Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

A Social Network Approach to Provisioning and Management of Cloud Computing Services for Enterprises

Kuada, Eric; Olesen, Henning

Published in:
Proc. of CLOUD COMPUTING 2011 : The Second International Conference on Cloud Computing, GRIDs, and Virtualization

Publication date:
2011

Document Version
Early version, also known as pre-print

Link to publication from Aalborg University

Citation for published version (APA):
Kuada, E., & Olesen, H. (2011). A Social Network Approach to Provisioning and Management of Cloud Computing Services for Enterprises. In *Proc. of CLOUD COMPUTING 2011 : The Second International Conference on Cloud Computing, GRIDs, and Virtualization* (pp. 98-104). IARIA.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy
If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

A Social Network Approach to Provisioning and Management of Cloud Computing Services for Enterprises

Eric Kuada, Henning Olesen
Center for Communication, Media and Information Technologies
Aalborg University
Copenhagen, Denmark
kuada@cmi.aau.dk, olesen@cmi.aau.dk

***Abstract* - This paper proposes a social network approach to the provisioning and management of cloud computing services termed Opportunistic Cloud Computing Services (OCCS), for enterprises; and presents the research issues that need to be addressed for its implementation. We hypothesise that OCCS will facilitate the adoption process of cloud computing services by enterprises. OCCS deals with the concept of enterprises taking advantage of cloud computing services to meet their business needs without having to pay or paying a minimal fee for the services. The OCCS network will be modelled and implemented as a social network of enterprises collaborating strategically for the provisioning and consumption of cloud computing services without entering into any business agreements. We conclude that it is possible to configure current cloud service technologies and management tools for OCCS but there is a need for new approaches that view enterprises as both service providers and consumers to facilitate the easy implementation of OCCS networks**.

Keywords-cloud service brokerage; social networking; and opportunistic cloud computing services.

I. INTRODUCTION

Though faced with several challenges which are mostly security and risk management related, cloud computing adoption is gaining grounds with enterprises [1] because of the flexibility, scalability, elasticity, and potential cost savings that it offers to businesses [2]. With the support of industry analysts (e.g., Gartner, PricewaterhouseCoopers) and companies such as Amazon, Google, IBM, VMware, Microsoft, Sun, Dell, etc., this trend is not expected to change. Additionally, Vinod, et al. [3][4] suggest that instead of perceiving cloud computing simply as a way to make internal Information Technology services cheaper and efficient, businesses could take advantage of cloud computing to drive business growth by developing a new business model which is termed as the extensible enterprise.

The benefits of cloud computing has caught the attention of all stakeholders in research efforts to address its challenges to pave the way for an accelerated adoption of cloud computing services. There are therefore currently numerous research efforts by Information Technology industry giants, academic institutions, governments and union of countries (e.g., European Union) to promote the adoption of cloud computing services [5][6][7]. These efforts are resulting in diverse cloud computing service offerings from cloud service providers which have left enterprise consumers trying to make sense of the offerings of service providers. This situation is increasingly necessitating the services of a special group of cloud service providers that offer brokerage services for enterprise consumers on the more fundamental services such as Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) provided by cloud service providers.

This research work proposes a social network approach to the provisioning and management of cloud computing services termed Opportunistic Cloud Computing Service (OCCS) that has some resemblance to Cloud Service Brokerage (CSB). OCCS deals with the concept of enterprises taking advantage of cloud computing services to meet their business needs without having to pay or paying a minimal fee for the services.

This innovative approach of OCCS can facilitate the adoption process since enterprises will require no financial commitments to begin using cloud computing services, and discovery of services on an OCCS network will be easier in light of how information spreads on social networks. Commercial cloud service providers can benefit tremendously in the long run by introducing some of their services onto such a network; especially new services can be introduced onto the OCCS network for a period of time to gain popularity before being withdrawn later. Additionally OCCS can promote SaaS collaboration, scalability for resource aggregation for particular services when needed, fostering of business collaboration and further reduction of cost in Information Technology services. Since the idea of OCCS will be to provide a governance platform and its associated cloud management tools with which interested enterprises will provision SaaS, PaaS, IaaS and other resources that would be used by other interested enterprises, but not necessarily create new technologies, the platform is compatible with future cloud computing technologies and solutions.

