Cloud Service Analysis

Choosing between an on-premise resource and a cloud computing service

Master of Science Thesis in the Master Degree Programme, Software Engineering and Technology

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Abstract

Cloud computing is a concept that has become increasingly popular in recent years through an increase in Internet connection capabilities, virtualization possibilities, and commercial successes. It offers functionalities over the telecommunications network in the form of services instead of as a delivered product. This in combination with that the user is agnostic to the underlying technology provides advantages like increased flexibility in the technical solution and payment model, robustness and availability, as well as security in size. The downside of cloud computing is for example the Internet connection dependency, loss of control over the data, and the risk of vendor lock-in.

These advantages and disadvantages make the decision between an on-premise resource and a cloud computing service complex. This case-based action research aims to provide researchers and IT personnel, like administrators, architects and designers, tools and guidelines to reduce the decision complexity. It is done by a presentation of an architectural solution that has the potential to boost the benefits of cloud computing, construction of an evaluation scorecard that indicates if a system is suitable for cloud computing or not and by identifying possible cloud computing alternatives to the systems indicated by the scorecard.

Through a literature study it is shown how the principles of Service Oriented Architecture (SOA) can improve the integration and strengthen the benefits of cloud computing. The literature study together with qualitative interviews and discussions with the client company also produce guidelines for the scorecard along with requirements for alternative cloud computing systems.

Keywords: Cloud Computing, SOA, Decision guidelines, Pre-investment process

Abbreviations

AD	Active Directory
API	Application Programming Interface
ASP	Application Service provider
AWS	Amazon Web Services
CapEx	Capital Expenditure
CRM	Customer Relationship Manager
DAPS	Distributed Application Platform and Service
DoS	Denial of Service
EC2	Elastic Compute Cloud
ERP	Enterprise Resource Planning
GQM	Goal Question Method
IaaS	Infrastructure as a Service
IDC	International Data Corporation
ISO	International Standardization Organization
iSOAMM	independent Service Oriented Maturity Model
LAN	Local Area Network
OpEx	Operational Expenditure
PaaS	Platform as a Service
REST	Representational State Transfer
S3	Simple Storage Service
SaaS	Software as a Service
SLA	Service Level Agreement
SOA	Service Oriented Architecture
SOAP	Simple Object Access Point
SSL	Secure Sockets Layer
VM	Virtual Machine
VPC	Virtual Private Cloud
VPN	Virtual Private Network
WSDL	Web Service Description Language

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1 Introduction

In this introductory section the background of the subject will be presented together with some earlier research on cloud computing. This is followed by the purpose and problem statement of this thesis along with the delimitations and disposition.

Cloud computing in its core concept is not a new idea, similar concepts like for example Application Service Provider (ASP) have existed for several years. What has happened recently, though, is that the networking and virtualization possibilities have increased severely, enabling a new and wider use of the concept. As with ASP, cloud computing revolves around the utilization and combination of services to deliver functionality that supports business values, instead of a delivered product. This has resulted in many new and innovative cloud computing solutions to be available for companies and private customers around the world.

This thesis is therefore aimed towards both the IT departments looking towards cloud computing as an alternative to an on-premise resource, as well as an academic audience researching adoption of cloud computing. The conclusions will be of interest to most IT departments interested in potentially improving their flexibility and efficiency. The thesis also presents cloud service alternatives, guidelines, and a work method that might be of interest to a broader academic community and IT personnel like administrators, architects and designers, regarding cloud services and on-premise resources.

1.1 Background

Many companies have moved away from custom applications and started to rely more and more on third party software. These companies have now also started to question whether the infrastructure issues, such as hosting and servicing these application models, are part of their core competence. This has encouraged a move towards cloud computing, which provides on-demand easy network access to a large pool of computing resources that can rapidly be put to use with minimal interactions and upfront costs (MDSOL 2010).

In 2006 Amazon released Amazon Web Services (AWS) which allowed customers to utilize Amazon’s storage and computing power for supporting their business needs (Amazon.com 2011). This can be seen as a first big step by a major company to deliver services as cloud computing. Since then, worldwide companies like Microsoft, Google and many others joined the trend and offered their own solutions (Staten, Schandler et al. 2009).

Although the potential benefits that cloud computing is said to provide are cost reductions, IT efficiency, and increased agility and flexibility, cloud computing is still perceived to be in a state of hype and is not currently accepted by some firms (Marston, Li et al. 2010). Several security risks and integration issues still remain, inflicting doubts in the minds of many IT administrators (Brodkin 2008).

Medius AB (from now on referred to as Medius) is a fast growing, small to middle sized IT consultant company based and founded in Sweden. Almost all of their current systems are run on-premise which may pose problems with their present, fast growth situation. This is something that the possible benefits of cloud computing may ease, although they lack a process for evaluating cloud computing solutions against their current solution. There is therefore a need for more research regarding considerations prior to a move to cloud computing.

1.1.1 Earlier Research

Research exists regarding Application Service Provider (ASP) and the benefits it may yield to an organization. For example Seltiskas and Currie (2002) partly base their report upon a large scale research program funded by European Union (EU) and Engineering and Physical Science Research Council (EPSRC) and explores the business model of ASP and which integration issues that belong to it. Regarding cloud computing, this type of research is harder to find. Another earlier researched subject is the architectural principles of SOA. There is, however, a need for studies on how a customer organization can utilize these principles to incorporate cloud computing effectively.

Because cloud computing is a slightly newer concept it is not as thoroughly explored. Especially, there is a need for research regarding the evaluation of on-premise resources and cloud computing. Among the research that does exist, there are several examples aimed at associated security issues and if cloud computing is mature enough to play its parts in enterprises. Brodkin (2008) states, for example, in his report the seven major security issues with cloud computing as listed by the analysis and recommendation company Gartner. Enquist and Juell-Skielse (2010) also shows that there has been a growth in the need for business supporting software on the Swedish market. At the same time Leavitt (2009) illustrate the immense growth rate of popularity and utilization of cloud computing and how it has become more and more suitable for corporations to benefit from. This means that the range of offerings regarding cloud computing business supporting services increases. It has therefore become increasingly necessary with decision supporting research.

1.2 Problem Statement

A problem with an on-premise resource is that it is very inflexible and hard to adapt to rapidly shifting business needs. Another problem is that it demands up-front startup costs and keeps IT staff occupied with tasks most likely not connected to the business core competence. These are problems that cloud computing possibly could help simplify.

The problem that many organizations face is how to decide whether to keep, and upgrade, their existing on-premise IT resource or to switch to and incorporate a cloud computing service solution. Furthermore, the organization needs to know if an available cloud computing solution can replace the existing resource. The final problem that is examined is how the software system architecture should be designed to smoothly incorporate and benefit from cloud computing. These problems lead to the main research question.

Main Research Question:
How can a small or medium sized, fast growing company choose between keeping, and upgrading, an existing on-premise IT resource and switching to a potential cloud computing service, to improve their corporate IT infrastructure and performance?

To answer this question we have divided it into several sub questions. The first question regards the prerequisites for integrating cloud service with the software system. The second question provides guidelines on how to choose between an on-premise IT resource and a cloud computing solution. The last question aims to provide evaluated alternatives that can improve a corporate IT infrastructure.

First Research Sub Question:
How could a software system architecture be designed for the system to benefit from cloud computing?

This question aims to explore prerequisites and guidelines for how a software system architecture could be designed and supported to enhance the benefits of cloud computing.

Second Research Sub Question:
Which aspects are important, for a small or medium sized IT company, when deciding between on-premise resources and cloud computing solutions?

This question aims to explore relevant aspects for evaluating a potential cloud service against an on-premise IT resource.

Third Research Sub Question:
Which types of currently available cloud services could replace an existing on-premise IT resource, at a small or medium sized IT company?

1.3 Purpose

The purpose of this research is to explore the suitability of cloud computing in an existing corporate IT infrastructure. This study therefore researches potential strengths, weaknesses, opportunities and threats that companies have to consider before adopting cloud computing services. It also aims to find general aspects and a decision model to consider when evaluating a cloud computing solution against an on-premise resource. Furthermore, the prerequisites and recommendation regarding the software system architecture, to integrate with cloud computing are examined together with the benefits that may be gained.

The results of this thesis fit in to the very beginning of the decision process regarding adoption of cloud computing. The guidelines and evaluation methods are meant to assist and support this initial decision and evaluation phase.

1.4 Delimitations

This study is delimitated to explore cloud computing services from a customer – company perspective and therefore does not analyze the system architecture of the service vendors. Further, it does not examine how a company’s offered services are affected by being supported by cloud computing. Since this thesis is aimed at small and medium sized businesses, which rarely have the opportunity to invest in private cloud implementations, the solutions examined are public cloud implementation solutions. The systems that are examined are those in which the client company has expressed an interest in evaluating and finding an alternative to.

This thesis does not present a road map for which specific services to use or how they should be implemented. Further, the thesis will not produce a complete requirements document for evaluating if a cloud computing service can replace an on-premise IT resource, due to the lack of existing documentation in the client company. Therefore only bullet point lists with the major functional requirements were produced for each system.

1.5 Disposition

In the following chapter the work flow throughout the case study is explained followed by a presentation of the academic method used. The methods mentioned in these sections are further explained in chapter 6 *Result:* Decision Model. Subsequently follows a description of the client company Medius along with an explanation of their current IT infrastructure and the systems that they are willing to evaluate.

Thereafter, in chapter 4 and 5, follows the theoretical framework and a presentation of possible available cloud services. Chapter 4 explains what cloud computing is, the strengths and weaknesses which stand as groundwork for the scorecard used in the case study, and the architectural prerequisites that would boost the benefits of cloud computing. In chapter 5 available types of cloud services are presented along with at least one example to further visualize how the service could be used in practice. The service types presented in this chapter are meant to somewhat reflect those systems mentioned by Medius as relevant for evaluation. In chapter 7 the results of the application of the decision model are presented. Finally in chapters 8 and 9 the results are analyzed and discussed followed by a conclusion.

1.6 Contribution

The contribution of this thesis is two-fold. First, a decision model for adoption of cloud services which is the results of theoretical investigations of literature. Second, the model was validated through static validation in an industrial case. An additional contribution was an overview of literature in the field of cloud computing which is focused on synergy effects between SOA and cloud services.

1.6.1 Investigation

In order to create a decision model that could address the problem, described in section 1.2 *Problem Statement*, a theoretical investigation was conducted. This investigation also identified a service oriented architecture maturity model, which could help evaluating the architectural foundation within an organization. The investigation highlighted both synergy effects between using service oriented architecture and incorporating cloud services, and important aspects to consider prior to incorporating cloud computing.

1.6.2 Decision model

The findings from the investigation resulted in the construction of a decision model which is the main contribution of this thesis. The first part of the model uses the model found during the investigation to evaluate the architectural foundation and the potential for incorporation of cloud computing services. For the second part the researchers created a scorecard consisting of the consideration aspects found in the theoretical investigation. In the decision model, software engineering aspects like software architecture play an important part and are included in the scorecard.

1.6.3 Model Validation

In order to perform a static validation of the model, it was presented and applied to the client company so that they could validate the relevance of the results to their situation. This resulted in recommendations for improvement of their service oriented architecture maturity, system cloud suitability and possible alternatives to the suitable systems.

2 Method

In this chapter the processes and methods used during the research are explained, starting with a brief explanation of how the main research question was answered. The next part of the chapter is divided into four sections, each describing one phase of the study. After that follows a presentation of the academic work model, the authenticity of the thesis and a criticism of sources section.

In order to answer the main research question a decision model were devised. It is based upon the findings of the initial study, architectural study, system and requirement study, and the market survey. The first part of the decision model aims to assess the architectural situation in the company. The second part is applied to a system to indicate whether it is suitable to be run as a cloud service or an on-premise resource. The last part compares the requirements of the system and strengths and weaknesses of the current solution, with available cloud service solutions to assess whether a potential cloud service exists with similar functionality. This decision model was tested on a number of systems at the client company Medius. The model was tested to examine its relevance for the client company.

2.1 Initial Study

An initial literature study was performed to establish knowledge within the field of research. This study resulted in the theoretical framework presented in chapter 4. It also provided the researchers with the knowledge needed to perform the research. The focus of the literature study was to explain cloud computing along with its strengths and weaknesses, how it should be used, and its prerequisites and preferred architectural structure.

Parallel to the literature study, an initial meeting with the respondent, who work as Medius Head of IT, was conducted. During this meeting an overview of their current system environment was presented, along with a list of systems that would be relevant for examination. These systems are further described in chapter 3.2.1 *Evaluated Systems*. The following interviews and discussions, performed during the study, were held with the same respondent. As the Head of IT he is responsible for the internal IT infrastructure in Medius.

