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Cloud Computing: A Qualitative Study and Conceptual Model

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ABSTRACT

"Cloud computing" is the new buzz term in the IT industry. Many practitioners have already adopted the technology or are in the process of adopting it. Yet, there is no methodological research investigating the adoption process. This paper reviews articles and interviews published mostly in practitioner journals to develop a theoretical framework that help us to better understand the cloud computing phenomena. As such, the framework provides a stepping stone for future cloud computing studies.

Keywords

Cloud Computing, Software as a Service, Platform as a Service, Infrastructure as a Service, Adoption

INTRODUCTION

Cloud computing is the new buzz term in the IT industry. Many IT executives have heard about it and have considered its adoption and use to some extent. Some IT experts believe that cloud computing is going to be the next big thing in the IT industry. It is reshaping the industry and is changing the way companies address their computational and information technology needs. However, despite its importance and popularity among practitioners, the research community is lagging behind. There are many articles published on and around cloud computing and its adoption, challenges, benefits and risks in business practitioner journals. Nevertheless, we were unable to find a reasonable number of articles in academic journals that directly investigate cloud computing from an academic stand point. Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi (2011) called for more academic oriented research on cloud computing phenomenon and did suggest some future research areas. Following the (Marston et al. 2011) recommendations, we will try to methodically investigate cloud computing and its related concepts to fill the gap between academics and practitioners.

In an attempt to gain a better understanding of this ever growing phenomenon and due to the lack of theoretical perspective in this area, we will employ a grounded theory approach as suggested by Strauss & Corbin (1990) to build a theoretical model. This model will discuss and explain cloud computing phenomenon in the context of the technology users along with its antecedents, consequences, and processes embedded in the adoption and use of this new technology.

LITERATURE REVIEW

Cloud Computing Services

According to Cusumano (2010) the very basic idea behind cloud computing dates back to computing time-sharing in the 1960s and 1970s when smaller companies used to buy computation time from larger enterprises that could afford having a mainframe computer on their own. Computing time-sharing used to be a very common practice when companies used to pay for the processing time they rented from the owner of mainframe computers. With the advancement of computational technologies and networking capabilities the practice of time-sharing gave place to application hosting in the 1980s and 1990s. Then with the advent of the Internet we saw a growing number of firms in the 1990s and 2000s deliver what used to be packaged software applications through the Internet either for free or for a nominal fee. These applications ranged from emails and calendars to groupware, simple word processing and even spreadsheets; however, these applications all shared one aspect: they were all designed for individual consumers. Later in the 2000s we started to see more web-based services developed for serving industries and enterprises. It is then that the word cloud computing started to surface among IT specialists.

Cloud computing is a very broad concept. Because there are many terms and concepts associated with cloud computing, in order to understand cloud computing, we first need to be able to make sense of concepts closely associated with cloud computing (Marston et al. 2011). If we look at the cloud computing industry from the stand point of the services it offers we can recognize three types of services (e.g. Armbrust et al. 2010; Creeger 2009; Durkee 2010; Owens 2010): Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

Software as a Service (SaaS) refers to software applications delivered as a service via the Internet (e.g. Armbrust et al. 2010; Creeger 2009; Cusumano 2010; Durkee 2010). These applications are fully hosted and managed by the service provider. Therefore, users should not worry about software updates or server maintenance. In many cases clients have no knowledge of physical location of the application and their data(Armbrust et al. 2010). In the SaaS model the client usually pays the provider in reoccurring payments. This mechanism gives some comfort to the clients knowing that providers will keep the application up and running to receive the ongoing payments (Farah 2010). SaaS is also supposed to be multitenant, a feature that allows more than one client to use the application at a time and yet all clients privacy remains inviolate. Furthermore, some SaaS providers guarantee ubiquitous access to their applications meaning that users can connect to their services and use the application from any browser and platform available on the web. This means that users are not supposed to install any type of software on their computers to be able to take advantage of the service (Iyer et al. 2010).