The remainder of the paper is organised as followers: Section II explains the OCCS concept and outlines some of the background ideas and concepts that have inspired it. Section II also presents cloud service brokerage and outlines the similarities of OCCS in functionality with CSB. We present the research challenges that must be

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-153-3

addressed for the implementation of OCCS in Section III. Section IV discusses some unintended advantages that could be leveraged from OCCS implementation and Section V concludes the paper.

II. OPPORTUNISTIC CLOUD COMPUTING SERVICES

This section begins with an overview of the opportunistic cloud computing services concept, an outline of some background developments inspiring it, then a discussion of its Cloud Services Brokerage features and then presents detailed reference architecture for its implementation.

A. Overview

Opportunistic Cloud Computing Service (OCCS) is a social network approach to the provisioning and management of cloud computing services for enterprises. Previous works that link cloud computing with social networks such as [8], looked at leveraging the pre-established trust formed through friend relationships within social networking sites to enable friends to share resources; and most other examples use Cloud platforms to host social networks or create applications within the social network. There is however no literature on a social network infrastructure for enterprises currently; and this is where OCCS comes in. OCCS deals with the concept of enterprises taking advantage of cloud computing services to meet their business needs without having to pay or paying a minimal fee for the services. The OCCS network will form a social network of enterprises collaborating strategically (possibly selfishly or even maliciously) for the provisioning and consumption of cloud computing services without entering into any business agreements. Unlike social networking sites for individual use where users creates their own network of friends, in an OCCS network, members do not explicitly create ties with other members but these ties comes indirectly through the services and resource contribution and consumption mechanism.

This concept is derived from the combination of the concepts of peer-to-peer network services and the utility model of cloud computing. As in peer-to-peer networks where users are both resource providers and consumers, the idea will be to provide a governing platform that serves as the social networking platform for the enterprises and also consisting of interoperable Cloud management tools with which interested enterprises will provision SaaS, PaaS, IaaS and other resources that would be used by other enterprises interested in these services. A major challenge besides risk management and security issues that such a network will face is how to develop incentive schemes that ensure sustainability of the network.

It is anticipated that such a network will not always provide all the cloud service needs of an enterprise; hence OCCS will also seek to explore the utility model of cloud computing for enterprises to consume services provided by commercial cloud computing service providers at specific times, geographic locations, and Service Level Agreement (SLA) requirements for which a utility function defined by the enterprise is minimized. Here again the framework will try to employ open source brokerage tools instead of employing the services of a commercial Cloud Service Broker (CSB) for arbitrating between the cloud service providers and the enterprises.

Furthermore, preliminary investigations indicate that the OCCS network will not be most ideal for large corporation and financial institutions but will be well suited for small and medium sized enterprises. There have however been indications of larger corporations joining an OCCS network mainly as services and resource contributors in promoting their businesses.

Figure 1 shows an overview of the major parts in an OCCS network. It consists of two layers – the service layer and the management layer. The service layer consists of all the services contributed by members. These will normally be fundamental cloud services such as SaaS, PaaS, and IaaS; but, it can also include value added services normally provided by cloud service brokers. The management layer consists of two main components – the governance component that manages the services from members and CSB component that serves as an interface between the OCCS network and commercial cloud services providers and cloud service brokers.

OCCS is derived from two main concepts: peer-to-peer network services and the utility model of cloud computing. It however has also been inspired by equally important phenomenon such as social network theory, social networking, Web2.0, and the open source movement.

Social network theory has been used to examine how companies interact with each other, characterizing the many informal connections that link executives together, as well as associations and connections between individual employees at different companies. These networks provide ways for companies to gather information, deter competition, and even collude in setting prices or policies. It forms the basis of the OCCS feature of having no formal business agreements between the participating member enterprises. The other characteristics of OCCS stem from concepts and ideas such as user-generated content, harnessing the power of the crowd, architecture of participation, data on a epic scale, and openness [9] that characterises Web 2.0, social networking and the open source movement. OCCS however focus on corporate organisations instead of individual users and deals with replacing simple data and files as resources with cloud computing services that would normally have been provided by commercial cloud service providers.