2.2 Architectural Study

To evaluate the Service Oriented Architecture (SOA) possibilities within Medius a maturity model was used. The independent SOA Maturity Model (iSOAMM) was produced by Rathfelder and Groenda (2008) and uses maturity levels to present how well an organization is utilizing the concept of SOA. One strength of this model is that it evaluates the levels of SOA independently of technology. The Model was also very applicable to our client company Medius, which further strengthened it as a model to use in the thesis. This model also explores similar questions as discovered in the literature study as well as presents new important consideration aspects.

To decide the levels of maturity of Medius SOA, an interview was conducted with the respondent. The criterions on each level in the model were used as foundation for the questions in a semi-structured interview. This kind of interview enabled us to ensure understanding of Medius current architecture so that we could more accurately estimate their actual level. Due to logistical complications the interview was held over telephone and was digitally recorded and transcribed. Since he possessed the knowledge needed for the level estimation in the model no further respondents were contacted. The questions asked during this interview can be found in the appendix section.

2.3 System and Requirements Study

A scorecard, explained in chapter 6, was used to analyze if a system were suitable as a cloud computing solution or as an on-premise resource. The aspects in the scorecard are based upon the summarizing bullet points of the theoretical framework. Therefore, each aspect represents a consideration point that each IT administrator evaluating cloud services needs to reflect upon. By asking the respondent to score these aspects, it forces them to think through and evaluate the questions in relation to the other aspects. To eliminate confusion and misunderstandings the aspects were written in Swedish before presented to Medius. Due to logistical and organizational constraints the scorecard was only answered by one respondent. It was answered during a interview where each aspect in the scorecard was presented and explained by the researchers. The respondent was then sent the scorecard via e-mail and was allowed an additional week to change any of the scores, so that they could be as accurate as possible.

The systems evaluated were the intranet, demo environment, backup system, storage and e-mail. These systems were selected through discussions with Medius Head of IT as appropriate for evaluation. To further test the scorecard, two additional systems were evaluated. First, a conference tool used by Medius, which they already access as a cloud service, was evaluated. This system is not a mission critical system and is used by Medius with varying demands. Second was the system Microsoft Dynamics AX which is run as an on-premise resource with high integration requirements and handles critical data.

The scorecard produced a set of recommended systems for which alternative cloud computing solutions were explored. Additionally, functional requirements were produced for the explored systems along with strengths and weaknesses for each system. These requirements, strengths and weaknesses were produced through discussions with the respondent on Medius and were digitally recorded and transcribed.

The requirements were meant to cover the major requirement aspects regarding their current on-premise resource systems. Medius had no previous requirements documented and a complete requirements analysis was not within the scope of the research. While a complete requirements document, with a list of the functional requirements, is important when deciding which service to use, it is not crucial for the construction of the decision model in this thesis.

2.4 Market Survey

A market survey was performed to evaluate the possible alternative solution offerings from the cloud. The offers evaluated were those from the major actors in the field that corresponded to the results of the scorecard and the requirements. Since Medius, at the time of the research, had no clear pricing documented for their systems, the pricing of the services were partially disregarded. The services were divided into general service solutions offered, accompanied with at least one specific service as an example. These examples do not in any case rule out other vendors' offered services as more or less appropriate. It only functions as an example of how the service solution could be offered to solve the associated business needs.

2.5 Academic Work Model

The thesis is conducted using a qualitative case-based action research methodology. Therefore, this research is not purely observational since issues, questions and potential solutions are discussed with Medius during the research, to enhance both the researchers and the client company's knowledge in the field. An action research is also said to be one of the more suitable approaches when performing software process improvements and technology transfer studies. The objective of this research is an improving case study, since our aim is to analyze an existing IT infrastructure and to try to improve it by the use of cloud computing (Runeson and Höst 2008). The IT infrastructure in this research is that of Medius.

2.5.1 Data collection and Analysis

The data collected in this research has been collected and analyzed by qualitative methods. Since this is study is a constructive study meant to raise awareness and knowledge within the field of research, this data collection method works very well. This qualitative research is performed according to a flexible design study to be able to best adapt to the circumstances on Medius and the vendor market. This flexibility of the research means that the analysis of the data was to some extent carried out in parallel with the data collection. This is because new insights were discovered during the analysis which in turn needed more data to be collected (Runeson and Höst 2008).

A qualitative research method can lead to a deeper and more accurate understanding of Medius, and how cloud computing could possibly assist in their IT infrastructure, than a quantitative research method. A qualitative research method enables the researchers to accurately evaluate the client, based upon the researchers acquired knowledge in the field together with the collected data. This choice of research method makes an exact replication of the study difficult (Sohlberg and Sohlberg 2002).

For this qualitative data to be valid we have performed a triangulation where the data was collected and compared from company documentation and interviews with the respondent and with existing academic theories on the subject. This means that we use first degree data from interactions with the subject as well as third degree data by analyzing infrastructural charts and documentation to validate our findings (Runeson and Höst 2008).

Which data that was collected was decided by the usage of the Goal Question Method (GQM). This means that the questions researched are based upon the goal of the study. The metrics used when collecting data is thereafter based upon these questions and is by definition linked to the goal of the study (Runeson and Höst 2008).

2.5.2 Theoretical study material sources

The theoretical materials used in this thesis were mostly found through searches in academic databases. Most of the material was found in ACM, IEEE Xplore or through Google Scholar. The searches were made up by different variations of the search words and phrases *Cloud, Service, Cloud Service Adoption, Application Service Provider, Service Level Agreement, Services Oriented Architecture, Enterprise SOA* and *Cloud integration.* The possible vendors that we compare were mostly found through searches on Google using phrases similar to *Cloud Service Provider, Cloud Computing, Backup, Computing, E-mail service, and Storage*.

2.6 Authenticity

The authenticity of a thesis can be evaluated in terms of its reliability and validity. Validity elucidates that the data most relevant for the research has been collected while reliability states the correctness of the measurements. The more clustered the spread of the collected data the higher the reliability. High validity is achieved if the collected data is as relevant as possible to the research, i.e. as close to the center as possible illustrated in the figure 1 below (Björklund and Paulsson 2003).

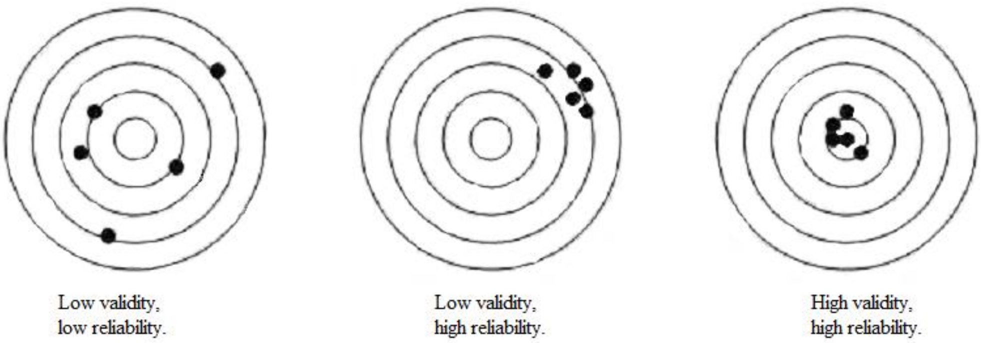

Figure 1
Illustration of reliability and validity. (Based upon figure from: (Björklund and Paulsson 2003))

The questions asked, regarding the iSOAMM analysis, were based upon the framework and the information regarding each level. Since these questions were asked using a semi-structured interview it enabled enough flexibility to more accurately estimate the level of each aspect. The validity is assessed to be relatively high because of the clearly defined levels of the maturity model that the questions were based upon. On the other hand, semi-structured interview allowed the researchers understanding of the subject to affect the result.

Regarding the scorecard the validity is expected to be reasonably high since the aspects were all based on a summary of the consideration aspects in the theoretical framework. To further guarantee a solid validity the scorecard will have to be more rigorously tested, since some aspects may have been missed or could be formulated in a more constructive way.

Validity regarding the requirements collection is expected to be sufficient to ensure a relevant result. A complete requirement analysis was not performed, which means that some requirements aspects were most likely missed. This, however, is not believed to disrupt the relevance of the result since a complete requirement as well as cost analysis has to be performed by Medius before an investment can be decided upon(Björklund and Paulsson 2003).

The researcher performed static validation of the decision model, similar to as performed by Wohlin, Gorschek et al (2006). The problem acting as foundation for the decision model was formulated through discussions with the client company. Furthermore, feedback from the client company regarding the results of the applied model confirmed the results as relevant and useful. The fact that the decision model was based on the problem formulated in cooperation with the client company and the relevance of its results, shows that the model is valid in this initial test for the client company.

The reliability of the results of the model is estimated to be relatively high because of the respondent's knowledge of the company and its systems. However, since only one respondent was interviewed it is not possible to fully verify the reliability of the results. If access to additional respondents from other departments such as development, finance, and top management would have been available it is possible that the results of the model would have been different and the reliability would have been increased (Björklund and Paulsson 2003).

2.7 Criticism of Sources

Since the research field of cloud computing is relatively young most of the cited sources were published between the years 2008 and 2010. This may mean that some of the expressed theories have not yet been completely scrutinized. On the other hand the sources published earlier may not still be fully relevant, because of the fast pace evolution of the market.

The different vendor's offerings have been used as sources for the market survey. This means that these sources are biased towards each associated vendor. Since this thesis explores the type of service offered rather than specific offerings, vendor's bias did not, however, have any major effect on the result.

The access provided by Medius was to the respondent, working as Head of IT, documentation of the system structure and to Medius annual report. Since no other respondent or documentation was available, the results of the interviews and discussions are based on the respondent's point of view.

3 Medius Group

Here follows a brief description of Medius, their background, their future perspectives, as well as their current IT infrastructure.

3.1 Company Background and their Future Perspective

Medius is a medium sized IT company based in Sweden but operates all over the world. They started 2001 in Linköping and have now expanded to include a little less than 200 employees with offices in several cities. The word expansion is actually a key word when describing Medius who has experienced a growth in turnover of 429% between the years 2005-2008 (Medius 2009).

Their strategy for the future involves a broader spectrum of services offered, increased customer net benefit and a continued expansion, especially on the international market. Medius have the ambition to develop in terms with the market and plans for a large number of recruitments, which will further tax their IT resources (Medius 2009). This, along with potential cost reductions and the ability to benefit from new technical possibilities, is the main reason for why they are starting to look towards cloud computing to improve their IT infrastructure.

3.2 Medius IT infrastructure

Medius is a Microsoft Gold Certified Partner which means that they have a strong relationship with Microsoft and high competence and knowledge in their field of business. Medius therefore heavily relies on the Microsoft platform and utilizes for example Microsoft Exchange server, Microsoft SharePoint, Microsoft Team Foundation server and Microsoft Dynamics AX.

At the moment almost all systems are run on servers on-premise stationed in Linköping and Stockholm, Sweden, creating an environment similar to a private cloud. Apart from the above mentioned Microsoft products the on-premise servers host a newly bought Customer Relationship Manager (CRM) -system, an internal communicator for sharing desktops and instant messaging, a fileserver and their own on-premise developed systems with their corresponding databases. Remote access to these systems is possible through Virtual Private Network (VPN) connections.

Apart from this they are using a demonstration environment which is rented from a third party provider and a SaaS-based conference tool. This is the only SaaS system currently used by Medius (Johansson 2011).

3.2.1 Evaluated Systems

Through initial conversations Medius clarified which systems that they could consider to consume as cloud services. The other systems were either newly bought or to mission critical to even consider and were therefore left outside this evaluation. To clarify which systems that will be evaluated, a brief description on each system follows below. The requirements, strengths and weaknesses for each system are produced through discussions between the researchers and the respondent and are presented in chapter 7 *Application of the Decision Model: Results.*

Backup. This involves backup and recovery of databases, e-mail, and common storage. Currently they are using an on-premise solution called Microsoft Data Protection Manager, which provides them with full backup and recovery for all systems.

Demo Environment. Medius sale personnel need to be able to show customers how their product works. This is today solved through installations of the relevant software on a Virtual Machine (VM), which can be run on a client computer.

Intranet. Sharing of documents, booking of resources and portal hosting are together called intranet. These are grouped together because it is today solved by SharePoint which handles all this functionality. Medius are on the other hand interested in a cloud computing solution that could handle this at least equally effective.

Storage. This is currently handled by a server sharing storage space to the internal Local Area Network (LAN) and also offers an ftp solution for external access.

E-mail. This is today handled by an on-premise e-mail server running Microsoft Exchange.

Besides the systems suggested by Medius two other systems were evaluated. This was done to further test the scorecard on systems not pre-selected by the client company as interesting for evaluation.

Conference Tool. A system for web meetings and conferences. This is currently solved by the use of a SaaS solution called Adobe Connect.

Microsoft Dynamics AX. An Enterprise Resource Planning (ERP) solution from Microsoft. This system is currently hosted on an on-premise server.

4 Theoretical Framework

This section will present theories in the relevant field of research. These theories will later be used in the analysis to be compared with our empirical data so that legitimate conclusions can be presented. This chapter will stand as ground for the formulation of our decision model for evaluating a possible adoption of cloud computing.