Platform as a Service (PaaS) refers to providing an environment in which users can develop and use their own applications (e.g. Armbrust et al. 2010; Creeger 2009; Durkee 2010). In this model of cloud computing the customer does not manage or control the underlying technological infrastructure including networks, servers, operating systems, or storage but has control over application developing and application hosting tools (Owens 2010). Examples of PaaS providers are Google and Salesforce.com that provide an environment with programming languages that can be used to developed new hosted applications. PaaS facilitates development and deployment of computer applications for the customers who are not willing or cannot afford to invest in hardware and infrastructure required for their applications to run (Marston et al. 2011; Shivakumar et al. 2010).

Infrastructure as a Service (IaaS) is the most basic model of the cloud computing services. The client will rent the infrastructure that meets or exceeds its application development and business continuity needs (e.g. Armbrust et al. 2010; Creeger 2009; Durkee 2010; Owens 2010). This type of service usually includes a choice of operating system on a server(s) with specific computing power and an agreed but expandable storage capacity. They also may offer limited control over the network such as choice of firewall and denial of service protection measures (Durkee 2010). IaaS is the latest in line of cloud computing services. It is the most promising type of offering and it is still evolving. It is the closest model to the idea of computing as a utility in which consumers treat computer processing power as a utility and only pay for what they have used (Iyer et al. 2010).

Cloud Computing Accessibility

Cloud computing services are also categorized based on who they offer their services to. Whether these services are open to public or not is a distinction point. There are also services that are only partially public. Private cloud refers to internal data centers of organizations that are not made available to public (e.g. Iyer et al. 2010; Katzan 2010; Owens 2010). According to Katzan (2010) a private cloud is operated only for a specific organization and it can be managed by either the company itself or a third party. It also can be located on or off the company's premises. Private clouds provide higher degrees of control over the infrastructure and are often suitable for larger organizations (Marston et al. 2011). Public cloud, on the other hand, is a computational service made available to general public or an industry group (e.g. Armbrust et al. 2010; Iyer et al. 2010; Marston et al. 2011; Owens 2010). Public cloud users have less control over its infrastructure and management but benefit more from the cost savings made available through economics of scale (Ryan et al. 2010). Community cloud refers to a computational service or infrastructure that is shared among a group of organizations and supports a specific community concern such as compliance consideration and security requirements. It may be managed by one of the member organizations, a consortium, or a third party organization (e.g. Iyer et al. 2010; Katzan 2010; Marston et al. 2011; Owens 2010). According to (Marston et al. 2011), U.S government is one of the largest users of a community cloud which is built on Terremark's Enterprise Cloud Platform. The platform allows different U.S departments to rapidly develop and deploy specific application that help their objectives as well as U.S government mission. A cloud infrastructure that is combination of two or more of described cloud structures (private cloud, public cloud, or community cloud) is named Hybrid Cloud (e.g. Iyer et al. 2010; Marston et al. 2011; Owens 2010).

Cloud Computing Drivers

There are some key factors that make cloud computing an interesting option for companies looking for new IT solutions. Scalability is the most frequently cited feature of cloud computing followed by low initial investment, pay for use, and ubiquitous access to clouds. Cloud computing models provide scalable computing power and storage capacity that enable organizations to easily adjust their computing needs with their organizational growth or downgrade (e.g. Brynjolfsson et al. 2010; Durkee 2010; Farah 2010). To illustrate, new business development plans would not create a burden on organization in terms of having to improve the current IT infrastructure in order to be able to meet new business demands with use of automatic and cost-free scalability provided through cloud computing. Organizations also benefit from scalable computation when they are downsizing. They do not have to be concerned about the scrap hardware or the depreciation cost of their investment (Farah 2010). Marston, et al (2011) state that cloud computing enables enterprises to scale their services based on the consumers' demand. Computing resources in cloud computing is managed through software and can be quickly deployed as new requirements arise. In fact the goal of cloud computing is to provide dynamic and automatic scalability (down or up) through software with minimal service provider interaction.

