelationships and value streams. Actors identified included: customer, service provider, infrastructure provider, aggregate service provider, platform provider and consulting. The roles are delineated as follows. A customer avails of cloud computing services through various distribution channels i.e. directly from a service provider or from a platform provider. A service provider or IT vendor create and operate services that offer value to the customer and aggregate service provider. An aggregate service provider is a form of specialised service provider that combines existing services to form new services which are then provisioned to customers.

Aggregate service providers can often fulfil dual roles in that they can be viewed as a customer in the eyes of the service provider and also be viewed as a service provider in the eyes of the customer. Infrastructure providers or IT vendors, supply a value network with all the “computing and storage services needed to run applications within the cloud and provide the technical backbone”. A platform provider provisions the environment on which a cloud computing solution can be deployed. A consultant offers a customer “support for the selection and implementation of relevant services to create value for their business model”. However, the cloud computing value network ecosphere may be far more complex. Thus, the aim of the following research is to propose a holistic cloud value network, utilising the methodology as proposed by Gordijn et al. (2001), which will frame the current state of play with regards to the cloud ecosphere as identified in (a).

Contribution

An increasing number of organizations are gaining market traction and adding value to their respective businesses through the correct application of tailored relationships in their respective markets. We envisage that this research will enhance our understanding of where the industry is heading in terms of physical structure, potential developments and innovative opportunities.

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Measuring Business Value within the Cloud Technology Stack

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Research Motivation

It is evident that cloud computing has become a hot topic, making headlines both within business and academic circles since the mid 2000's. Nonetheless, it is surprising that there appears to be limited literature which focuses specifically on measuring the business value which subscribers to cloud based services can extract by way of utilising these same services in place of committing funds, resources and significant time, to building out, managing and maintaining traditional centres. Given the scarcity of empirical work in this area, further research is required to allow customers/organisations and cloud providers to better understand and measure the true business value that cloud based alternatives offer them in terms of both consuming resources and providing services.

Literature Review

Looking at both business value and cloud computing, one can reflect on conclusions drawn by Kohli and Grover (2008), whose study serves as a catalyst for a broader research agenda of IT value research. These authors suggest that the themes they introduce represent important departures from prior research in this area highlighting the example of the subtle shift from IT co-value creation to IT co-creation of value, which demonstrates how joint value can be created. As this hypothesis is based on the premise that by emphasising how joint value is created, we can evolve from the largely transactional perspective and begin examining how different companies with different IT can join together and create new value (Kohli & Grover, 2008). When measuring business value, researchers tend to utilise one of two approaches to assist in terms of defining and ultimately measuring business value - the variance approach and the process approaches (Davaraj & Kohli, 2002). In evaluating both approaches as they might relate to the measurement of business value within the cloud stack, it will be

important for the purpose of this study, to explore the existing theories of the firm to better understand how this literature relates to how value (creation/capture can be measured within the cloud stack.

Within the realm of the cloud, many customers come together in a co-located datacentre opting to consume cloud based resources at various tiers within the cloud stack, for certain periods of time, at various volumes. It is this flexibility that is the essence of why customers chose cloud, and why it is being considered at the highest levels of organisations with respect to influencing the future direction of corporate strategy.

A study conducted by Forrester research in 2008, interviewed more than 30 companies in the cloud space, including providers, customers and infrastructure suppliers. Results revealed that they were not able to verify enough customer references (even off the record) to conclude that cloud computing has crossed over from early adopter to phase to early majority phase (Staten, 2008).

Methodology

This particular study is likely to take a post-positivist, qualitative research approach. Given the scarcity of empirical work in this area, an exploratory study is needed. This type of research is suitable for “new fields of study where little work has been done, few definitive hypotheses exist, and little is known about the nature of the phenomenon” (Patton, 1990). Moreover, the research will encompass a case study or field study approach. The primary sample will consist of individuals from each of the following cloud stratifications: cloud users and/or perspective users; cloud providers; and infrastructure providers to cloud providers (Lincon & Guba, 1985).

Contribution

It is hope that this study will provide researchers and potentially decision makers within organisations with a valuable model that can be utilised when making decisions to invest in cloud based initiatives. This model will focus on the inherent business value that can be derived by companies with different IT resources, partaking in the co-creation of IT based value, while also looking to the indirect and intangible paths to economic value which can be influenced by cloud based technology.