4.1 Services

Instead of running an application to provide a specific functionality, that functionality could be accessed as a service. These services can easily be combined with other, both internal and external, services to provide additional functionality.

A service should have *self-contained* functionality, i.e. it should provide the same functionality independently of other services. This functionality should be provided directly from the service without the need for access through other services. A service should also be *loosely coupled.* This means that the service could be seen as a black box, where the user does not need to know how the computation is performed but only which information that should be provided and returned. This is important since a loosely coupled service can easily scale and be maintained. Together these principles allows for services to become reusable system components (Sanders, J. A. Hamilton et al. 2008).

4.2 What is Cloud Computing?

Cloud Computing utilizes services to provide specific functionalities over the Internet. It is basically a couple of Internet-connected servers, either located together or distributed over several locations, that provides applications and data for the client users. These servers can be virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers. The main idea is that the customer is agnostic to the underlying hardware (Buyya, Yeo et al. 2008; Leavitt 2009).

For the user there are mainly three aspects that are new with cloud computing, compared to an on-premise resource. First there is the appearance of an infinite amount of computing power and hardware support. Second is the elimination of the up-front cost of new hardware and third is the possibility to pay for the amount of resources that is actually used (Michael Armbrust 2010). Basically a service with comparable functionality is offered instead of a delivered product. Services are not mechanized processes; in fact, they are usually recursively made up by other services with humans taking care of maintenance and managing the supplier-consumer relationships. This is a relatively new model within the software industry (Bennett, Layzell et al. 2000).

For something to actually be a cloud service it has to be delivered over the telecommunication network. The user relies on the services for processing and access to the data, which also has to be under legal control of the user. Since some of the resources on which the services are depending are virtualized the customer does not need to know which server that is running the service or where it is located. This along with a very flexible contract creates the very dynamic and scalable environment that cloud services enable (Clarke 2010). This environment promotes a use of both thick and thin clients since all capabilities are available over the network and access through standard mechanisms (GICTF 2010).

4.2.1 The three layers of cloud services

Depending on the services needed by the user different layers of the cloud are available. These different layers provide services ranging from pure applications to a deeper more direct control of the hardware.

First of all we have what is called Software as a Service (SaaS), which are applications that are run on the servers in the cloud instead of on the customer's computers or servers. This allows the customer to run the application in their web browser without the need for installation (Leavitt 2009; Marston, Li et al. 2010). These services are often run as web applications and are usually very scalable along with a high availability which makes them very easy to adopt (Michael Armbrust 2010). Many SaaS solutions allow the customer to start utilizing them as soon as the payment is received by the vendor, resulting in a rapid upstart process (Pattabhiram and D'Anna 2010).

The second layer is what is called Platform as a Service (PaaS). This gives the users more freedom to develop their own applications and programs on a vendor's cloud environment and run everything from there. This can effectively eliminate the need for expensive development tools and internal resources. A PaaS can be seen as access from the operating system and upwards (Leavitt 2009; Marston, Li et al. 2010). Microsoft Windows Azure (2011) is an example of a platform where users can develop, upload, and manage their own applications.

Third is the bottom layer called Infrastructure as a Service (IaaS) where the user get access to the core parts of the server (Leavitt 2009; Marston, Li et al. 2010). These instances look very much similar to physical hardware and gives the users control of nearly all software from the kernel and upward (Michael Armbrust 2010). This is mainly used for storage and computational capabilities, and is usually designed for developers and system architects (Marston, Li et al. 2010). An example of an available infrastructure service is Amazon Elastic Compute Cloud (EC2) (Amazon.com 2011), where users can allocate virtual servers and manage them as if they were real hardware.

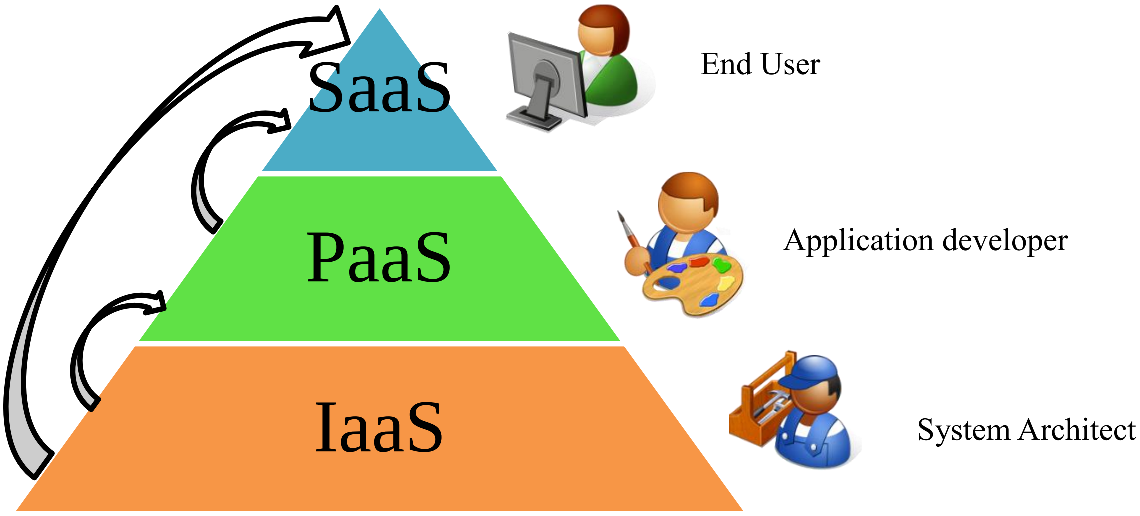

Figure 2
The different layers of cloud computing. The figure shows how IaaS can support both PaaS and SaaS solutions while PaaS can support SaaS solutions.

4.3 Why is Cloud Computing Rising now?

Cloud Computing have been on the rise as the recent trend within the IT business these days. The concept and technology to use and apply Virtual Machines (VM) to better utilize the computing infrastructure and reducing up-front and operational costs is not what makes cloud computing so revolutionizing, in fact it has been around for several years. Nor is it a new phenomenon to offer services over the Internet, this is what Application Service Providers (ASP) have done for many years. What is new is the ability to utilize the full potential of the technology. It is only recently that computer power and network connections have become powerful enough to deliver the performance level that people are used to on local computers (Marston, Li et al. 2010)

Another major aspect that has jump started the development and business of cloud computing are the large corporations promoting it. The cloud industry would still be a lot smaller if world leading actors in the IT business such as Microsoft, Amazon and Google had pasted on the opportunity to promote the trend and market their solutions. These actor might in turn be motivated, according to Staten, Schandler et al. (2009), by the success of companies such as Salesforce.com has had with their cloud computing solutions.

A move towards economies of scale, where relative value increases as the usage and the capacity increases is an argument against an on-premise solution and traditional outsourcing. Economies of scale allow for more efficient utilization of the server resources. This has led to various variants of colocation services where several departments or organizations share the same server computing resources. At the same time, economies of skill, where value increases as the skills of the vendor increases, argue for letting third party companies, with this as their core competence, manage the computing resources. This allows for the customer company to focus on their own core competence. This means that when both these two economies increase, cloud computing emerges as a suitable solution (Staten, Schandler et al. 2009).

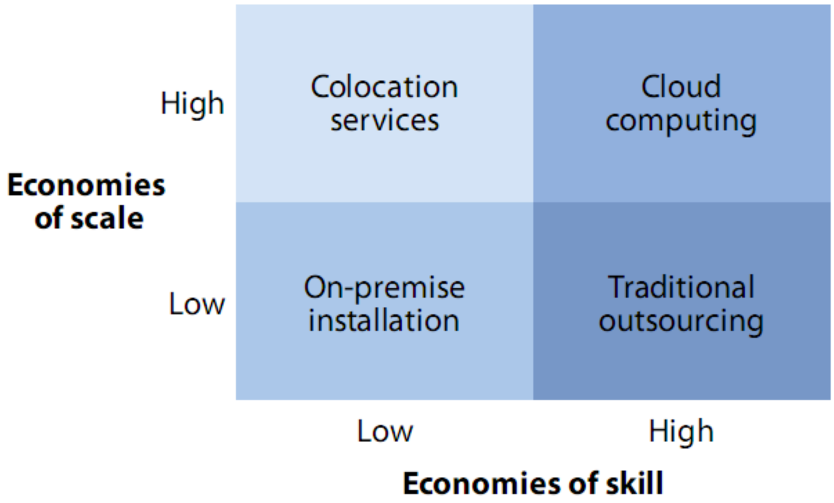

Figure 3
Economies of scale and skill. As they both increase, cloud computing emerges as the most suitable alternative (Staten, Schandler et al. 2009).

4.4 Different implementations of Cloud Computing

This section will present the different implementations of cloud computing on the market. These different implementations are aimed at different business and organizational needs and ranges from internal private clouds to shared public implementations.

4.4.1 Public Cloud

A public cloud is available from a third party service provider via the Internet. In a public cloud all data and computations are stored and performed on the vendor's servers. This means that the users interact with the vendor's servers instead of their own. The public cloud is usually a convenient and fast way for organizations to deploy their IT-solutions compared to investing in and install on-premise hardware. This effectively reduces up-front costs for hardware and maintenance. On the other hand this implementation forces the customers to be dependent on the vendor. The key enabling features of public clouds are the scale and availability of the cloud vendors' data centers and server farms. This means that user perceives an almost endless amount of computing power and hardware support (Marston, Li et al. 2010).

4.4.2 Private Cloud

In contrast to the public cloud is the private cloud, which is managed and hosted from within the organization. It benefits from many of the positive effects of a public cloud, such as being elastic and service based, but it also provides a greater control over the organization's critical information than the public cloud (Marston, Li et al. 2010). A private cloud solution needs to be very large to gain the advantages of scale otherwise associated with public cloud services. If the capacity of the servers are not large enough the user might not get the expected perception of an almost endless amount of computing power and hardware support. This means that we should be careful in naming a private data center or server farm a private cloud, since these may not have all the advantages we assign to cloud computing (Armbrust, Fox et al. 2010).

4.4.3 Hybrid Cloud

A third alternative is a combination of these two cloud implementations called a hybrid cloud. This means that critical information is kept within the organization while the non-critical is outsourced to external providers of public clouds. This means that parts of the cloud are hosted internally within the organization and handles the critical information, while the rest of the functionality is accessed through public vendors. The internal part of the cloud does not have to be able to support all business needs but only the ones handling the critical information. The companies can then leverage the advantages of cloud computing without sacrificing the control of their critical information (Marston, Li et al. 2010).

4.5 Service Level Agreements (SLA)

A Service Level Agreement is a document between a service provider and a customer where they decide the performance quality of the service the customer can expect. One of the declared advantages with cloud services is that the service is accessible whenever, wherever and by whomever. This makes SLAs important because of the inherent disjointed relationship between the consumer and the provider (Patel, Ranabahu et al. 2009).

The SLA includes technical definitions of measurable aspects of the service, such as availability, percentage of packet loss, or percentage of transaction failures. These can be seen as quality requirements. The SLA defines the different attributes of the service and the minimum service levels. It also defines the warranties from the vendor and the corresponding consequences of non-compliance with the SLA (Azure 2011). How quality requirements correspond to vendor's SLA is illustrated in the figure 4 below.

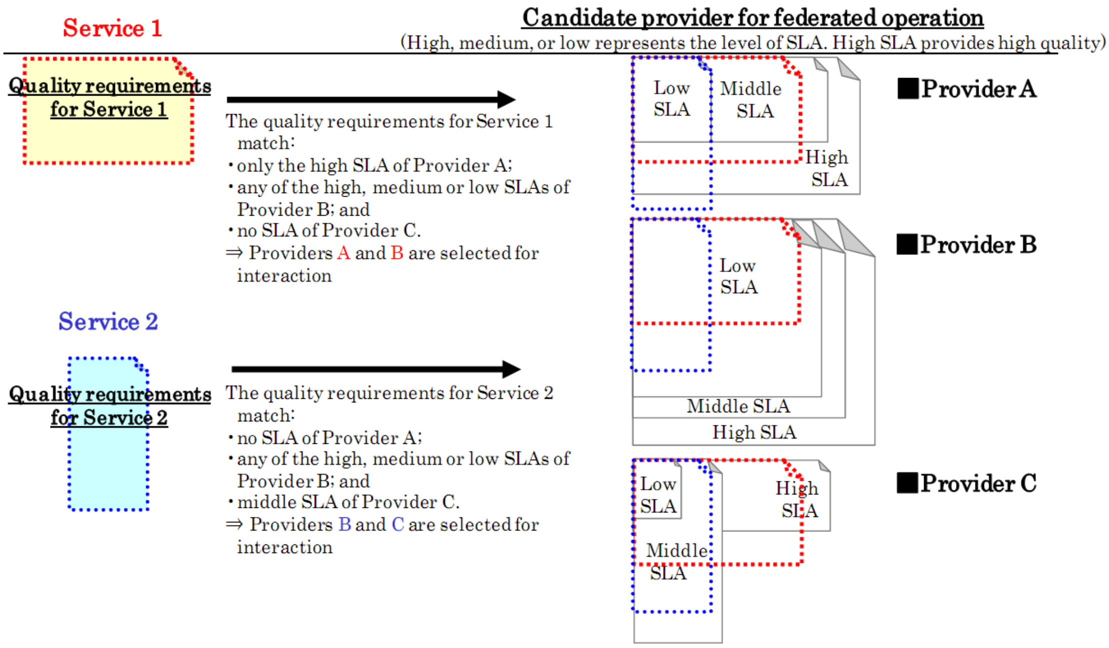

Figure 4
In the figure above the Quality requirements are presented in the form of a square. If this square has the same size as, or fits inside the shape of the SLA they are considered to be fulfilled. While it matches the larger the difference in shape between the Quality requirements square and the SLA square the more surplus items in the SLA (GICTF 2010).