One of the great advantages of cloud computing is the absence of up-front capital expenses that is required in traditional computing models (e.g. Katzan 2010; Marston et al. 2011; Ryan et al. 2010). This severely lowers the cost of computing for small firms. They can benefit from the computing-intensive business analytics that used to be only available to larger organizations (Marston et al. 2011). The low cost of using a state of the art computing services also is very appealing to startup businesses. IT investment used to take a big chunk of investment money that entrepreneurs had access to. With cloud computing they can invest that money into other aspect of their business (Creeger 2009).

Cloud computing models allow users to pay for their computing needs per usage (e.g. Armbrust et al. 2010; Chatman 2010; Ryan et al. 2010). For example, clients can pay based on the hours they use processing powers or pay for the days they are taking advantage of specific storage capacities. Pay for use is also tied to scalability, meaning that clients who need to scale down or up, would pay for the exact amount of their computational services usage. (Armbrust et al. 2010).

The last but not least feature that makes cloud computing an interesting model to address organizations' computational needs is its availability through the Internet. The ubiquitous access means that companies can take advantage of a cloud computing service anywhere in the world, given the presence of the Internet access (Farah 2010; Iyer et al. 2010; Marston et al. 2011). Cloud computing services are designed to ensure effective communications with most of the computing and communication platforms (e.g. Windows, Mac OS, Linux, TCP/IP, IP V6, etc) available to clients. This factor increases their popularity among organizations that are currently employing a combination different systems to achieve their organizational goals (Iyer et al. 2010).

Cloud Computing Obstacles

Security and privacy are two main concerns of cloud computing. How to effectively protect clients from each other as well as outside threats is what cloud computing providers need to address in order for clouds to gain more popularity and market (e.g. Anthes 2010; Chatman 2010; Ryan 2011). Outsider security threats to cloud computing are similar to that of current large data centers. However, the responsibility to protect the clouds from outside threats is shared among many parties involved in cloud computing such as cloud user, vendor, and third party organizations who provide security solutions. According to Armburst et al. (2010) cloud users are responsible for application level security and cloud vendors are responsible for physical level security as well as enforcing external firewall policies. The security for intermediate levels of software application and infrastructure hardware is shared among the vendor and the user. The more the level of infrastructure is exposed to the users the more responsible they will be. Nevertheless, this user responsibility can be outsourced to a third party organization specializing in security solutions. The shared nature of protecting clouds from outside security threats introduces its own challenges. Effective communications among parties is a key to establishing a good security procedure.

In addition to external threats, cloud computing introduces internal security concerns as well. Due to the multi-tenancy nature of the cloud computing we will have several users sharing the same infrastructures and they need to be protected against each other (Anthes 2010; Armbrust et al. 2010). Based on the Anthes (2010) the primary mechanism to protect user's privacy and security in clouds is the use of virtualization. Virtualization is believed to be the most effective means of securing clients against each other. However, not all resources can be virtualized and not all virtualization environments are bug free (Armbrust et al. 2010). These bugs may result in internal security breaches that indeed may compromise the privacy of other clients' data and applications. In addition to virtualization, encryption is sometimes seen as the ultimate security measure in clouds, however it represents its own issues. The way that most of the current encrypting technologies work is to decrypt the information for local use and processing and then encrypt it again to upload it on the clouds which is cumbersome and time consuming. The ability to search in and process encrypted data has been the dream of cryptographers for many years and it continues to be, despite the many scientific efforts (Anthes 2010).

Data ownership is yet another challenges facing cloud computing. There are many debates around the legal issues associated with data ownership. In traditional model of computing, consumer and businesses owned their data and knew the exact physical location of the data. The distributed nature of cloud computing changes many assumptions about the residency and ownership of data and information (Marston et al. 2011). Clients are not aware of the exact physical location of their data and such information is not usually provided by vendors either. Data can be stored and processed anywhere in the world that the cloud provider has established computing facilities. This can potentially become a problem. For example, if the data is stored in a different country other than its owner – the data ownership debate aside- many questions would arise such as: Which country's privacy and security laws should be followed by the cloud provider? What if law enforcement agencies need to access the data or shut down some illegal operations conducted by cloud client? Should they seize the cloud providers' servers or shut them down? Where is the data even located? Issues like this make it necessary to actively develop national and international regulations.