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An Investigation into the Impact of Cloud Computing on the Sustainable Competitive Advantage of Irish SME's

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Research Motivation

Cloud Computing is a relatively recent technology to emerge in industry. Drawing on previous innovations such as grid computing and virtualization, it has the potential to bridge the gap between large multinational organisations and small to medium sized enterprises that traditionally could not afford to implement complex IT systems to help streamline their processes. With the emerging “pay as you go” business models associated with the implementation of cloud services, the large initial cost that was a barrier to entry for SME's has been removed. This study aims to analyse the way in which Cloud Computing as a resource can enhance the capabilities of Irish SME's, leading to Sustainable Competitive Advantage, and in turn bring clarity to the hype surrounding Cloud Computing in mainstream publications.

Literature Review

Because Cloud Computing is an emerging technology, it has attracted significant interest in academic and industry publications, as well as mainstream media. Cloud computing, although being a relatively new technology, is not a completely new innovation. Rather, it is the culmination of existing technologies such as utility computing, grid computing and virtualization (Zhang et al, 2010). Quittner (2009) identifies the potential for Cloud Computing to make core operations within an SME more effective, whilst providing them with large-scale savings. Paul Rellis (Goodbody, 2011) identifies that cloud represents a fundamental shift in culture as well as technology that will enable business, state organisations and government to increase efficiency by using cloud services to streamline operations and enable growth.

Resource Based Theory as set out by Ravichandran and Lertwongsatien (2002) consists of two mechanisms – Resource Picking and Capability Building. The coupling of these mechanisms is said to lead to Sustainable Competitive Advantage. In the literature review, three capabilities were identified as enabling an organisation to achieve

Sustainable Competitive Advantage. These included Improved Linkages between activities as set out by Porter (1985) in his value chain model, leaner work processes as set out by Singh et al (2010) and increased agility as defined by Zhang and Sharifi (2000). Therefore, the aim of this research is to analyse the impact of Cloud Computing on each of these capabilities as they relate to Irish SME's in order to assess the impact of the implementation of cloud-based resources on the Sustainable Competitive Advantage of each organisation.

Methodology

This stage of the research was conducted through five case studies. Information was gathered through a number of semi-structured interviews with people within the management team of five Irish SME's ranging from manufacturing to service providers. The aim of these case studies was to identify how these companies implemented cloud services, and the extent to which they proved effective. In addition to this, a number of enablers of cloud computing were interviewed, in order to gain a wider picture of the cloud computing landscape in Ireland. This represents a first step towards gaining a more thorough understanding of the impact of Cloud, by investigating the effect of cloud based resources on further capabilities within Irish SME's, as well as gaining a more longitudinal view of the effects of cloud computing by conducting similar case studies with the same five companies at a future date.

Contribution

It is envisaged that this research will make contributions in the form of bringing clarity to the large volume of claims within industry and academic publications with regards to the perceived benefits of cloud computing.

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Self-Adaptive Resource Scalability for Elastic Service Provisioning in Cloud Architectures

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Research Motivation

Cloud computing exemplifies a computing paradigm, where resources are provisioned as a service (Armbrust, et al., 2010) (Jamshidi, et al., 2013). A key distinguishing factor in cloud computing, other than in similar paradigms like Grid or High Performance Computing, is the provision of service-level agreements (SLAs) to service users (Brandic, 2009). Thereby, applications can function considering predefined non-functional requirements such as execution time, cost, security or privacy standards. However, due to changing services, workload, external environment, hardware, and software failures, established SLAs may be violated. On the other hand, application providers (i.e. consumers of cloud-based services) want to minimize their cost while meeting the SLAs (Ghanbari, et al., 2012). As a result, application providers must interact with their systems to adjust their cloud resources. However, this frequent user interaction lead to a barrier for successful service provisioning of cloud-based infrastructures. We identify the central research challenge as *“how to autonomically scale an application in order to satisfy the non-functional requirements of software systems while minimizing cost of service provisioning through multiple cloud providers and considering the involved uncertainties?”*

State-of-the-art

An elasticity policy (Vaquero, et al., 2011) governs how and when resources are added or removed from a cloud-enabled software system. Automated cloud application scalability (called auto-scaling) is one of the most recent development for dynamic and automated resource provisioning (Vaquero, et al., 2011) (Ghanbari, et al., 2012) (Shen, et al., 2011). Auto-scaling is responsible for implementing such application's elasticity policies. The most recent auto-scaling capability, which is available for the commercial cloud providers (e.g., Amazon EC2 or Windows Azure) enable rule-based specification of elasticity policies (Vaquero, et al., 2011) (Ghanbari, et al., 2012). However, the

default auto-scaling in the cloud providers may not necessarily optimize the cost incurred from the allocation of resources to the application (Ghanbari, et al., 2012). Moreover, cloud providers do not let application providers to express rules containing uncertainty. Furthermore, the metrics based on which the provider decide to apply elasticity rules are imprecise and contain measurement noise.