4.6 Strengths of Cloud Computing

There are several positive aspects with cloud computing that corporations can utilize, spanning from reduced infrastructure costs, technical advantages, and lower upgrade and maintenance costs. This section will present some of these aspects and how they can benefit an organization.

4.6.1 Economical

To cope with a rapidly changing market, with a strong need for security and a high potential for expansions, along with an increasing complexity of managing the infrastructure and architecture, companies have been forced to look for new ways to administrate their IT capabilities (Marston, Li et al. 2010). Managing the internal information systems is not the core competence for most companies (Leavitt 2009). This mean that utilizing cloud services will free up IT staff to focus on supporting the corporate business values (Schadler 2008).

One of the major advantages with cloud computing is the possibility to pay-as-you-go or by subscription, where you only pay for the amount of a resources that you use or respectively for the time the service is accessible. The pay-as-you-go model or the subscription model both allow companies to avoid a large initial investment and instead pay for the functionality as an operational cost. Which is most preferred is usually up to each individual company and where they are in their current business growth curve (Ghosh and Arce 2010). The steeper the growth curve for the company or the associated line of business the harder it is to predict future expenses. The cloud payment model is a good way to handle spikes in workloads and to cope with increasing or decreasing demands since it automatically scales without the need for the user to invest in new on-premise hardware (Leavitt 2009; Michael Armbrust 2010).

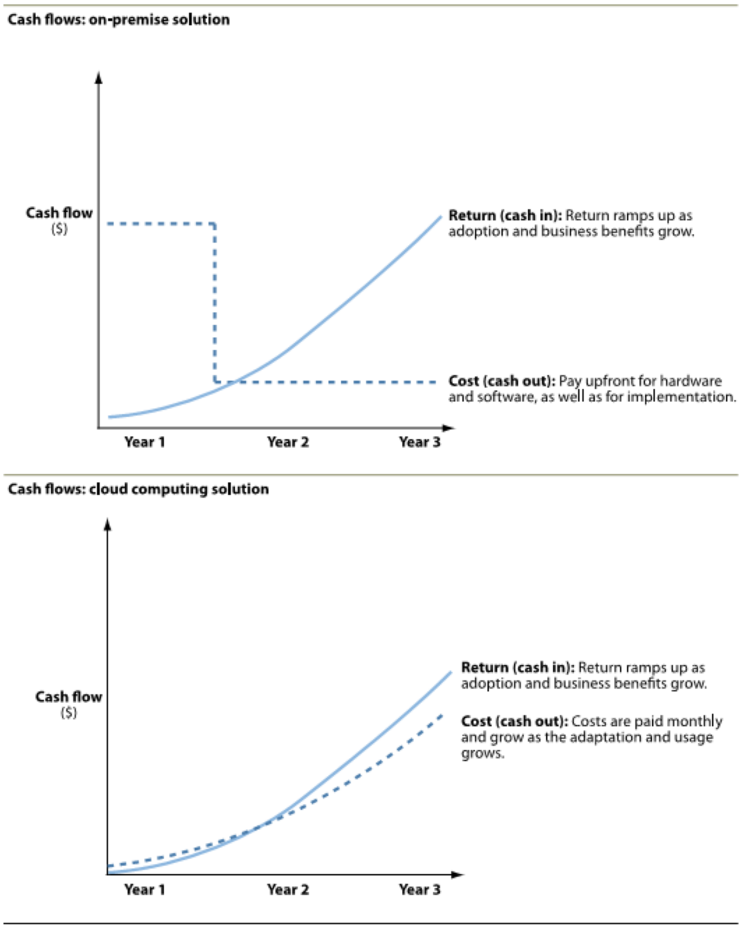

Figure 5
Where an on-premise solution requires a larger initial investment creating a huge gap between the cost and return on investment, the cloud computing solution grows according to the needs. (Schadler 2008)

This payment model is similar to the way a company receives and pays for electricity or gas, where they pay for the amount that is consumed (Buyya, Yeo et al. 2008). According to a survey done by Gartner Research around two-thirds of the average corporate IT staffing budget goes towards routine support and maintenance. The need for reducing costs has initially been the main driver for adopting cloud computing, although recently the increasing technical possibilities have grown to be an important factor too (Leavitt 2009).

4.6.2 Technical

A technical strength with cloud computing is that a system run by a large provider with lots of resources and redundant equipment is more likely to offer a greater availability and robustness than a system that is run on-premise. This is especially helpful for a small or middle sized company that may not have the resources needed to achieve this level of stability (Leavitt 2009). By utilizing possibilities with cloud computing, companies gain both the hardware and software benefits without any upfront capital investments (Marston, Li et al. 2010).

To further simplify the usage of cloud computing services many providers are generally using the Simple Object Access Protocol (SOAP), Web Service Description Language (WSDL) or other XML-based protocols for interactions with legacy systems and other services (Leavitt 2009).

The flexibility of Cloud Computing also makes it easier for companies to scale their services according to the user demands. For a company that is on a steep growth path, with an increasing number of users, a cloud solution makes it possible to keep up with the growing demands. The same goes for companies with decreasing demands. Through cloud computing the computation loads gets balanced on-the-fly as the number of requests increase or decrease (Marston, Li et al. 2010).

Another technical advantage with cloud computing is applications and data delivery services. One example is the usage of mobile devices, which are local-, environment- and content-aware, that can respond in real-time. By leaving the heavy computational parts in the cloud smaller and less powerful devices receives the ability to utilize programs that would otherwise require a much more competent machine (Marston, Li et al. 2010).

4.6.3 Operational

To use a cloud computing service instead of an on-premise resource makes most sense when the functionality is used with low frequency. An on-premise resource would in this case be an expense even when idle, while the cloud service would only be paid for when used. At the same time cloud computing can handle spikes in demand by automatically increase the provided resource depending on the amplitude of the demand (Armbrust, Fox et al. 2010).

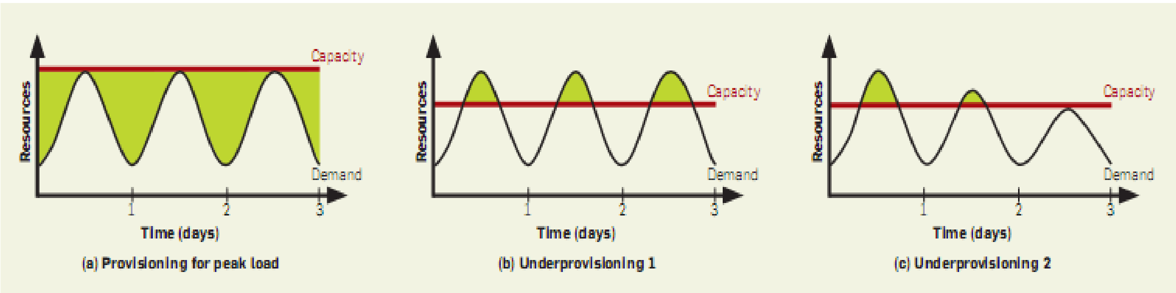

Figure 6
(a) Even if the peak load is correctly anticipated, a not elastic solution will waste resources. (b) & (c) If peak loads regularly or unregularly exceeds the capacity revenue might be lost since users will experience poor service (Armbrust, Fox et al. 2010).

Estimates show that the average server utilization in data centers range from 5-20% with peak workloads that exceeds the average factor by 2 to 10. The ability to dynamically scale the usage based upon the current demand that cloud computing provides can therefore drastically reduce the amount of wasted resources (Marston, Li et al. 2010; Michael Armbrust 2010).

4.6.4 Security

The threat to data security will always be present, whether the data is stored locally or in a cloud. Service providers are paying a lot of attention towards authentication issues so that the customers will be presented with an easy and convenient way to reach their data and at the same time keeping intruders away. Regarding Denial-of-Service (DoS) and similar attacks it is even so that most companies reduce this risk in a cloud computing environment, because of multiple and separate servers (Clarke 2010).

4.7 Weaknesses of Cloud Computing

There are some aspects that argue against an adoption of cloud computing. These aspects are presented and explained in the sections below.

4.7.1 Day to day Operational Risks

Day to day operational risks are events that may occur, where the customers do not have any control. Amazon currently commits, through their Service Level Agreement (SLA), to an annual uptime of 99.95% per service year, which translates to approximately 4.5 hours of downtime per year (Amazon.com 2011). This might not be enough for critical data in some organizations. This dependency of the vendor's reliability is something that all cloud service customer have to pay attention to (Marston, Li et al. 2010).

Some systems rely on heavy integration with other systems. If these systems are replaced with services, those services need to support the same level of integration. Since the customer organization does not handle the software in a cloud solution, it is dependent on the vendor for sustained quality. Changes to the underlying structure might negatively affect functionalities or disrupt dependent systems. For a user this could be apparent in the form of a change in user interface or functionality. For example an application that is dependent on a service might stop working as expected by the user, if that service provider performs changes to that service (Clarke 2010).

4.7.2 Contingent Risks

The customer needs to know, and have guarantees for, what will happen to the data if the cloud vendor goes bankrupt or leaves the cloud vendor business for any reason. If the vendor does not guarantee that, in case of termination, they will provide the customer's data in a usable format the customer will most likely lose valuable data. The vendor also has to be able to guarantee that the data is not made public as some of the data may contain critical information (Clarke 2010).

Even if the cloud vendor remains in operation there is always a risk of data loss due to for example disasters. There have already been reports of incidents where data and whole databases have been lost. Occurrences like these are extremely rare but it is important for the customer to be aware of (Clarke 2010).

Another contingent risk is that whenever dealing with software form outside of the organization there will be an issue of compatibility. If the service provider does not use software that is fully compatible with that of the customer it may imply heavy additional adaption costs to fully utilize the service. This means that if the customer requires a highly customized Application Programming Interface (API) or a specific technology, solution, or development platform, it might be hard to find a suitable cloud computing solution. This might cause additional problems if the service provider switches or updates their software in a way that forces that customer into extensive adaptations. (Clarke 2010).

4.7.3 Business

A common problem with using a third party vendor is that the user organization might lose control and knowledge of the application and the costs associated with it. This might lead to lock-ins where it is very hard and costly to switch from one service provider to another or to an on-premise solution. In these cases the user is very vulnerable to the vendor’s price-increases or software changes (Clarke 2010).

It is because of these aspects that the International Standardization Organization (ISO) has formed a subcommittee Distributed Application Platform and Services (DAPS) that include a study group for standardizations of cloud services so that customers can more easily switch between vendors (Buyya, Yeo et al. 2008; Leavitt 2009; Marston, Li et al. 2010).

Another issue is that of regulatory compliances, both from within the company and from outside. The customer is ultimately responsible for the data even when hosted by another organization. Business or governmental regulations may force companies to keep certain information within the organization. There might also be regulations from within the organization the system has to comply with or that prohibits certain systems to be hosted by public clouds. This might also force some systems to follow specific processes or guidelines that may be hard to combine with available cloud service (Kandukuri, Paturi et al. 2009).

4.7.4 Security Issues

There is a general concern in larger organizations towards handing over their operations and data to outside companies (Marston, Li et al. 2010). The security issue and the fear of storing sensitive data at other companies is one of the major aspect speaking against cloud services (Leavitt 2009; Michael Armbrust 2010). A recent study done by International Data Corporation (IDC) shows that almost 75% of CIOs and IT executives are concerned about the security when using cloud services (Leavitt 2009).

Cloud computing is still in its upstart phase and user may not fully grasp how to utilize the capabilities of the concept (Buyya, Yeo et al. 2008). One of the more potentially harmful risks is an involuntary change or loss of data. This includes any changes to data in ways not expected by the user. In addition to the data being influenced by someone or something else than the intended user the customer has to completely rely on the vendor to handle the problem. Handling a problem like this involves investigations, information on the cause of the problem, compensation and corrective actions, all of which must be performed by the vendor (Clarke 2010).

4.8 Prerequisites for Utilizing Cloud Computing

To start utilizing cloud computing within an organization companies may have to consider certain aspects that affect the interaction between the multiple systems. Some of the major aspects are presented in the following section.

