CLOUD COMPUTING FRAMEWORK
A Framework to Evaluate Cloud Computing for IT Service Providers

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Abstract: Cloud Computing will be one of the most important technology triggers in the information technology for the next two to five years. Thus companies which provide IT solutions have to evaluate Cloud Computing in the context of their customer-driven IT projects. For this evaluation of Cloud Computing there is a need for a comprehensive framework to analyse the project scenario, the requirements of costumers and business scenario of the IT provider. Therefore this paper provides an approach of a comprehensive evaluation model of Cloud Computing for a prospective Cloud Computing provider and includes all necessary aspects of customer-driven IT projects.

1 INTRODUCTION

In the recent past the quality and utilization of Cloud Computing has rapidly increased. According to Gartner Research's Hypecyle of 2010 (Gartner Inc, 2010) Cloud Computing will be one of the most important technology triggers in the next two to five years. Thus for companies wanting to provide Cloud Computing services within their customer-driven projects it is a main interest to evaluate Cloud Computing for their own business model.

These companies have to compare the benefits, costs and risks of Cloud Computing in each IT project. Therefore they need a comprehensive evaluation framework which compares their current business model and the customer-driven IT projects with the requirements of Cloud Computing. In addition to these challenges in these IT projects is a need to estimate the profitability of Cloud Computing solution and compare it with the present project solution e.g., hosting services. Within the evaluation a prospective Cloud Computing provider has to include several aspects and requirements of the customer-driven IT projects and the present business model to make a decision, e.g., the risks undertaken or the fit to the business IT alignment. A proper framework will lead the management of a company according to their requirements to the most profitable decision and give an overview of the most expected costs, risks and business alignment of Cloud Computing within an IT project.

The main objective of this paper is to provide a framework to evaluate Cloud Computing in the context of a customer-driven IT project. This is motivated by the fact that all current frameworks in literature only provide some aspects of a comprehensive analysis for a prospective Cloud Computing provider.

This framework allows companies to specify their requirements of a customer IT project and to analyse and compare the IT project with different project solutions. This practical approach compares schematically the different solution scenarios and gives exact answers about costs, risks and security issues as well as profit.

2 LITERATURE REVIEW

With the rise of Cloud Computing several evaluation frameworks have been developed. Some of these are only partly suitable in a scenario of Cloud Computing and have a different focus in their evaluation. Therefore in the next section we point out some important analysis approaches and compare these with the requirements for a holistic Cloud Computing project.

2.1 Models for Cost Analysis in Cloud Computing

The decision model of Henneberger et al. (Henne-

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berger et al. 2010) offers the opportunity to make a valid decision for adopting Cloud Computing in strategic applications in three steps. Using this model a company is able to evaluate the risks and benefits for Cloud Computing in a specific scenario while selecting specific Cloud services. Kram (Kram, 2010) developed a framework, which leads a company in six steps to a detailed opportunity and risk analysis for different sourcing strategies. The framework identifies and measures the costs, benefits and risks for an analysis. In a concluding report different sourcing options are compared. The Cloud Computing ROI (return on investment) model of O'Neil and Dubowski (O'Neil, Dubowski, 2010) evaluates Cloud Computing in a specific business case. Therefore they identify the business critical demands and measure the influence of Cloud Computing and the ROI within a business case. Matros et al. (Matros, et al. 2009) provide a very formal model for a make-or-buy decision in the context of Cloud Computing. Within this model the costs for an on-premise solution are compared with the cost of an off-premise solution. The model considers the utilization of the resources but not the initial hardware cost. The evaluation model of Klems et al. (Klems, et al. (2009) provides an abstract approach to measuring Cloud Computing in a business case of a company. In the analysis costs and benefits of a reference model of different Cloud Computing scenarios can be compared.