Copyright (c) IARIA, 2011. ISBN: 978-1-61208-153-3

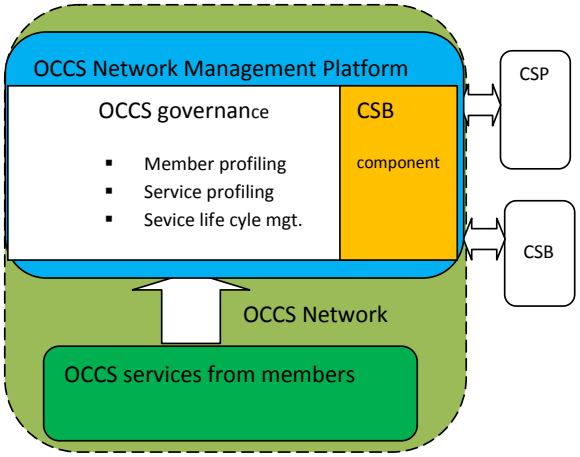

Figure 1. Major components of an OCCS network

B. Cloud Service Brokerage Functionalities

Cloud services brokerage is a business model where a company or other entity adds value to one or more (generally public or hybrid, but possibly private) cloud services on behalf of one or more consumers of those services [10]. The major functionalities that CSB provide to enterprises include service aggregation, customization, governance, new applications, services billing and arbitration, security, and insurance services. The services of CSB are becoming increasingly necessary to both enterprises and cloud service providers because of their different perspectives, objectives, and expectations from the cloud computing industry, coupled with the challenges enterprises have to deal with in selecting from cloud service providers and using the diverse cloud computing services.

An OCCS network consists of two main components - a platform for managing the services provisioned by members and a brokerage component for interfacing with commercial cloud service providers. The OCCS concept thus inherently provides new applications, service aggregation to multiple consumers, governance, and service arbitration and billing.

C. OCCS Architecture

In light with the principles on which the OCCS concept is built – namely: user-generated content, architecture of participation and openness; a successful implementation of an OCCS network will have to in the barest minimum provide the following features

- Support for the management of fundamental cloud computing services (SaaS, PaaS, IaaS)
- Support for the management of any arbitrary cloud computing service – anything as a service (XaaS)
- Interoperability with major cloud computing standards
- Interoperability with major cloud computing management tools
- Support for future cloud computing technologies

These factors have been considered in the design of the OCCS network reference architecture shown in Figure 2.

OCCS Services: these consist of all the services and resources that have been contributed to the network by members. These could be coming from contributing member's data center, private cloud, etc. Services are mainly fundamental cloud computing services such as SaaS, PaaS, IaaS; and other cloud computing services (XaaS) and resources.

Resource Manager: this together with the cloud computing deployment and management tools found in the Contributions Component and the Discovery & Utilization Component abstract the contributed services from the services layer and interface it to the OCCS management platform.

Contributions Component: it is responsible for handling the resource contribution process. Its main objective is to simplify and make it easy for members to contribute resources to the network. It performs two sub functions – providing cloud computing management tools and service life cycle management. It thus consists of cloud computing deployment and management tools for all types of services and resources. The service management involves service creation, service certification and service profiling which includes service review and ranking by users and service ranking by platform administrators.

Discovery & Utilization Component: its role is to simplify services and resources discovery and utilization process. It performs service recommendation by taking service requirements description by members and matching these with service properties description by contributors together with the profile rank of services. It also consists of cloud computing management tools for services and resources provisioning and utilization.

Categorization Component: this component is needed to ensure OCCS network supports arbitrary services while also ensuring easy management of these services. It is responsible for the categories creation process. It handles service category creation requests from members which is evaluated for approval by the platform administrators; and

also delegates privileges of categories creation given to some level of membership.

***Membership Manager**:* this is the main social network user management module for the OCCS network management platform. It is responsible for managing existing users and the registration of new members (enterprises, companies, institutions, etc.). It handles membership requests and in cooperation with the Governance Component performs company profile verification based on data provided by enterprises during registration to make decisions on membership approval or rejection.

Incentives Manager: Dynamic re-computation of cost in real time to be credited to service contributors and debited to resource users. Cost of service or resource utilization is dependent on demand.

QoS & Pseudo SLA Manager: it uses information from the Incentives Manager to provide service differentiation and pseudo SLA management to members.

Governance Component: it is the logical module that provides supervision for all the other components in the OCCS network management platform. It is implemented as the interfaces through which platform administrators interact with the platform to make governance decision.