4.8.1 Architectural Issues

Even if many cloud services are made so that the customer can start using them the same second as the subscription payment has been transacted, some issues will still remain.

One example of these kinds of issues is where the cloud service will be integrated with the rest of the software used by the organization. These systems can be either on-premise or in other cloud locations (Pattabhiram and D'Anna 2010). Even if it would be beneficial for the customer if the service vendor could provide all the services that the customer would need, this is not usually the case. To fulfill the variety of IT needs an organization might have, they will most likely have to combine systems from several vendors and with their existing, on-premise systems (Demirkan, Kauffman et al. 2008).

The major disadvantage with the traditional client-server architecture is the inflexibility with regards to changing company scenarios. The constantly changing business climate that most companies find themselves in demands a way to handle these changes in a cost effective way (Liegl 2007). The loosely coupled and self-contained services used in SOA can easily be combined to offer an additional new service. SOA is designed to provide guidelines for a wide variety of industries with different kinds of service. Therefore, as more and more service become available through cloud computing these can easily be integrated into a service oriented architecture. Cap Gemini and HP provides the following five major key reason why SOA should be adopted to fully utilize cloud computing (Mulholland, Daniels et al. 2008).

1. Accessibility

The cloud services that are currently available are delivered with standard SOA interfaces. This design makes cloud computing service easily adopted into a service oriented architecture.

2. Visibility

By having an SOA it becomes visible which services the organization needs and may benefit from. Because there already exists a very large amount of services it is most likely that the service desired by the organization already is available.

3. Extensibility

The service oriented architecture invites for an easy adoption of new services. This means that it is also easy to combine services to create additional functionalities.

4. Matching expectations

In SOA each service provides a service level agreement that states its responsibilities. This provides insurance that the service matches the expectations of the user. Cloud services use the same concept and are therefore easily integrated into SOA.

5. Adherence to standards

With cloud vendors it may be important to enforce certain policies such as data security. SOA contains policy management techniques for validating that appropriate standards are followed.

In order to use the type of flexible services that most cloud services are, the architecture needs to be equally flexible. This is why a Service Oriented Architecture (SOA) inspired architecture is greatly encouraged (Bennett, Layzell et al. 2000).

4.8.2 Service Oriented Architecture

Traditional enterprise architecture consists of mainly two layers, the business process layer and the application layer. The application layer should be tightly linked with the business layer and continuously support and adapt to changes in the business processes. In SOA a third layer, called service interface layer, is introduced to replace the connections and dependencies between the business architecture and the application architecture (Erl 2005).

This service interface layer in turn contains three sub layers. The first layer, called business service layer, handles the interaction against the business process layer. A second layer, called the application service layer, handles the interaction with the application layer and finally a third layer, called orchestration layer, handles the interaction between services within the service interface layer. New services can herby be created and built up by combinations of existing services (Erl 2005). This is illustrated in the figure 7 below.

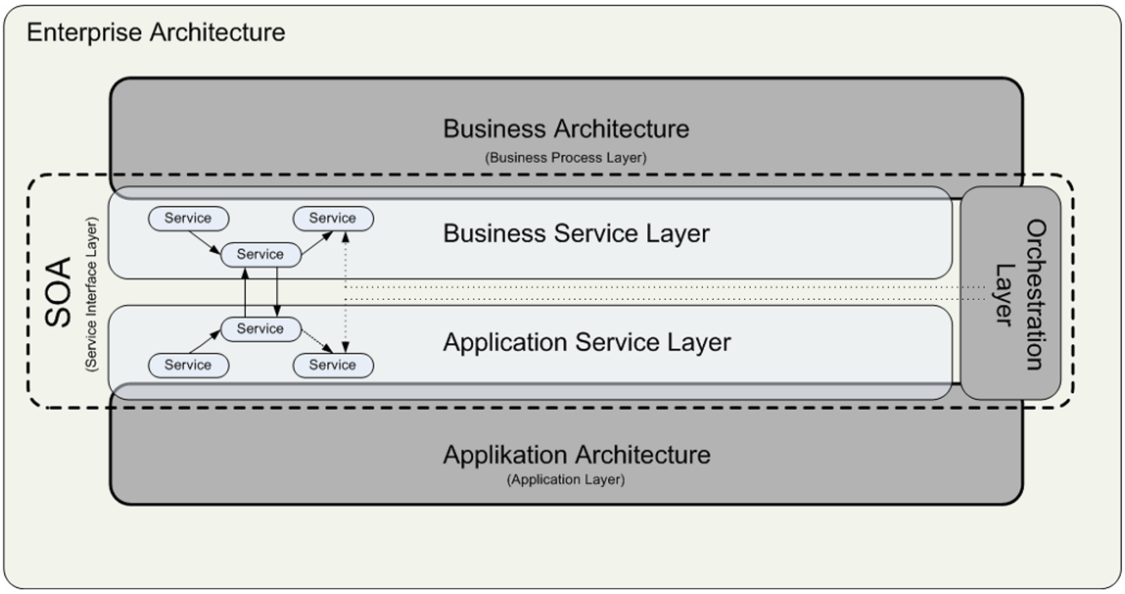

Figure 7
The SOA Service Interface Layer is introduced to handle the connections and dependencies between the business architecture and the application architecture (Friberg, Gyllander et al. 2007).

4.9 Summary of the Theoretical Framework

The theoretical framework is summarized into several bullet points. These are grouped into sub categories regarding; *what is cloud computing*, *which consideration issues exists prior to adoption*, and *which architectural prerequisites would benefit the use of cloud services*.

4.9.1 What is cloud computing

- Cloud computing provides service with specific functionalities over the Internet. These services should have the appearance of having infinite resources available, let the user be agnostic to the underlying hardware, and be paid for with subscription or by amount utilized.

- Cloud computing can be described as three layers; SaaS, PaaS, and IaaS. These three layers offer three different types of services according to different levels of abstraction. IaaS provides full control of the running software, PaaS offers partial control and with SaaS users get access to a preconfigured, fully functional service.

- There are different implementations of cloud computing. In this report the three categories private, public, and hybrid cloud are discussed. These are separated by the provided level of control of the hosted data. In a public cloud the services are hosted by vendors who control the data and software. The private cloud has similar functionalities as the public cloud but is hosted from within the user organization. In a hybrid cloud an organization uses both a private and a public cloud enabling them to decide in which of them to host their data.

- To guarantee a certain level of quality, service vendors provide SLAs. In an SLA the vendor and the customer agrees upon quality requirements for measurable aspects of the service. These also contain corresponding consequences of non-compliance with the SLA.

4.9.2 Which consideration issues exists prior to adoption

- The possibility to pay for the amount utilized eliminates large investments to compensate for future demands as well as allows companies to only pay for a system when it is used. This enables costs to be viewed as operational expenses (OpEx) instead of capital expenses (CapEx).

- The steeper the growth curve for the organization or the line of business the harder it is to predict their future IT demands. The current growth curve is therefore an important consideration regarding a cloud computing adoption because of its resource flexibility.

- A large variation in the amplitude of the demand can lead to a resource being either over or under provisioned. This is an aspect that can be adjusted automatically by cloud computing. It also means that the client user does not need any heavy computational power at their end.

- A system which is used with low frequency produces a cost even when unused. The cloud computing model allows for an automatic adjustment so that a system is only producing costs when used. It is easier to predict resource needs for a system with a high frequency of usage which means that such a system would benefit less from a cloud computing solution.

- A user is dependent on the vendor to keep the service functional and secure. If the vendor would fail to uphold their promises the customer might lose the ability to use mission critical systems without the possibility to handle the restoration of the system themselves. It might also cause the customer to lose valuable data or suffer from having it exposed to the public. This means that an organization needs to be aware of the critical level of the system run as a cloud computing service.

- Since cloud computing services are delivered by a vendor and not controlled on-premise the customer needs to be aware of its quality requirements. If the requirements are high enough it is not guaranteed that vendors can deliver on those demands.

- A system that integrates with other systems can be very complicated to replace with a service, since the service in that case needs to be equally able to integrate. This also produces a risk of vendor lock-in since switch from service provider to another might result in large additional integration costs.

- If the customer organization desires a specific technology or highly customized API the selection of possible services is drastically reduced.

- The customer is ultimately responsible for the information even when hosted by a cloud vendor. Business or governmental regulations may therefore force companies to keep certain information within the organization

- Internal regulations can prevent companies from hosting certain systems in a public cloud. It may also provide complications in the form of guidelines and processes that may be hard to combine with available cloud services.

4.9.3 Which architectural prerequisites would benefit the use of cloud services

- There are five major advantages with using SOA together with cloud computing. These are; accessibility, visibility, extensibility, matching expectations, and adherence to standards.

- A service in SOA should be both self-contained and loosely coupled. This means that services becomes reusable system components.

- SOA introduces the Service Interface Layer between the business architecture and the application architecture. This layer in turn contains a business service layer, an application service layer, and an orchestration layer. These handle the connections and dependencies between the business architecture and the application architecture.

5 Cloud Market Service Survey

Based upon the systems that Medius are willing to evaluate we have conducted a study of the relevant cloud computing services on the market that offers an alternative solution to Medius on-premise resources. This chapter will provide examples of types of cloud computing solutions along with examples of services delivering the desired solution.

5.1 Available Cloud Services

This chapter will present examples of the major different types of cloud services on the market. They will represent the three layers of cloud computing; IaaS, PaaS, and SaaS and are meant to cover the systems evaluated in this thesis. The different types of services will be explained together with an example of a service provided by a vendor.

5.1.1 Computing

Computing means that the vendor provides the customer with computing capabilities. This essentially means that the vendor provides the customer with access to a virtual server that could act as an actual server in the customer's network. Some vendors provide the opportunity for customers to fully extend their own network capabilities with Active Directory (AD) support which can be done securely with a Virtual private Network (VPN) connection (Amazon.com 2011; GoGrid 2011). This is a typical IaaS.

One advantage with virtual server instances hosted by a vendor is the perception of endless scalability. These instances can be scaled to meet any changes in demand of computing power. These changes can either be managed by the user at will or automatically by the vendor. Most offer automatic load balancing between instances to ensure performance. The user also receives complete control over the number of instances, which instances to shut down, copying of instances and what is run on each server instance. Another advantage is that these virtual instances provide a simple solution to store a snapshot, an image of the working virtual instance, for redundancy and backup (Amazon.com 2011; GoGrid 2011).

An example of a vendor that provides these possibilities is Amazon. Through their service Elastic Compute Cloud (EC2) they enable customers to either use a template instance image provided by Amazon or create their own specialized one, with the applications, libraries, data, and settings the customer needs. An amazon EC2 instance can be managed just like any server on the customer network. Enterprises can extend their existing IT infrastructure with a Virtual Private Cloud (VPC). This means that the company can access isolated EC2 instances with a VPN connection and thereby extend their existing security measures such as firewall to the VPC.

To lower latency and raise responsiveness within different regions Amazon have multiple datacenters spread throughout the world. This can also help in complying with regional rules and regulations.

5.1.2 Storage

There are several different types of cloud storage services. The major differences are how the customer uses the storage. For example Amazon's Simple Storage Service (S3) is aimed at developers utilizing the storage to support the applications (Amazon.com 2011). While for example Box provides storage and content management for private and enterprise users (Box 2011).

Another difference is how the user accesses the storage. S3 provides several interfaces, such as Representational State Transfer (REST) and Simple Object Access Point (SOAP), to access the data. The default download protocol is http. Amazon also provides a BitTorrent protocol interface to lower costs for high scale distribution (Amazon.com 2011). For private users the only way to access and manage data at Box is through a web interface. Paying customers can also receive additional benefits such as synchronization and redundant offline access (Box 2011).

While S3 leaves encryption and security management to the developer, Box offers business customers the opportunity to use a 256-bit AES SSL encryption for all data and AD/LDAP integration for Active Directory support (Amazon.com 2011; Box 2011). Administrator accounts which can manage users, groups and access permissions as well as monitor files and user activity provide additional security for the customer company. Folders and files can easily be shared both within and outside of the organization (Box 2011).