Cloud Computing Consequences

Cost saving is the most evident result of cloud computing adoption for many organizations (e.g. Chatman 2010; Creeger 2009; Shivakumar et al. 2010). Cloud computing cost savings are twofold. One results from the savings in IT investment. Comparing to the traditional IT, cloud computing approach does not require a big chunk of money to meet an organization's IT needs. Companies can establish or improve IT services required for their business to run with a lot less investment when compared to traditional way of establishing IT support (e.g. Katzan 2010; Marston et al. 2011; Ryan et al. 2010). The other results from the savings in operational and maintenance expenses associated with having full scale IT support in organizations. In traditional model of organizational IT, companies had to provision the highest IT demand and plan for it in order to ensure flawless operations and continuity of their business. For example if in their pick time they had to support thousands of users at a time but on average they had hundreds of users connecting to their system. Companies had to have enough technological and computational power to meet the demand of projected users in their peak time. This requires heavy investment in IT infrastructure. It also incurs huge operational costs to support and maintain such systems. With scalable clouds companies are not worried about the under or over provisioning of their IT use. They pay for their usage amount in clouds. Also, organizations are not concerned about the maintenance and management operations, software licensing, hardware depreciation, and other costs associated with traditional model. All these operational costs will be shared among many users of cloud computing and provide an economy of scale. Therefore results in lower operational costs compared to the situation in which an organization has its own data center and IT infrastructure (Chatman 2010).

With widespread adoption of cloud computing models by industries, another long held vision of IT specialist may come true, that being computing as a utility (Anthes 2010; Armbrust et al. 2010; Carr 2003; Marston et al. 2011). John McCarthy, a MIT computer pioneer has suggested back in 1961 that computing may turn into a public utility one day, just like telephone system (Anthes 2010). According to Brynjolfsson et al. (2010), businesses depend no less on electricity than on IT. However, they don't need a "Chief Electricity Officer" and well trained staff to take care of their electricity needs. Similarly this will be the future of organizational IT with development and widespread adoption of cloud computing. It won't quite become like electricity or telephone system but companies will not heavily invest in IT infrastructure, developing IT solutions and hiring well trained specialist as they used to do in the past unless they are the utility provider themselves (Brynjolfsson et al. 2010; Carr 2003).

However, the effects of cloud computing are not limited to cost saving and utility as computing. It also makes organizations more agile if it is used to its full potentials (Iyer et al. 2010; Katzan 2010; Marston et al. 2011). The low cost of establishing new services in clouds and service scalability increases enterprise abilities in responding to environment changes with innovative IT solutions and turn IT to a competitive tool. As the term business agility implies, cloud computing is not all about cost saving and cheap computing. It is also about enabling businesses to use computational utilities that can be deployed and scaled quickly to provide competitive advantages to organizations (Marston et al. 2011).

Cloud computing also helps us to save the environment through having a greener IT industry. It can improve environmental sustainability in three ways. First, by maximizing the processing usage time through sharing the processing power among clients at the same time, so fewer servers would be running idle. Second, cloud computing enables on-demand usage meaning that firms do not need to consume electricity resources way above what they need to keep their servers running to be ready for peak times (2010). Third, cloud vendors can be physically located in areas that are close to cheap electricity resources in order to increase their efficiency (Marston et al. 2011).