Besides these models mentioned above there are other evaluation models which do not focus on Cloud Computing. However for the holistic approach of this paper they provide some relevant aspects. Therefore we point out some of these models. The IT sourcing model of Lacity et al. (Lacity, et al. 1996) compares different solutions of sourcing (e. g. Cloud Computing) and allows a company to detect the most promising solution for the strategic alignment of a company. The model of Martens et al. (Martens, et al. 2010) measures the level of maturity of Cloud services offered by companies. The model analyses the services offered hosted by a Cloud Computing provider. Dias de Assunção et al. (2009) developed an evaluation model to estimate different performance strategies in the context of the Cloud service IaaS (Infrastructure as a Service). The model of Kondo et al. for analysis (Kondo, et al. 2009) compares the cost benefits of Cloud Computing versus desktop grids. Both models, the one of Dias de Assunção et al. and the one of Kondo et al., allow companies to compare the different options within a specific business case. Opitz et al. (Opitz, et al. 2008) analyses in their model the specific cost structure inside Grid Computing. In this model all the costs of resources needed from different providers are evaluated.

The models of Friedrich (Friedrich, 2008), Koomey (Koomey, 2007), Yao (Yao, 2004), Chang (Chang 2010), Jayatilaka et al. (Jayatilaka, et al. 2003), Eren & Yates (Eren, Yates, 2010) or Xin et al. (Xin, Levina, 2008) can be seen analogically in the line of the models presented above and don't provide any new perception; therefore we won't focus on them any further.

2.2 Evaluation of cost analysis models

For a comprehensive analysis of Cloud Computing a service provider needs a framework which includes a lot of criteria. Besides costs, benefits and risks there are other important parameters like strategy, security and usability. The most important evaluation criteria are the view as a prospective service provider instead of the view of a customer and the option to compare different solutions within a business case. Table 1 shows an overview of the models presented and their included evaluation criteria.

Table 1: Evaluation of approaches in literature.

Evaluation model	Criteria							
	Costs	Benefits	Risks	Security	Strategy	Provider view	Usability	Business case
Henneberger et al.	✓	✓	✓				✓	✓*
Kram	✓	✓	✓		✓		✓	✓*
O'Neil and Dubowski	✓	✓			✓		✓	✓*
Matros et al.	✓						✓	✓
Klems et al.	✓	✓			✓			✓
Lacity et al.	✓	✓			✓		✓	✓
Martens et al.	✓*		✓				✓	✓
Dias de Assunção et al.		✓						✓
Kondo et al.	✓	✓					✓	✓
Opitz et al.	✓						✓	✓

*possible, but not part of the model

To get such an approach the models of Dias de Assunção and Martens are not completely suitable because the cost and benefit analysis is missing. The models of Henneberger, Kram and Martens only include a risk analysis of Cloud Computing, but no security analysis. The models of Kondo and Opitz are also not suitable for the required approach in this paper, because the evaluation of risks, security and strategy are missing.

The main concern within all models reviewed is the lack of security analysis and the evaluation view over all. A prospective Cloud Computing provider needs a framework with a specific view of Cloud

Computing. No reviewed model includes a view of a service provider; all models evaluate Cloud Computing from the point of the view of a Cloud Computing user.

Thus a new framework is necessary to offer a complete framework for evaluating Cloud Computing with all its aspects from a Cloud service provider view.

3 CLOUD COMPUTING FUNDAMENTALS

To develop a comprehensive framework several technical aspects about Cloud Computing are given.

3.1 Cloud Architecture

The Cloud Computing architecture is based on four layers, which are shown in figure 1.

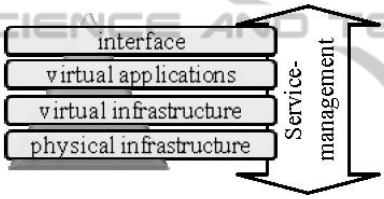

Figure 1: Cloud architecture.

The **physical infrastructure** (server, network and storage nodes) is the basis of Cloud Computing and part of a data center in general. They are connected to the internet and have their own security and failover concept. (Baun et al., 2010, p. 7; Dodani, 2009)

The **virtual infrastructure** provides the physical hardware within different virtual resources. Therefore several virtualisation manufacturers offer virtualisation solutions.