Proposition and Methodology

Auto-scaling is one of the particular features of cloud infrastructures that allows providers to define rules that govern how their services shall scale up (out) or down (in) to adapt to a variable load (Shen, et al., 2011). These rules can be defined based on composition of a set of condition, which when met, they trigger the elasticity controllers. The elasticity controllers are able to scale the service up horizontally (e.g. adding a new VM for load balancing) or vertically (e.g. assigning a new server to an existing VM) (Vaquero, et al., 2011). In this work, we enable elastic multi-cloud application by integrating them with such an elasticity controller in a closed-loop style to provide self-optimization of resources and self-adaptation of cloud services when facing a SLA violation. The elasticity controller (see fig.1) implements the self-adaptation loop to:

- (i) Monitor* application and its interaction with environment (e.g., average resource usage).
- (ii) Analyze* the monitoring data to identify any violation of SLAs.
- (iii) Plan* an adaptation to provide cloud resources by either vertical or horizontal scaling.
- (iv) Execute* the scalability actions by means of the actuators.

In this work, we exploit fuzzy logic controller (Mendel, 2001) to enable specification of imprecise elasticity rules to feed the rule base in the controller and robustly handle dynamic uncertainty. One reason for the use of a fuzzy controller in our system is that the elasticity policies are easy to support in the inference rules that form the basis of the fuzzy controller's decisions. Furthermore, estimation noises and resource fluctuations introduce some uncertainty factors in the control process, which can be handled by fuzzy logic.

Contribution

The contribution of this work is a novel fuzzy logic controller that acts as a (third party) broker (cf. Figure) to enable *autonomic scalability* of multi-cloud resources. Providers can use this broker to enable cost-efficient elastic provisioning of their platform or software as a service. In case of service failures, environmental changes and others as such, cloud-based applications manage themselves autonomously following the principles of autonomic computing. This approach decreases *human intervention* and increases service *reliability*. This approach handles the different sources of uncertainty in the cloud infrastructure. Additionally, this approach optimizes the *cost* incurred to the application providers during service provisioning.