RESEARCH METHOD

We adopted a grounded theory approach to develop a theoretical frame work to help us understand cloud computing phenomenon, its antecedents and consequences, contextual and intervening conditions, and the processes involved in cloud computing adoption. Grounded theory approach was deemed necessary due to the lack of theoretical understanding of the phenomenon. Using this approach, a theoretical model is discovered, developed and tested through systematic data collection and analysis related to cloud computing. Grounded theory is not bound to the assumptions of positivist research and helps us to approach the nature of phenomenon in structured and replicable manner (Day et al. 2009). It is an inductive and systematic way of collecting and analyzing qualitative data with emphases on theory generating from data by going back and forth between data analysis and collection. Information systems scholars have a long history of using grounded theory methodology in developing theoretical framework and this methodology is well accepted among IS community (e.g. Day et al. 2009; Orlikowski 1993; Pace 2004)

We followed guidelines provided by Strauss and Corbin (1990) for data collection, data analysis and theoretical development. The process starts with open coding and moves back and forth to axial coding. As explained by Strauss and Corbin open coding consist of breaking down, examining, comparing, conceptualizing and categorizing data. We, line by line analyzed all the data. We labeled phenomena, discovered and named emerging sets and then grouped the sets into abstract categories. Then we moved to axial coding. In this stage, we defined logical links among categories. Axial coding is the process where data are put back together in a new way after their breakdown in the open coding to help us look at the phenomenon from a different perspective following a coding paradigm model. Based on the paradigm model we classified categories into causal conditions, phenomenon (cloud computing), contextual conditions, intervening factors, action/reaction strategies, and consequences of the phenomenon. However, we moved back and forth between open coding and axial coding as we gained more knowledge about phenomenon. We revisited earlier categories and modified them based on our improved understanding of the phenomenon, its antecedents, consequences and processes. In the final step, we integrated and refined our model by following the selective coding guidelines. Selective coding consists of selecting the core category and systematically relating it to other categories as well as validating the model. The result of selective coding is the well supported theoretical model. During this process we cross-validate our model and improved the model where necessary till we reached theoretical saturation(Eisenhardt 1989).

DATA COLLECTION AND ANALYSIS

We used secondary data sources for this study. By secondary data source we mean interviews, case studies and published informatory articles in mainly professional and trade journals. The use of secondary data sources is an established research strategy in business and management research (Jarvenpaa 1991). Collected documents include interviews with employed professionals among service providers and users, statements from organizations at both sides of clients and providers, semi-scholarly studies amid at understanding the phenomenon, and case studies. These publications were retrieved between September 2010 and February 2011.

We utilized both public and institutional databases to search for related documents. We started with Business Source Complete and ABI/Informs online databases and moved to Google Scholar service. At the end we performed a search on Google general web search engine to conclude our searching process. Despite the hybrid nature of cloud computing which includes different typologies, because we were interested in understanding cloud computing pheromone, we only used the key word “Cloud Computing”. We were specifically concerned with documents that were about cloud computing adoption by businesses. We used relevance as the criteria for retaining the retrieved documents and ended up with 51 documents in total. The majority of the articles were retrieved from trade journals such as CIO Magazine, InfoWorld, PCWorld, and Computer World. A few were from academic/executive journals such as MIS Quarterly Executive and Harvard Business Review. A couple from academic journals such as Decision Sciences and the rest were from various news outlets. Furthermore, more than half of selected documents included interviews, round table discussion records, and personal opinions of professionals from both sides of clients and providers. The rest are documents trying to define the phenomenon, providing insights on how to adopt cloud computing and what to adopt, and cases of cloud computing adoption.

We believe that our collection of cases, interviews, and opinions are a good representative of how service providers, clients, media, academia and other stakeholders understand and perceive cloud computing. Furthermore, the diversity of our collection enable us to look at the could computing from different perspectives. Being able to view a phenomenon from different angles is a key factor in conducting a qualitative research that is aimed at theory development (Strauss et al. 1990).

We used NVivo 8 to manage and facilitate coding processes explained by Strauss and Corbin (1990). Nvivo is software package designed to help qualitative researchers when they are dealing with large amount of text-based or multimedia data.

Nvivo enables deep levels of data analysis and supports all coding processes, from open coding to selective coding, as described in grounded theory methodology. The result of our analysis is the theoretical model (Figure 1) aimed at understanding of cloud computing adoption by organizations. We cross validated our model using the collected data.