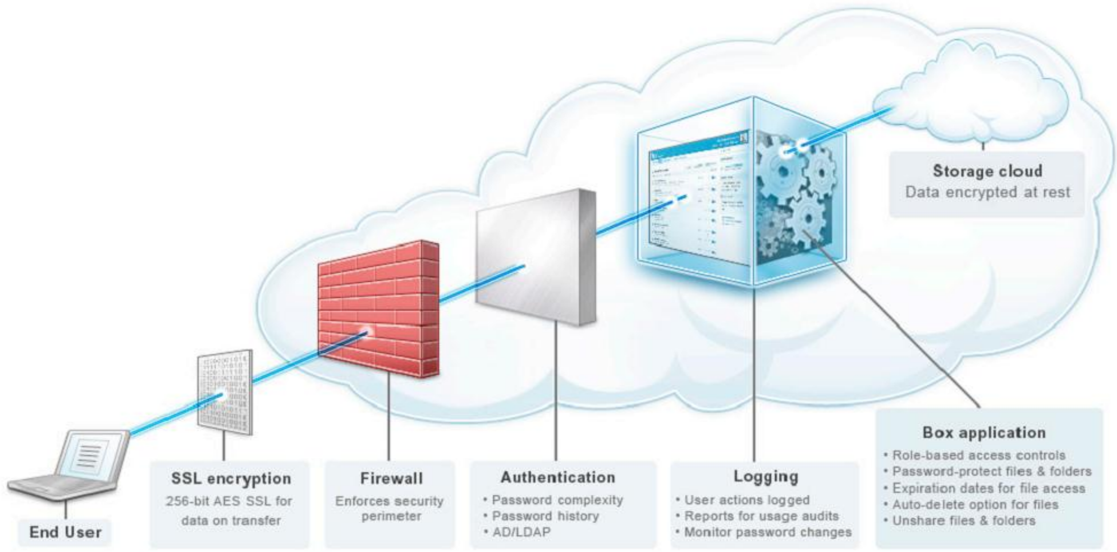

Figure 8
Box security illustration (Box 2011)

5.1.3 Platform

A platform is an application platform where customers can host, scale and manage their applications. The advantages of this are similar to those of computing, as explained in 5.1.1, such as scalability with load balancing and a predictable operational cost model. The difference from computing is that the user does not receive complete control of a server but a fixed set of tools and a platform to run and manage their applications.

An example of this is Windows Azure platform which provides the customer with Windows Azure which acts as an operating system, Microsoft SQL Azure which is a cloud enabled version of the Microsoft SQL Server, and Windows Azure AppFabric that lets the user develop, manage and host their own applications (Azure 2011). Security is achieved by Secure Sockets Layer (SSL) authentication and tools are provided to the customers for encryption of data (Kaufman and Venkatapathy 2010). The customer can choose to pay for the platform with fixed monthly subscription or a pay-as-you-go model where the fee changes depending on the resources used (Azure 2011).

5.1.4 Cloud Backup Service

An advantage of managing backup in the cloud is that the data is available from anywhere. This means that even in case of disaster the data can be accessed since it is stored off-site. On the other hand a cloud backup service requires the devices to be connected to the internet for backing up and retrieving of data (VisionSolutions 2011). The Internet connection capabilities can in some cases be a deciding factor since very large amounts of data are moved back and forth.

Some companies supports both local and online backup, where a local backup is stored for speed and convenience and an online backup is stored of-site. These two backups do not have to occur simultaneous, which means that where the local backup can be performed with scheduled frequent intervals and the online backup can be performed with less frequency. Backups can be scheduled and managed through associated backup management tools. These services have full support for Microsoft systems and servers and delivers version recovery up to 30 days in the past. The payment model for this service is built up by subscription and a tiered pricing for the amount of stored data. There is therefore no practical upper limit regarding the amount of stored data (Decho 2010).

5.1.5 E-Mail Service

One advantage with hosted e-mail services is that the storage scales according to the demand. As the demand for extra storage increases the customer can add additional storage by either pay a fee for the extra space needed without having to install additional hardware. For example Google guaranties 99.9% uptime in the SLA for the Google Apps for Business. This means that as the customer’s performance needs increases the e-mail service will employ measures to ensure the performance, stated in the SLA, for every user (Google-Apps 2011).

An example of a cloud computing hosted e-mail service is Microsoft Exchange Online. It offers the same functionality as a regular on-premise exchange server, like for example support for Outlook, active directory, and a web interface. At the same time it provides the benefits from being a cloud computing service like support for mobile devices and scalability with regard to the number of users, who all receives mailbox storage of 25GB (Microsoft 2009).

5.1.6 Hosted Servers

Companies that are currently hosting a server on-premise but would like to take advantage of the cloud possibilities can in some cases choose to run the same service as before but hosted by a cloud vendor. For example there are several vendors that offer hosted instances of the Microsoft product Team Foundation Server (Praktikgroup 2011; TeamDevCentral 2011). Microsoft themselves offers some of their server packages as cloud hosted instances, for example Exchange Online, Lync Online, and SharePoint Online.

6 Result: Decision Model

In the following chapter the models and frameworks used in the thesis are presented and explained. First follows a description of the decision model produced by the literature study. Then each model or framework, used in the decision model, is presented and explained.

The decision model produced by the literature study consists of an evaluation of SOA maturity, a system evaluation through the use of a scorecard and a comparison between available market services and on-premise resources. As shown in chapter 4, the principles of SOA provide a good framework for incorporating cloud computing services and enhance their benefits. It is therefore recommended that an organization performs a SOA maturity evaluation to determine the maturity within the organization and to provide recommendations for improvements. The SOA maturity model used in this research is explained in chapter 6.1.

The organization then needs to evaluate which system that could be run as a cloud service. This could be done by evaluating the consideration aspects in the scorecard presented in chapter 6.2. This scorecard indicates if the evaluated system would be recommended to be run as a cloud service or as an on-premise resource. The next step is to compare the requirements of the recommended systems and the strengths and weaknesses of the current resource, to those of the available market services. This is done to assess whether there exists a potential solution with similar functionality to the on-premise resource.

The decision model therefore consists of the following three steps:

- Perform an SOA maturity evaluation.
- Evaluate which system that is suitable to be run as a cloud computing service with the use of the scorecard.
- Perform a market survey to compare available services with the current on-premise resource.

6.1 Independent SOA Maturity Model

For an organization to start adopting the SOA principles it needs to adjust to certain changes. Some services need a fully functional service oriented architecture to be in place, for them to be beneficial. To handle this complexity it may be beneficial to see how mature the organization is regarding SOA compliance.

A model for handling this evaluation is the iSOAMM which is an independent SOA Maturity Model. Independent in this context means technology independent, i.e. the maturity model is not based on any specific technology platform. It contains five different aspects which are evaluated in five different levels depending on maturity (Rathfelder and Groenda 2008).

These five aspects are as follows:

1. Service Architecture

This regards how service oriented the architecture of each application is as well as the system architecture in whole. It also evaluates how well the various applications interact with each other both internally and externally.

2. Infrastructure

The infrastructure is measured separately from the services because the need for a stable infrastructure as a foundation for rapid adaptation to new business requirements. The SOA infrastructure should provide a common communication layer to all services.

3. Enterprise Structure

How well the enterprise organization is aligned with the SOA concept. This regards responsibilities, duties and the affected divisions of the company.

4. Service Development

This aspect regards the design, development and implementation of services and how well this is adapted to the principles of SOA. Automation of the development increases with the maturity level.

5. Governance

The changes, rules and guidelines that are relevant for the whole enterprise. These are not limited to the *Enterprise Structure* and *Service Development* but also cover the whole organization.

The maturity model is divided into five different levels where each new level is an enhancement of the previous level. To advance to the next level the previous changes will have to be fulfilled. On each of these levels the above five aspects are evaluated to determine the maturity level of each aspect. These levels and aspects are briefly presented in figure 9.

Maturity Level \ Viewpoint	Service Architecture	Infrastructure	Enterprise Structure	Service Development	Governance
5 On Demand SOA	dynamic services	service marketplace	service as business	service on demand	automated
4 Cooperative SOA	processes	management, event-driven	service alligned	model-driven	fair compe-tition control
3 Administered SOA	orchestrated services	monitoring, security	centrally managed	documented, tool support	rules
2 Integrative SOA	integrated applications	communica-tion	IT-oriented	hands-on experiences	guidelines
1 Trial SOA	islands	inhomo-geneous	separated	unstructured	none

Figure 9
Maturity Levels (Rathfelder and Groenda 2008).

Level 1: Trial SOA
In this level separate and independent SOA projects are performed but there is no set of standardizations within all projects. This is usually where enterprises gain their first experience with SOA.

Service Architecture. The interfaces between existing applications are replaced by services that can be used by more than one application. The services do not have to follow any standards, which mean that they could be incompatible with each other.

Infrastructure. Due to the fact that the service may not follow the same standards they are likely to have different communication systems. This inhomogeneous infrastructure can lead to incompatible service islands.

Enterprise structure. The organization is separated into several independent business departments with their own application landscape managed by a separate IT section. Cooperation across these departments is very rare.

Service Development. Each SOA project is developed independently without any structured process.

Governance. SOA is regarded as an IT project which barely affects the rest of the business units. These projects usually lack support from top management.

Level 2: Integrative SOA
The target of SOAs at this level is mainly the integration of existing systems. New projects are developed with SOA integration in mind.

Service Architecture. Services use standardized service interfaces which leads to common Application Programming Interface (API). This API can be used to access different back end systems by fronted applications.

Infrastructure. All services are implemented so that they can use the same communication protocol. How this communication protocol is designed is up to each organization.

Enterprise structure. The organization is concerned with handling SOA issues and team of IT experts is introduced to handle all SOA related questions. The team members are responsible for handling the communication protocol and for training personnel regarding implementation and integration of services.

Service Development. The developers have access to guidelines and lessons learned to support the development. Regulations of standards and used technology provide a tool support so that developers do not have to find the most appropriate solution on their own.

Governance. Enterprise-wide guidelines that standardize the handling of change requests and rollout of altered services have to be defined. Since services can be used by several applications a consistent versioning is needed.

Level 3: Administered SOA
Administrated SOA is characterized by orchestrated services. By orchestrated means that several integration services are combined to implement services that is better aligned with the business processes.

Service Architecture. An orchestration layer is implemented that combines integration service to provide more business oriented services. Business relevant data types are standardized to minimize the need for data transformation and to make the orchestrated services easier to reuse.

Infrastructure. The infrastructure needs to be extended with an orchestration engine to handle the combination process and integration of new services. The communication infrastructure needs to be complemented with a monitoring and security infrastructure. Monitoring and security does not have to be stricter than message level.

Enterprise structure. The services are split up into different service domains according to the functionality and data provided by the services. Each department is responsible for a certain domain and the included services. The SOA team contains representatives from every domain which handles the common data standards.

Service Development. The knowledge and tool repository is enhanced and the share of automated development steps is increased from the previous maturity level. This will further help developers create standardized services.

Governance. All IT systems are affected by an enterprise-wide policy that ensures the service orientation paradigm. Establishment of enterprise-wide rules, guidelines and policies which regulate security concerns are also introduced at the level.

Level 4: Cooperative SOA
The Cooperative level is characterized by fully functional service level agreements that have been agreed upon by the service provider and the service consumer. This

guarantees the consumer a certain level of quality as long as the service is used in conformance to a specific usage profile. Additionally a process layer is introduced into the architecture to close the gap between the services and the business process. It enables support for both business to business processes and internal processes.

Service Architecture. The combined orchestrated services are included into business processes. The service architecture needs to support both business to business interaction as well as human user interaction. Services utilized in these business processes do not have to be exclusively internal.

Infrastructure. The communication infrastructure has to support events from other process as well as actions from users. This leads to an increased need for an extended security infrastructure.

Enterprise structure. The departments responsible for each certain domain are refined into smaller groups, each responsible for separate services.

Service Development. The service development process is atomized enough for business experts to easily combine services into further new services and processes. This could for example be done through a graphical interface.

Governance.
All new IT systems are implemented in a service oriented manner. The legacy applications have to be extended with service interfaces and integrated into the SOA.

Level 5: On Demand SOA
When requested, a service is automatically configured through combinations of the existing available services. Furthermore an SLA is automatically negotiated based upon the services utilized.

Service Architecture. Service needs to be described, configured and grouped such that an automated process could identify the correct required services.

Infrastructure. A trading platform is required for identifying and acquiring desired services. The infrastructure furthermore needs to be extended with functionality for automatic SLA negotiation and service selection. Since this is performed in runtime an increased monitoring will be needed.

Enterprise structure. The only significant change from the previous level is that provisioning of services is now a primary target for the enterprise.

Service Development. Since services in this level are automatically selected and utilized at runtime, it is important to focus on policies and rules to control this selection process.

Governance. A business process management is in place for handling the control and optimization of the business processes.

6.2 Scorecard

The conclusions of the theoretical framework highlighted important consideration points to evaluate before deciding upon replacing an on-premise resource with a cloud computing service. Each of these consideration points were then used as aspects in an evaluation scorecard. These aspects, and thereby also the scorecard, are thus anchored in the theoretical recommendations.

Since the aspects are not equally essential for the outcome of the scorecard, each aspect were divided depending on relevance into three groups. These groups were those of high, medium, and low importance. Each group is represented by a weight from1 to 3, where 3 represent aspects of high importance and 1 aspects of low importance. The relevance of each aspect was based upon the findings from the theoretical framework and on discussions with the client company. The weights regarding each aspect can be modified by the organization using the scorecard depending on how relevant the aspect is for the whole organization and not for each system.