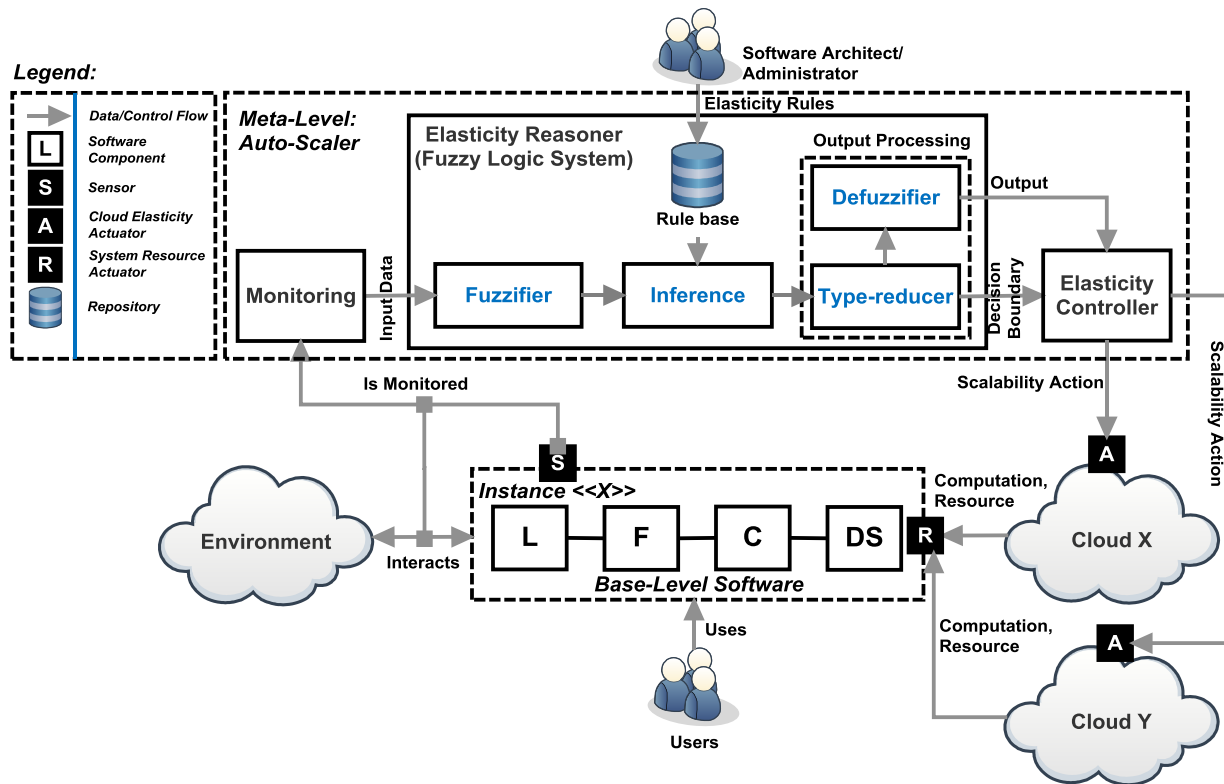


Figure 1. High-level view of autonomous cloud auto-scaler.

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Mobile Cloud Computing: The Impact of Location-Based Services and Context-Awareness on Enterprise Services

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Research Motivation

The purpose of this research is to study context-aware mobile computing, using the cloud, for enterprises. From the literature search it became evident that existing research in the three domains of contextual, mobile and cloud computing is mainly focused on the technical aspects and the consumer market, with very little research focused on enterprises. This research plans to address this gap in the literature where the main focus of this research will be on the enterprise.

Literature Review

Context-aware computing has been researched for at least a decade but only in recent times, context and in particular location information is used by a broad variety of applications allowing for more adaptive, useful and user-friendly systems (Baldauf et al. 2007). Mobile computing is an established field of research but the exponential growth of smartphones and tablets is challenging the boundaries (Fischer and Smolnik 2013). Using the mobile device capabilities, the ability to collect fine-grained, location-specific, context-aware, highly personalized content through these smart devices has opened new possibilities for advanced and innovative services (Chen et al. 2012). Mobile devices are restricted by their processing abilities, battery life, storage capacity and visualization power (Sanaei et al. 2013). Mobile cloud computing can overcome these limitations, in particular processing power and data storage for the huge amounts of sensor data and may also help to extend battery life by moving the computations “to the cloud” (Klein et al. 2010). There are already many services developed that utilise these technologies in retail, tourism, location-based advertising, sales and marketing, games, tracking and navigation systems, emergency services and information/directory. According to Junglas and Harris (2013) IT consumerization can drive innovation, increase productivity and help companies attract and retain talent. Enterprises are at various degrees of embracing IT consumerization and bringing a variety of mobile

devices into the workplace (Harris et al. 2012). Forrester (2013) reports that mobile technologies remain the top area for new investments in 2013 in enterprises globally, followed closely by consumerization, smart computing and cloud computing. Other commercial sources (MobileIron 2013) claim that Mobile First, meaning the mobile device as the primary IT platform replacing desktop computers, will be the future way of working. In his blog, Hall (2013) predicts that soon we will be seeing cutting-edge mobile enterprise applications using a combination of enterprise social, mobile and analytics technologies but there are still many challenges for enterprises facing these technologies: privacy, data ownership, data security in the cloud, heterogeneity of mobile devices, proprietary systems/lack of standards, network connectivity. IT budget constraints, complex backend systems, complex internal workflow processes, latency and performance (SLA), less developed social networks and work/life balance.

Methodology

The literature review highlighted some under-researched areas (Fischer and Smolnik 2013, Recker et al. 2009) which led to the main research question:

How does the use of mobile cloud computing, in particular the use of context-aware and LBS functionalities, impact organisational structure and business processes in enterprises?

The research will be conducted within Hewlett Packard (HP has 300,000 employees). The research is mixed methods consisting of mainly qualitative research with an element of quantitative research to cross-check the findings. Triangulation) Semi-structured interviews will be the main part of the research, supplemented by a discussion through an online focus group and a web survey.