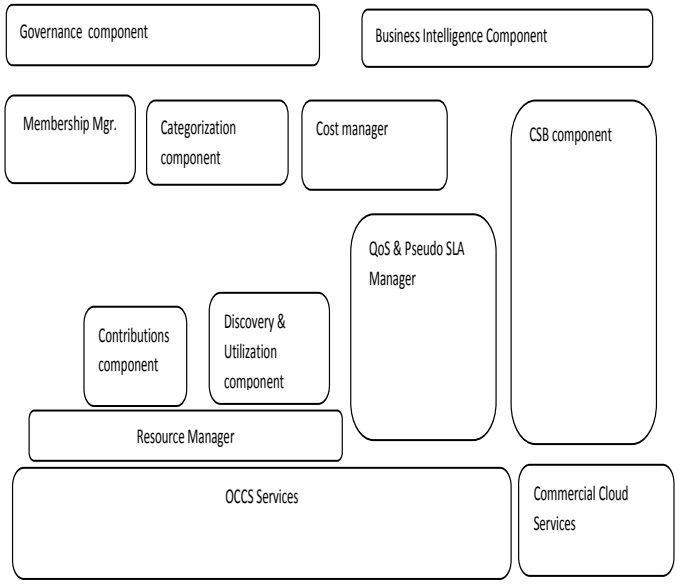

Figure 2. OCCS network Reference Architecture

Business Intelligence Component: this module is not essentially required for the operation of the OCCS network but provides means for the gathering of business intelligence from the platform and may include for example:

- Analysis of services contributed, their categories, utilization and their profile performance
- Analysis of member profiles with their contributed services and the enterprises that are utilizing these services
- Analysis of the services and resources requests that are not currently being provided by the platform

***CSB Component**:* it consists of cloud computing management tools and processes that interface the OCCS network to commercial cloud computing services and provide cloud brokerage services to members.

D. Implementation Strategy for OCCS

To ensure that the barest minimum features required for a successful implementation of a OCCS network is met, a typical OCCS network implementation will use the feature requirements of support for the management of fundamental cloud computing services, support for the management of any arbitrary cloud computing service, interoperability with major cloud computing standards and cloud computing management tools, and support for future cloud management technologies, in selecting a suitable cloud management tool (likely a non proprietary cloud management tool) which will form the base on which other functionalities can be added. The various components outlined in the OCCS reference architecture in Section III *C* above can then be developed on this base cloud management tool.

III. RESEARCH ISSUES WITH OCCS

Some of the major challenges of cloud computing receiving research attention currently include legal and compliance risk management, migration of applications, meeting SLA requirements, managing cloud services, and security concerns. The introduction of OCCS brings new research issues and adds a complexity dimension to some of the existing ones. This section outlines some of these research issues and the intuitive approaches of addressing them, which will have to be researched carefully for the successful implementation of OCCS networks.

A. Sustainability and Pseudo SLA

The sustainability of an OCCS network revolves around the concepts of architecture of participation and harnessing the power of the crowd. A potential problem that such a network will face is that of free-riding where member enterprises will want to only use services on the network without contributing [10]. The challenge here will be to develop appropriate incentive mechanisms for the sustainable operation of the network.

Another challenge is that of service differentiation and service quality management. Unlike conventional cloud computing service offerings by commercial service

providers, no SLA exist between the participating members in an OCCS network, hence such service quality differentiation must be handled through the incentive mechanisms that will be designed so that when limited resources are being contended for by multiple candidates those that have supported the system more can be given some form of preference. Additionally, there will be the need for transparency in dynamic demands and cost of service utilisation. Several research efforts have applied game theoretic approach to the modelling of incentives in peer-to-peer networks to solve the free-riding problem in peer-to-peer networks. [12] presents a resource allocation mechanism based on a distributed algorithm to enable service differentiation in peer-to-peer networks that also increases the aggregate utility in the whole network. Work on incentives for sharing in peer-to-peer networks by [13] analyzes several different payment mechanisms designed to encourage file sharing in peer-to-peer systems. The game theoretic approach can be explored in the design of incentive mechanisms for OCCS networks and the concept of pseudo SLA introduced for service differentiation and service quality management.

B. Reliability and Fault resilience

An OCCS network will need to provide a certain level of reliability to its members under normal operations and must be resilient enough to recover from faults. The reliability and resilience is however threatened by poor quality of services provisioned by members, failure and withdrawal of services from members, and the introduction of malicious services. Dynamic algorithms are required for detection, notification and responding to faults and poor quality services. Of particular importance is how to respond to faults in the network. A simple approach will be to notify service consumers of problematic events for them to take their own decisions; it may however be necessary to develop mechanisms that reassign alternative services to consumers based on certain usage policies and preferences indicated by the service consumers. The challenge here is the precise capturing of the properties of services in service descriptors and effectively matching these to the usage policies and SLA requirements of potential service consumers so that the entire process is transparent to them and their customers; and more so this transparency in fault handling must be achieved in the context of the fact that no SLA exists between the contributors of the services and the consumers of these services.