For each system, the scorecard is used by evaluating each aspect and giving it a score from 1 to 10. These scores are multiplied by the corresponding weight and the products are summarized into a total score. A high score, which in this case is above 120, is viewed as an indication towards a suitability for cloud computing. Respectively, a low score, in this case below 100, indicates that the system should be kept on-premise. The gap between 100 and 120 represents the average values for all questions and a total score in this gap indicate a moderate suitability towards cloud computing.

Aspect	**Weight (1-3)**	**Score (1-10)**	**Total Score**
How varying is the demand and usage rate of the system? This can be seen as the amplitude of usage of the system? (The higher the score, the higher the demand (amplitude))	3		
With which frequency is the system used? This can be seen as the frequency of the usage, i.e. is it used in intervals or is it used constantly? (The higher the score the, the less constant is the usage)	2		
How mission critical is the system for the organization? (The higher the score, the less critical is the system)	3		
In which state of growth is the organization and the market? (The higher the score, the steeper the growth curve)	1		
How strict are the governmental and industry rules and regulations that the system needs to follow? (The higher the score, the less rules and regulations for the system to follow)	2		
How important is it for the organization that the system supports a specific technology, solution or platform? (The higher the score, the less important it is)	1		
How advanced are the integration requirements for the system? (The higher the score, the less advanced are the integration	2		

requirements)			
How strict are the internal regulations that the system needs to follow? (The higher the score the less strict are the internal regulations)	3		
How does the organization prefer their expenses? (The higher the score, the more inclination towards operational expenses rather than capital expenses)	1		
How important are high quality requirements for the system? (The higher the score, the less important are the requirements)	2		
		Total Score:	

If the weights for the aspects are changed, by the client company, the thresholds regarding the cloud computing suitability are changed. To adjust for this the top value should be changed to 6 times the sum of the weights to reflect higher than average values. Respectively, to reflect lower than average values the bottom value should be changed to 5 times the sum of the weights.

7 Application of Decision Model: Results

The results of the evaluation methods, interviews and discussions will be presented in the following chapter. These are the results of the decision model. Initially the results from the iSOAMM evaluation will be explained. This is followed by a section regarding Medius' requirements and needs containing the results from the scorecard, the functional requirements, and a strength/weaknesses evaluation.

7.1 iSOAMM Results

All the results from the iSOAMM analysis indicated that Medius, at their current state of their IT infrastructure, is in the very initial stages of a SOA implementation. In some aspects they do not fully qualify for the prerequisites regarding the first level. In those cases motivations, individual for each aspect, are presented to decide if the SOA maturity level is viewed as a 1 or as none at all. Each aspect and its achieved level are presented separately along with motivations.

Service Architecture. In few cases services has been used instead of an on-premise applications. These services are most likely, however, incompatible with each other since they cannot be used by more than one application and follows no present standards. Even if these services cannot be used by more than one application Medius are still viewed as at the first level of SOA maturity since the prerequisites, in all other major aspects are fulfilled. They do not, however, qualify for the second level of Service Architecture.

Infrastructure. The services used follow no common standards and have different communication systems. These services can therefore be seen as incompatible service islands. This indicates that Medius SOA maturity in the *infrastructure* aspect is at the first level.

Enterprise structure. The Medius organization is divided into several independent business departments, cooperating with each other. These are, however, not managed by separate IT sections. This makes the requirements unfulfilled for the first level in this aspect. SOA is therefore viewed as not present in the *enterprise structure.*

Service Development. Currently no SOA projects are developed within Medius and no structured process is present for any future SOA development. This lack of SOA projects being developed means that Medius' maturity cannot be viewed to be at the first level of SOA *service development.*

Governance. No recommendations or decisions from top management regarding SOA exist within Medius. The ambition to adopt its principles is although present but is purely view as an IT project. This fulfills the requirements regarding the first level of SOA *governance.*

Level 1: Trial SOA
Medius is currently achieving its first experience with SOA but has no top management involvement or any standards regarding how these services should be handled or developed. In most of the aspects the first, but no higher, level of SOA maturity is achieved. This indicates that the maturity level of Medius service level architecture is at the first overall level called *Trial SOA.*

7.2 Medius Requirements and Needs

7.2.1 Scorecard Results

The results of the scorecard showed that some systems would benefit from being run as cloud services instead of as on-premise resources. The most prominent result was that of the *backup* system which received a score of 152. This indicates that this system would clearly benefit from being run as a cloud service in this company. At the same time the *intranet* system was scored at 106, which is in the gap between suitable and not suitable but still low enough to not recommend a cloud computing solution.

The two systems aside from those suggested by Medius received very different scores. The conference tool, which is already run as a service, is used with varying demands and is not viewed as a mission critical system were indicated as suitable for a cloud service solution. Microsoft Dynamics AX, on the other hand, is to critical, have stringent compliance needs, have many integration requirements, and handles to much sensitive data to be suitable as a cloud computing solution.

It is interesting to point out that MS Dynamics AX received high scores on the two aspects that often are considered as the important reasons for adopting a cloud solution. With wildly varying, and growing, demand and cyclic frequency of use, the scalability of the cloud together with the pay as you go model should provide an ideal solution for this system. As shown in the section above, however, the system is to mission critical and has to large integration issues to be replaced with a cloud solution in its current state.

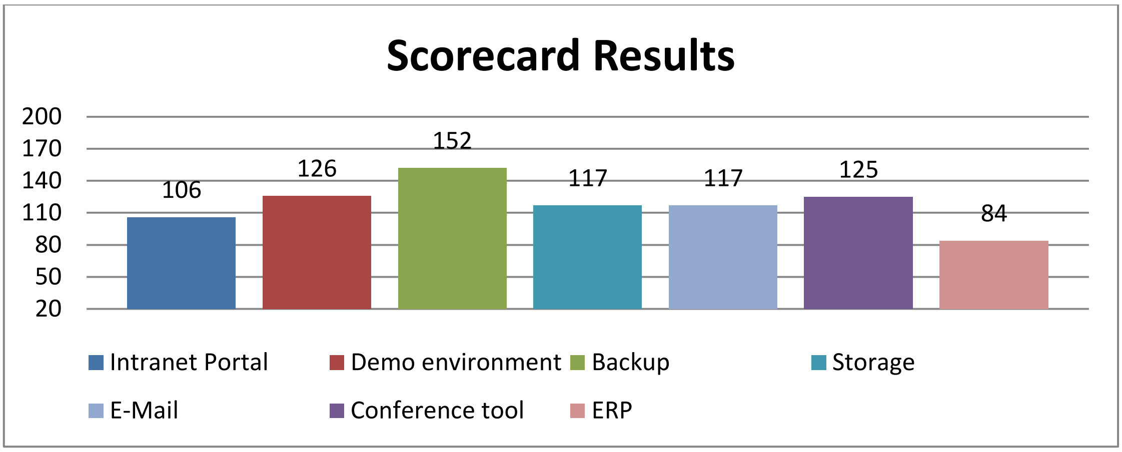

Figure 10
The outcome of the scorecard. Above 120 is viewed as a cloud computing suitability while a score below 100 is viewed as a suitability towards an on-premise solution.

The weights used in the scorecard were presented and agreed upon by Medius as relevant for their organization and its priorities. When presented with the outcome of the scorecard they also agreed on the relevance of the results.

7.2.2 Functional Requirements, Strengths and Weaknesses

The requirements discussion resulted in several functional requirements for each current system evaluated. These results are presented in their final state, by system type, below. Along with these requirements, the strengths and weaknesses of each system currently in use are presented. These strengths and weaknesses reflect only Medius' perception of their systems and are not influenced by academic arguments.

Backup.

Requirements:

- The system shall perform backup at least once a day, with the option to increase the frequency for individual systems.
- The system shall provide at least 14 days of data retention.
- The system shall be able to handle at least 3 TB of data.
- The system shall be able to back up at least 5GB per hour.
- The system shall be compatible with the following Microsoft products; Exchange, Microsoft SQL, SharePoint and Windows.
- The system shall support backup of; Databases, E-mail and common storage.

Strengths:

- Rapid backup and recovery.
- All data is kept within the organization.
  - Medius have full control of the system themselves.
  - No outside individuals have access to the backup data.
- No operational costs, aside from maintenance.

Weaknesses:

- No protection for on-premise disaster.
- Operational costs for maintenance.
- Incremental investments in extra storage space.
- Keeps IT personnel occupied with tasks not connected to increased business value.

Demo Environment.

Requirements:

- The system shall be accessible from outside of Medius.
- The system shall be able to run Medius software products.
- The system shall support multiple instances of the demo environment.

Strengths:

- Support for scenario customization.
- Offline accessibility.

Weaknesses:

- Demanding system requirements.
- Bandwidth intensive to distribute.

E-mail.
It is assumed that the system supports standard e-mail functionality.

Requirements:

- The system shall be compatible with Microsoft Outlook.
- The system shall be compatible with Active Directory (AD).
- The system shall support a mobile client.
- The system shall provide access through a web interface.
- The system shall provide at least 5 GB of mailbox storage space.

Strengths:

- No operational costs, aside from maintenance.
- All data is kept within the organization.
    - Medius have full control of the system themselves.

Weaknesses:

- No redundancy.
- High costs for upgrades.
- Not adjusted for Medius' current growth curve.

Storage.

Requirements:

- The system shall provide management of group access to files and folders
- The system shall be compatible with Active Directory (AD).
- The system shall support external access to files and folders.

Strengths:

- Rapid internal access.
- Non expensive.
- High adjustability.

Weaknesses:

- Incremental investments in extra storage space.
- Administration intensive.
- Several different storage options.
    - Complicated interfaces.
- Externally bandwidth intensive.
- Complicated external access.

Intranet.
Functional requirements were not collected since the scorecard indicated that the system was not suitable as a cloud computing supported system.

8 Analysis/Discussions

In this section the findings regarding the research questions will be discussed and presented. Each sub question will be discussed separately.

8.1 Software System Architecture Design

To integrate cloud services into an existing IT architecture some issues have to be overcome. Existing on-premise resources need to be able to communicate with the services. This means that a service interface is needed for their on-premise resources. Since services are self-contained with granular functionality companies may have to combine several services to achieve the desired functionality. This may result in additional adaptation costs to make the rest of the systems support the services.

In a traditional architecture, where the application architecture and the business architecture are connected with system dependencies, adapting to rapidly changing business scenarios may present difficulties. Changing needs in the business architecture may not be supported by the application architecture.

These are problems that can be reduced with a service oriented architecture. The loosely coupled and self-contained services in SOA can easily be combined to meet changing business needs. SOA also provides guidelines on changing the existing IT structure for integrating services, reducing otherwise needed adaptation costs.

Cloud computing is built upon the same type of services as used in SOA. This means that several of the advantages with SOA are also applicable to cloud computing. Some of these advantages, as presented by Cap Gemini and HP, are the enhanced accessibility, visibility, extensibility, matching expectations, and adherence to standards. To fully utilize the flexibility of cloud services the architecture needs to be equally flexible. This flexibility could be achieved by continuous evaluations and improvements to the organization's SOA maturity.

For Medius to fully take advantage of cloud computing they will have to introduce and enhance their service oriented architecture. The results from the iSOAMM analysis indicated that they are ranked on the first level in the maturity model. To increase their maturity they need to improve their work with the aspects in the model. Since Medius does not develop any software for their internal IT, however, the aspect *service development* does not need to be prioritized and is thereby not included in our recommendations.

8.1.1 Architectural Recommendations

Regarding the *service architecture* we recommend that they work with a standard for integrating services into their existing architecture, so that eventually they can implement a common API and reach the second level in the maturity model.

To further increase their overall maturity level Medius should improve the *infrastructure* aspect by implementing a communication protocol, i.e. a service bus, which all services can implement.

In their *enterprise structure* they need to work with dividing responsibility within the IT department for each enterprise department. This will mean that they have fulfilled all requirements for the first level of maturity in this aspect.

To enhance the SOA *governance* maturity Medius needs to implement enterprise-wide guidelines and standards on how to incorporate services into the service bus. SOA is thereby not something that only is of concern to the IT department.

8.2 Deciding Between On-Premise Resources and Cloud Computing Solutions

Economies of scale, where the relative value increases as the capacity and usage increases, argue against traditional on-premise installation and outsourcing. At the same time economies of skill, where value increases as the skill of the vendor increases, argue for letting a third party company manage the server resources. Together these two economies points to cloud computing as a suitable solution.

The strengths of cloud computing involves increased flexibility in the technical solution and payment model, robustness and availability, and security in size. As business requirements change cloud services make it easy to add, replace, and combine functionality to cope with these changes. The payment model for cloud computing solution is designed so that customers pay for the amount utilized. This payment model simplifies modification of the amount of resources provided to uphold robustness and availability to handle increasing and decreasing demands. A large cloud computing provider also has the monetary and technical resources to uphold a higher level of security than most small and medium sized companies.