THEORETICAL MODEL AND DISCUSSION

The goal of this study is to better understand cloud computing and its antecedents, consequences and processes related to its adoption by organizations. In doing so, we developed a model that demonstrates all processes, causes and effects related to cloud computing in an integrated framework. The model focuses on the cloud computing as the main phenomenon under study. It explains causal conditions that could lead to cloud computing adoption. It also demonstrates contextual conditions in which the phenomenon is taking place. The model demonstrate factors that intervene with the adoption processes as well as strategies that organizations need to take to make the adoption of technology a success. Figure 1, is a graphical representation of our theoretical model.

The model expresses and explains motivations for cloud computing adoption as well as its results. It also depicts contextual conditions that impact the adoption process. Furthermore the model explains obstacles and discusses strategies that organizations need to consider in order to mitigate the negative effects of obstacles on the adoption process.

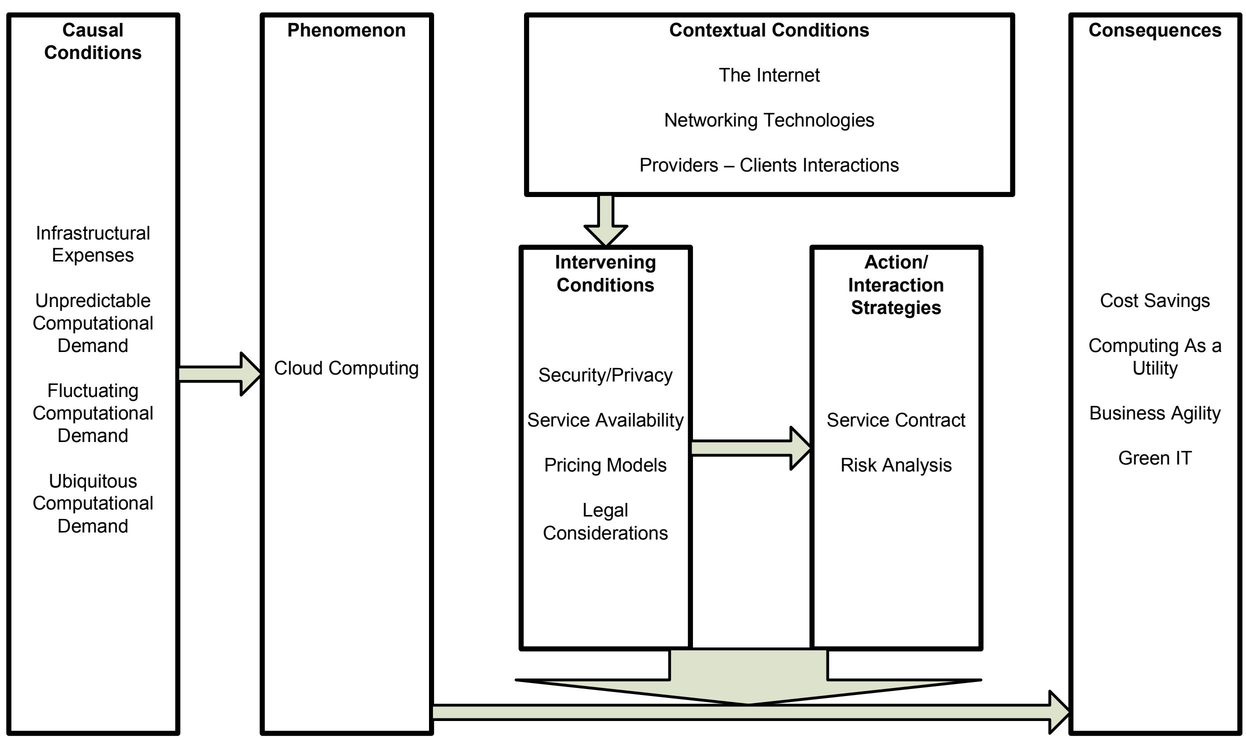

Figure 1. Theoretical Model of Could Computing Adoption

CONCLUSION AND LIMITATIONS

This study is the first methodological attempt in providing a theoretical framework to help us have a better understanding of cloud computing adoption by organizations. We synthesized many definitions available for cloud computing and provided a comprehensive definition for the phenomenon as well as model that could be used in feature empirical studies. Unfortunately, due to the paper length constraint we were not able to include a full articulation of the model and provide detail definition of concepts elaborated in the model as well as supporting evidences and arguments. However, we would be glad to provide readers with more details upon request. At the end, it is needless to say that the model would benefit from further empirical validations.