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Using Smartphones For Data Entry

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Research Motivation

The ability to provide a user with create, read, update and delete (CRUD) data entry functions has long been regarded as key functionality for most PC business applications. For example, this can be seen in many applications such as in Customer Relationship Management and Contact Management systems. With great technological advancements in recent decades, application mobility is a central part of mobile computing (Yu et al., 2013). Whilst 'on the road', mobile workers may need to add or manipulate entries in their company's central databases or they may need to respond to customer queries, searching through data to find specific information. Cloud-based data storage and services can facilitate mobile access to information. However, there are many challenges facing smartphone business applications.

Literature Review

York and Pendharkar (2004) define mobile workers as "typically professional white-collar workers using wireless communication to remotely access office documents, e-mail, and corporate knowledge applications" and ranging from "health care providers to insurance claims adjusters to blue-collar service workers." Smartphones are one type of ubiquitous tool for mobile workers. Aside from the many benefits which smartphones bring, there are some key areas that must be considered for an application to be successful. There are usability and accessibility issues, such as mobile web browsing and groupware heuristics to overcome, as identified by Billi et al. (2010). Limited screen size, electronic keyboards (see Sears (2003) for an overview) and application design are other primary challenges. For example, Brewster (2002) states that "taking the desktop interface and implementing it on a mobile device does not work well". There is much research which discusses user interface and hardware limitations of using mobile devices. There appears to be little which relates to mobile workers' opinions of the same devices. There is also much research into data entry and data processing but there appears to be little if any, specifically focused on CRUD data entry. So this begs the questions - what do business users actually feel about using these CRUD apps on smartphones?

Methodology

A mix of both quantitative and qualitative research methods may be appropriate for this study. A survey using a questionnaire involving a significant number of carefully chosen participants will be undertaken and later statistically analysed. Additionally, semi-structured interviews will be performed which may identify other possibilities to performing CRUD using a smartphone. The results of the questionnaires will be calculated and categorized to help determine a picture of specific benefits and/or limitations to entering data on a smartphone. Based on the results, key areas will be singled out for more acute investigation of the issues using semi-structured interviews.

The interviews for this study will be conducted on a one-to-one basis. At this stage it is envisaged that the interview structure will be broken into two categories:

1. General feelings on using CRUD on smartphones (strengths and weaknesses)
2. Alternative ways of working and opinions on using those alternatives.

The participants will comprise a wide variety of business user. Participants must use CRUD functionality on a smartphone on at least a weekly basis. Participants using CRUD functionality less frequently are not central to the goals of this study as CRUD usage will be a very minimal part of their work. There are no controls as to what actual smartphone devices the participants actually use. However, we are not looking at the limitations between different devices, so spreading the participants across multiple devices will be more representative of how mobile CRUD is performed on smartphones today.

Contribution

This research may be of interest to business managers who are considering providing smartphone devices to their ex-office workers. It may also interest creators and designers of mobile products. Further research from a quantitative perspective, to investigate the actual amount smartphones users who perform CRUD data entry could later be undertaken.

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Over 200 members make up the faculty, creating the largest critical mass of business and social science researchers in Ireland, with expertise spanning across the College of Business, Public Policy and Law and the College of Arts, Social Sciences and Celtic Studies. Subsuming the University's Centre for Innovation and Structural Change (CISC), the Whitaker Institute builds on a decade of research-excellence and policy-focused contributions supported by over €11 million in competitive national and international research funding.

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The Institute is named in honour of eminent economist and former Secretary of the Department of Finance, Dr. T.K. Whitaker, who played a central role in devising the economic plan that set Ireland on the road to regeneration in the early 1960s. Drawing inspiration from his unparalleled service to Ireland, the newly formed Whitaker Institute has over 200 members and serves as the country's largest research body focused on contemporary and relevant business, social and policy issues.

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Lero's *mission* is to deliver world-leading research in software engineering with a special emphasis on Evolving Critical Systems. Lero will enhance the quality and competitiveness of the Irish software industry through shared projects, knowledge transfer and education

The centre has the proven capacity to attract and retain global research leaders and to make a substantial contribution both to software engineering research and to the Irish economy. Lero is now ready to take on key challenges of Evolving Critical Systems.

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Lero interfaces with a wide range of industry, state agencies, educational bodies and international collaborators to deliver on its twin goals of research excellence and social and economic relevance.

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Notes