At the same time, drawbacks concerning control of the system, dependencies, integration issues, and a larger target for security attacks exist with cloud computing. When a third party company handles systems used by a customer, the customer is dependent on the vendor to provide and manage the system according to the agreements. If the vendor choses to discontinue the service or goes bankrupt this dependency can become a problem for the customer. Also if data hosted by the vendor is involuntary changed the customer must rely on the vendor to investigate, restore, and address the problem. Simultaneously, large and well known vendors may be seen as more attractive targets for malicious security attacks, than would most small and medium sized companies. Therefore hosting a mission critical application as a cloud service may be problematic.

Another problem occurs with integration heavy applications. If changes are made by the vendor to a service used by an application, such as this, major additional adaption costs may occur. Adaptations like these may cause vendor lock-ins, where switching provider lead to extensive problems.

As there are both advantages and disadvantages with cloud computing in general, the process of deciding between an on-premise resource and a cloud computing solution will be unique for each system in each organization. To account for this we devised a scorecard with 10 consideration aspects. The scorecard is adjusted with weights for each aspect to account for the uniqueness in each organization. The scorecard is meant to be an indicator for the system hosting decision. However, because it is important that all aspects are considered, the user of the scorecard has to score each aspect with regards to the evaluated system.

We believe that this scorecard produces a relevant result because of the tight connection between the consideration aspects and the important aspects highlighted in the theoretical framework. Therefore, the scorecard may assist organizations in the decision process since decision makers have to consider and evaluate each of these aspects. This, along with the fact that Medius found the results interesting may suggest that it can assist similar organizations in their decision process.

8.3 Suggested Types of Cloud Services

The results of the scorecard indicated that the systems handling backup and the demo environment would be suitable to be run as cloud computing services. The systems handling storage and e-mail were scored close to suitable and therefore were also explored. In order to make a final decision regarding if a system should be run by a cloud service a complete requirements analysis and market survey needs to be performed. To show that the systems chosen by the scorecard could be run as cloud computing services the system’s functional requirements, strengths, and weaknesses were compared with offering from cloud computing vendors. This could be seen as an initial step to the investment process.

8.3.1 Suggested Alternatives

Backup. A backup system on Medius would have to support most Microsoft systems like Exchange, Microsoft SQL, SharePoint, and Windows Server. Additionally, it needs to be able to handle the company’s capacity and speed requirements. This could be solved by a cloud computing service like that of MozyPro (Decho 2010). This service uses both a local and an online backup to achieve this level of speed and capacity. A cloud solution like this would also provide protection for on-premise disasters and reduce operational costs for maintenance.

A downside would be that Medius would not have complete control of their data since it would be stored at a third party company. On the other hand the service allows the customer to choose which data to back up so that critical data can be kept within the organization. Another problem could be that uploading large amount of data could be taxing on the available bandwidth. A possible solution to this would be to upload large files during off-business hours, when the connection is not as heavily used.

Demo Environment. The system for hosting Medius’ demo environment first of all needs to be able to run Medius’ software products. It also needs to be accessible from the outside and handle multiple instances of the demo environment. A possible alternative would be to set up server instances on a service similar to Amazon EC2. This would give the accessibility needed and would drastically reduce the hardware requirements of the client computer. It would still be as customizable while eliminating the heavy distribution tax on the bandwidth. The drawback with this alternative is that it offers no offline access.

E-mail. For Medius it is very important that an e-mail system supports Microsoft Outlook and Active directory. Along with this it also has to support a web interface and mobile clients. A cloud computing service like Exchange Online offers all this along with 25GB of storage per user which is more than enough for Medius requirements. A cloud solution would also handle the weaknesses of their current system regarding redundancy, high upgrade costs, and adjustment to their steep growth curve. On the other hand Medius would lose the control of handling the e-mail service system. Critical information might therefore be handled by a third party company.

Storage. The system handling storage on Medius needs to be able to integrate with Active Directory and provide management of group access to files and folders. The system also needs to support remote access. This could be provided by the SaaS solution Box. Data would in this case be synchronized between both local and online locations, which mean that the rapid internal access and high adjustability remains. Stored data can then easily be shared and accessed both internally and externally. With this solution there is no need to invest in large amounts of extra storage. The downside and its solutions would in this case be the same as those regarding the backup service.

9 Conclusions

To answer the main research question a decision model was devised. This model takes into consideration; prerequisite software architecture, important evaluation aspects, and whether an alternative cloud computing service with similar functionality, as the current resource, exists.

- Since cloud computing offers the same kind of services as described in the SOA guidelines, the benefits of a service oriented architecture is also applicable to cloud computing. This means that introducing SOA into the organization and to continuously work with improving the SOA maturity is important to fully utilize cloud computing.

- The ten aspects evaluated in the scorecard are shown to be important to consider when assessing whether a system should be run as a cloud computing service or as an on-premise resource. This scorecard is meant to work as an indicator on the suitability of a system to be run as a service and to initiate discussions on the consideration aspects.

- To further ensure that a system can be replace by a cloud computing service a complete requirements analysis of the system and market survey needs to be performed. This is meant to provide a starting point prior to the investment process.

    - Another alternative is to perform a preliminary requirements analysis and market survey to assess whether the basic functionality exists as a cloud computing service. Strengths and weaknesses of the current solution could also be taken into account in the assessment to narrow the selection. A complete requirements analysis and market survey will still have to be made in the investment process.

These steps make up the parts in the decision model presented in this thesis. This decision model was tested on a small to medium sized IT consultant company with approved results. It is therefore possible that similar organization may benefit from the use of this decision model. While this initial test was perceived as successful further tests are needed to evaluate its relevance with regards to other types of companies.

9.1 Suggestions for Further Research

Since the decision model is tested on one single organization, further research and testing, of organizations of varying sizes and in different industries, is needed to examine its general relevance. Further, more research is needed on how to find the most appropriate cloud solution for a given organization and system. To strengthen this decision, additional research regarding the long term effects on organizations of adoption of cloud computing is needed.

10 References

Armbrust, M., A. Fox, et al. (2010). "A view of cloud computing." Commun. ACM **53**(4): 50-58.

Bennett, K., P. Layzell, et al. (2000). Service-Based Software: The Future for Flexible Software. Department of Computer Science, Department of Computation, Department of Computer Science, University of Durham, UMIST, Keele University**:** 8.

Björklund, M. and U. Paulsson (2003). Seminarieboken: att skriva, presentera och opponera. Lund, Studentliteratur.

Brodkin, J. (2008). "Gartner: Seven cloud-computing security risks." Network world: 2.

Buyya, R., C. S. Yeo, et al. (2008). Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities. Department of Computer Science and Software Engineering, The University of Melbourne.

Clarke, R. (2010). User Requirements for Cloud Computing Architecture. 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, IEEE Computer Society.

Decho (2010). MozyPro Online Backup for Businesses. MozyPro.

Demirkan, H., R. J. Kauffman, et al. (2008). "Service-oriented technology and management: Perspectives on research and practice for the coming decade." Electronic Commerce Research and Applications: 21.

Enquist, H. and G. Juell-Skielse (2010). Value Propositions in Service Oriented Business Models for ERP: Case Studies.

Erl, T. (2005). Service-Oriented Architecture: Concepts, Technology, and Design. Crawfordsville, Prentice Hall.

Friberg, D., K. Gyllander, et al. (2007). SOA- Tänk Före: Ett organisationsförberedande ramverk inför implementering av en tjänsteorienterad arkitektur. Institution for applied information technology. Göteborg, IT University of Göteborg. **Master**.

Ghosh, A. and I. Arce (2010). In Cloud Computing We Trust — But Should We? Computing Now, IEEE COMPUTER AND RELIABILITY SOCIETIES**:** 3.

GICTF (2010). Use Cases and Functional Requirements for Inter-Cloud Computing. G. I.-C. T. Forum. Tokyo, Keio University.

Johansson, K. (2011). Medius Servicemap. servicemap.vsd.

Kandukuri, B. R., V. R. Paturi, et al. (2009). Cloud Security Issues. Services Computing, 2009. SCC '09. IEEE International Conference on.

Leavitt, N. (2009). "Is Cloud Computing Really Ready For Prime Time?" IEEE Computer Society: 6.

Liegl, P. (2007). The Strategic Impact of Service Oriented Architectures. Engineering of Computer-Based Systems, 2007. ECBS '07. 14th Annual IEEE International Conference and Workshops on the.

Marston, S., Z. Li, et al. (2010). "Cloud Computing - The Business Perspective." ELSEVIER B.V.: 14.

MDSOL (2010). Cloud Computing - Driving Security, Performance and Quality, Medidata solutions worldwide.

Michael Armbrust, A. F., Rean Griffith, Anthony D. Joseph, Randy Katz, Andy Konwinski, Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica and Matei Zaharia (2010). "A View of Cloud Computing." Communications of the ACM.

Microsoft (2009). Microsoft Exchange Online - Data Sheet, Microsoft.

Mulholland, A., R. Daniels, et al. (2008). The Cloud and SOA: Creating an architecture for today and for the future, Cap Gemini.

Patel, P., A. Ranabahu, et al. (2009). Service Level Agreement in Cloud Computing. Knoesis Center, DA-IICT, Wright State University, Gandhinagar: 10.

Pattabhiram, C. and J. D'Anna (2010). "Integration: The critical Path to Cloud Computing." Cast Iron Systems: 9.

Rathfelder, C. and H. Groenda (2008). iSOAMM: An Independent SOA Maturity Model. 8th IFIP WG 6.1 international conference on distributed applications and interoperable systems, DIAS.

Runeson, P. and M. Höst (2008). "Guidelines for conducting and Reporting case study research in Software Engineering." Springer: 34.

Sanders, D. T., J. J. A. Hamilton, et al. (2008). Supporting a service-oriented architecture. Proceedings of the 2008 Spring simulation multiconference. Ottawa, Canada, Society for Computer Simulation International: 325-334.

Schadler, T. (2008). Talking to your CFO about cloud computing. Forrester.

Seltiskas, P. and W. Currie (2002). Evaluating the Application Service provider (ASP) Business Model: The Challenge of Integration. 35th Annual Hawaii International Conference on System Sciences. Hawaii, The Computer Society.

Sohlberg, P. and B.-M. Sohlberg (2002). Kunskapens former. Vetenskapsteori och forskningsmetod. Stockholm, Liber.

Staten, J., T. Schandler, et al. (2009). "Q&A: By2011, CIOs Must Answer The Question , "Why Not Run In The Cloud?"." Forrester: 11.

Wohlin, C., T. Gorschek, et al. (2006). "Technology and Knowledge Transfer in Practice - Requirements Engineering Process Improvement Implementation"." IEEE Software(November/December): pp. 88-95.

10.1 Websites and Company Reports

TeamDevCentral (2011). Retrieved 2011-04-19, from www.teamdevcentral.com.

VisionSolutions (2011). "Double-Take Recover Now." Retrieved 2011-04-19, from www.visionsolutions.com/Products/DT-BK.aspx.

Praktikgroup (2011). "Praktikgroup." Retrieved 2011-04-19, from www.paraktikgroup.com.

Kaufman, C. and R. Venkatapathy (2010). "Windows Azure Security Overview." Retrieved 2011-04-19, from www.microsoft.com/windowsazure/whitepapers/securityoverview/default.aspx.

GoGrid (2011). "GoGrid." Retrieved 2011-04-18, from www.gogrid.com.

Google-Apps (2011). "Google Apps for Business." Retrieved 2011-04-19, from www.google.com/apps/intl/en/business/.

Azure, W. (2011). "Windows Azure." Retrieved 2011-04-19, from www.microsoft.com/windowsazure/.

Amazon.com (2011). "Amazon Web Services (AWS)." Retrieved 2011-04-18, from www.aws.amazon.com.

Box (2011). Retrieved 2011-04-18, from www.box.net.

Johansson, K. (2011). Medius Servicemap. servicemap.vsd.

Medius (2009). Medius Annual Report 2009, Medius.

Microsoft (2009). Microsoft Exchange Online - Data Sheet, Microsoft.

11 Appendix

11.1 iSOAMM Interview

The interview was conducted in Swedish and is presented in is original state below.

Fråga 1:
En sak som vi tänkte på när vi diskuterade med vår handledare är hur moget Medius är för att ta in molntjänster som alternativ. Det innebär ju en viss omstrukturering. Han tipsade om något som heter iSOAMM, som är en Service Oriented Architecture Maturity Model. Den har 5 olika aspekter och 5 olika nivåer. Och så ser man på vilken nivå man står. Medius kanske inte kommer vara så högt på de nivåerna men det är intressant att se vad nästa steg kan vara. Men ni känner till SOA? Jobbar ni något med det?

Fråga 2:
Finns det några system som körs som tjänst just nu?

Fråga 3:
Finns det någon standardisering för hur man kommunicerar med applikationerna och tjänsterna?

Fråga 4:
Är IT-avdelningen uppdelad för de olika avdelningarna i företaget, där varje avdelnings system sköts av en speciell del av IT-avdelningen?

Fråga 5:
Utvecklar ni några egna tjänster för internt bruk?

Fråga 6:
Har ni övervägt SOA, och var kommer i så fall initiativet från? Är det från användare eller är det från ledningen.