REFERENCES

1. "What We're Watching in... Cloud Computing," *Harvard Business Review* (88:6) 2010, pp 24-30.
2. Anthes, G. "Security in the cloud," *Communications of the ACM* (53:11) 2010, p 16.
3. Armbrust, M., Stoica, I., Zaharia, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., Lee, G., Patterson, D., and Rabkin, A. "A view of cloud computing," *Communications of the ACM* (53:4) 2010, p 50.
4. Brynjolfsson, E., Hofmann, P., and Jordan, J. "Cloud computing and electricity," *Communications of the ACM* (53:5) 2010, p 32.
5. Carr, N. G. "IT Doesn't Matter," *Harvard Business Review* (81:5) 2003, pp 41-49.
6. Chatman, C. "How Cloud Computing is Changing the Face of Health Care Information Technology," *Journal of Health Care Compliance*:May) 2010, pp 37,38,69,70.
7. Creeger, M. "CTO roundtable," *Communications of the ACM* (52:8) 2009, p 50.
8. Cusumano, M. "Cloud computing and SaaS as new computing platforms," *Communications of the ACM* (53:4) 2010, p 27.
9. Day, J. M., Junglas, I., and Silva, L. "Information Flow Impediments in Disaster Relief Supply Chains," *Journal of the Association for Information Systems* (10:8) 2009, pp 637-660.
10. Durkee, D. "Why cloud computing will never be free," *Communications of the ACM* (53:5) 2010, p 62.
11. Eisenhardt, K. M. "Building Theories from Case Study Research,," *The Academy of Management Review* (14:4) 1989, pp 532-550.
12. Farah, S. "Cloud computing or software as a service-which makes the most sense for HR?," *Employment Relations Today* (36:4) 2010, pp 31-37.
13. Iyer, B., and Henderson, J. C. "Preparing for the Future: Understanding the Seven Capabilities of Cloud Computing," *MIS Quarterly Executive* (9:2) 2010, pp 117-131.
14. Jarvenpaa, S. L. "Panning for Gold in Information Systems Research: 'Second-Hand' Data," IFIP TC8/WG 8.2 Working Conference on the Information Systems Research Arena of the 90's Challenges, Perceptions, and Alternative Approaches, North-Holland, Copenhagen, Denmark, 1991, pp. 63-80.
15. Katzan, H. "On An Ontological View Of Cloud Computing," *Journal of Service Science* (3:1) 2010, pp 1-6.
16. Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J., and Ghalsasi, A. "Cloud computing — The business perspective," *Decision Support Systems* (51:1) 2011, pp 176-189.
17. Orlikowski, W. "CASE tools are organizational change: Investigating Incremental and Radical Changes in Systems Development," *MIS Quarterly Executive* (17:3) 1993, pp 309-340.
18. Owens, D. "Securing elasticity in the cloud," *Communications of the ACM* (53:6) 2010, p 46.
19. Pace, S. "A grounded theory of the flow experiences of Web users," *International Journal of Human-Computer Studies* (60:3) 2004, pp 327-363.
20. Ryan, M., and Loeffler, C. "Insights into clould computing," *Intellectual Property & Technology Law Journal* (22:11) 2010.
21. Ryan, M. D. "Cloud computing privacy concerns on our doorstep," *Communications of the ACM* (54:1) 2011, p 36.
22. Shivakumar, B. L., and Raju, T. "Emerging role of cloud computing in redefining business operations " *Global Management Review* (4:4) 2010, pp 48-52.
23. Strauss, A. L., and Corbin, J. M. *Basics of qualitative research: Grounded theory procedures and techniques* Sage, Newbury Park, CA, 1990.