C. Network Governance

The purpose of the OCCS network governance will be to promote the overall quality of the system. Of particular research interest is the development of community management enabling technologies for profiling, service life cycle management and transparency in the pseudo SLA management. Both network members (enterprises) and the services they provision will have to be profiled to maintain trust in the individual services, member enterprises and the entire system platform. For example service provisioning will have to be in phases such as testing, and various levels of certification through continual ranking of services. Both central ranking by the platform administrators and peer review ranking by the members may have to be adopted. The service ranking and certification will need to promote new services from good profiled enterprises while quickly identifying malicious and poor quality services and revoking their certification.

D. Security

Security is the ability to protect information and information systems from unauthorized access, use, disclosure, disruption, modification or destruction and to respond and recover in case of a fault or incident. The implementation of OCCS will not bring any new technical demands on security in terms of confidentiality and data integrity apart from what is already necessary in ordinary cloud computing implementations. An area of research interest however is how to harness the available resources on the platform and the collaboration of members in combating security threats. If we consider the introduction of malicious services onto the OCCS platform, the OCCS network governance which includes member profiling, service profiling and life cycle management should prevent such occurrences. In the event of such an occurrence however, the system has to respond and recover quickly. It is therefore useful to research into mechanisms for harnessing the available resources on the platform and the collaborative efforts of members in dealing with such a threat.

E. Other Research Issues

Some other issues that are of importance and worth looking at are regulations and service provisioning. Current cloud computing vendor technologies and management tools assume distinct roles for the service providers and service consumers. But with some cloud management tools offering features such as delegated control and autonomous virtual enterprises [14]; and support for the technologies of most of the major cloud solution providers [15], it will be possible to configure these cloud management tools for OCCS. There may however be a need for new approaches for cloud management that view enterprises as both resource providers and consumers to facilitate the easy implementation of an OCCS network.

An issue with regulatory authorities for enterprises joining the OCCS platform could be that of tax evasion implications. This is because enterprises will be offering and using services, which are not being paid for and hence may not be subject to taxes depending on the country in which they are. Also most enterprises have internal policies that need adherence, and there may be industry specific laws and regulations that they need to comply with. Furthermore, different countries have their own laws concerning user data handling. Storing data in the Cloud therefore presents enterprises and service

providers with several risk management challenges. These challenges are further compounded by the concept of OCCS and hence can hamper its successful implementation.

IV. POSSIBLE FUTURE BENEFITS

This section gives brief discussions on some of the unintended benefits that can be leveraged from the implementation of an OCCS network. Some of benefits as discussed below include platform for new business models, promotion of SaaS collaborations, and promotion of cloud computing standardization.

A. Platform for new Business Models

OCCS can serve as a platform for enterprises to adopt new business models such as the extensible-enterprise model (deep B2B integration and highly modular web services). The adoption of cloud computing by any two companies in general reduces the complexities in business-to-business (B2B) integration. Companies can therefore leverage cloud computing by exposing their business processes to potentially large ecosystems of partners who often find ways of joining and integrating their business processes in the value chain. It is envisaged that OCCS will promote the adoption of cloud computing by enterprises and hence indirectly promoting such new business models. Secondly, enterprises on an OCCS network would already have been using similar services with similar cloud management tools; this should facilitate the integration of their business processes.

Additionally, the platform can foster the creation of new business that will provide commercial cloud brokerage services to members on the OCCS network.

B. Promotion of SaaS collaborations

The implementation of an OCCS network can promote SaaS collaborations. Enterprises on an OCCS network are very likely to participate in collaboration efforts in the development of software solutions that they deem useful to their own business. As an example, a construction company in need of a specialized software for design simulation that is currently not being provided by any member on an OCCS platform can initiate a SaaS project to involve other interested members in the development of the software which can then be contributed to the platform upon completion. Such SaaS collaborations could also come about by a member enterprise identifying an application of interest and providing the development platform with specific tools and providing it as a PaaS on the OCCS network; this could spark interest in the development of such an application by other members and can eventually lead to collaboration by interested members in its development.

C. Promotion of Cloud Computing Standardization

As already indicated in Section II C and Section II D, a successful implementation of an OCCS network must provide support for the management of fundamental cloud computing services, support for the management of any arbitrary cloud computing service, interoperability with major cloud computing standards and cloud computing management tools, and support for future cloud management technologies. Thus to start with, the OCCS concept must carefully follow cloud computing standards; the situation is however reversed if OCCS network implementations become successful. Thus those standards that are dominant on the OCCS platform will then be followed closely by cloud management tool developers and cloud service providers. This will further promote the success of the OCCS platform; and hence the promotion of cloud computing standardization and promotion of the OCCS implementations will be in a virtuous cycle.

V. CONCLUSION

Support for major hypervisors and role-based delegated control make it possible to configure current cloud computing technologies and management tools for OCCS even though they assume distinct roles for the service providers and service consumers. There is however a need for new approaches to cloud management that view enterprises as both resource providers and consumers which when complemented with standards for interoperability will facilitate the easy implementation of an OCCS network.

Successful implementation of OCCS networks can result is some unintended benefits such as serving as a platform for new business models, promotion of SaaS collaborations, and promotion of cloud computing standardization. These benefits together with providing a platform for enterprises to start using cloud computing services without any initial financial commitment will however be possible only if the research challenges identified in Section III (namely, developing appropriate incentive mechanisms and the associated quality of service differentiation, security, reliability and fault resilience, network governance and regulatory issues) are carefully dealt with.

REFERENCES

[1] Justin Pirie, "Setting the Standards," *European Communications*, pp. 30-31, Autumn 2010.

[2] Vinod Baya and Randy Myers, "How CFOs should audit the cloud balance sheet," *PricewaterhouseCoopers Technology Forecast*, no. 4, pp. 44-53, 2010.

[3] Vinod Baya and Galen Gruman, "Making the Extensible Enterprise a reality," *PricewaterhouseCoopers Technology Forecast*, no. 4, pp. 26-35, 2010.

[4] Vinod Baya, Bud Mathaisel, and Bo Parker, "The cloud you don't know: An engine for new business growth," *PricewaterhouseCoopers Technology Forecast*, no. 4, pp. 4-13, 2010.

[5] OPTIMIS: Optimized Infrastructure Services. (2011, March) OPTIMIS. [Online]. http://www.optimis-project.eu/project 11-07-2011

[6] Contrail consortium 2010. (2011, March) Contrail. [Online]. http://http://contrail-project.eu/objectives;jsessionid=E1961F3D98F3B602D34CFC9445D63DC7 11-07-2011

[7] RESERVOIR. (2011, March) RESERVOIR. [Online]. http://www.reservoir-fp7.eu/ 11-07-2011

[8] Kyle Chard, Simon Caton, Omer Rana, Kris Bubendorfer, "Social Cloud: Cloud Computing in Social Networks," in *2010 IEEE 3rd International Conference on Cloud Computing*, Miami, Florida, 2010, pp. 99 - 106.

[9] Paul Andeson, "What is Web 2.0? Ideas, technologies and implications for education," JISC , JISC Technology and Standards Watch Feb. 2007.

[10] Benoit Lheureux. (2010, December) Gartner Inc. [Online]. http://www.gartner.com/it/content/1461800/1461813/december_2_cloud_services_brokerage_blheureux.pdf 12-07-2011

[11] Markus Hofmann and Leland R. Beaumont, *Content Networking: Architecture, Protocols, and Practice*, Rick Adams and Karyn Johnson, Eds. San Francisco, USA: Elsevier, 2005.

[12] Richard T. B. Ma, et al, "A Game Theoretic Approach to Provide Incentive and Service Differenciation in Peer-to-Peer Networks," in *SIGMETRICS/Performance'04*, New York, NY, USA., June 12–16, 2004.

[13] Philippe Golle, Kevin Leyton-Brown, Ilya Mironov, and Mark Lillibridge, "Incentives for Sharing in Peer-to-Peer Networks," in *Springer WELCOM 2001, LNCS 2232*, Verlag Berlin Heidelberg, 2001, pp. 75-87.

[14] Abiquo, Inc. (2011, March) abiquo. [Online]. http://www.abiquo.com/products/features-and-benefits.php?lang=en 11-07-2011

[15] enStratus Networks LLC. (2011, April) enStratus. [Online]. http://www.enstratus.com/page/1/cloud-providers.jsp 11-07-2011