The **hypervisor of the virtual resources** supports several operating systems and applications. The user can install these applications in the virtual environment and use them directly as physical resources. (Baun et al., 2010, p. 25)

The access to the **Cloud environment** is possible via an interface. This interface can be a web browser or a specific Application Programming Interface (API). (Stanoevska-Slabeva, Wozniak, 2010, p. 50)

Over all architectural layers of Cloud Computing there is a need for **service management**. A provider needs specific business processes which provide automatic and dynamic resources. Basic services such as backup restore and lifecycle management are the main requirements for a functional model. (Dodani, 2009)

3.2 Cloud Services Models

To provide Cloud Computing within IT projects a provider has to use one of three fundamental types of Cloud service which based on the Cloud architecture shown in section 3.1 (Mell, Grance, 2009; Stanoevska-Slabeva, Wozniak, 2010, p. 47):

Software as a Service (SaaS): The provider delivers a complete infrastructure with preinstalled software and the user gains access over an API or web interface. Users can only use the software for their requirements and cannot change the configuration of the applications.

Platform as a Service (PaaS): The user gains access to a complete development environment and tools. The user is allowed to change the configuration of the applications (platform) but not of the basic infrastructure.

Infrastructure as a Service (IaaS): The user gets access to the complete virtual infrastructure of the provider and can install operating systems and applications to his demands. The user has the control over these applications but not over the basic hardware resources of the Cloud.

3.3 Cloud Deployment Models

In general there are different Cloud types to provide Cloud services within customer-driven projects. (Mell, Grance 2009; Stanoevska-Slabeva, Wozniak, 2010, p. 47)

A **Private Cloud** provides the Cloud infrastructure exclusively to one specific organisation. The Cloud can be managed by this organisation or third party and may exist on- or off-premise.

The **Community Cloud** is a Cloud infrastructure shared by several organisations and supports a specific community with equal concerns. Like the Private Cloud it can be managed by the organisation or third party and may exist on- or off-premise.

The **Public Cloud** provides the Cloud services to the general public and is managed by an organisation selling Cloud services.

The **Hybrid Cloud** combines two or more Clouds and provides a standardized or proprietary technology that enables data and application portability but remains a unique entity.

4 FRAMEWORK APPROACH

To evaluate Cloud Computing the following framework approach features a comprehensive model from the point of view of a Cloud Computing provider. The framework can be structured into the three phases business scenario, analysis and evaluation (see figure 2).

4.1 Overview

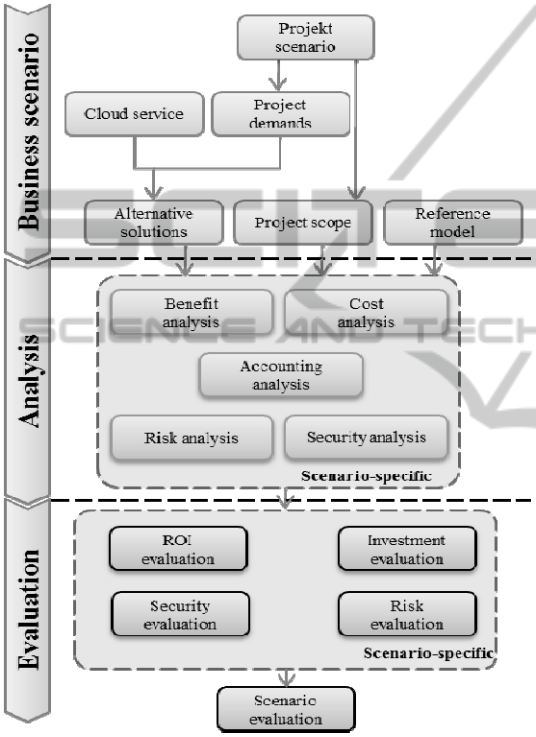

Figure 2: Overview of the framework to evaluate Cloud Computing.

4.2 Business Scenario

Within the business scenario all essential parameters to provide Cloud Computing are identified. Therefore the model of Klems et al. (Klems, et al. 2009) delivers basic ideas such as the definition of a reference model. The analysis of the project scenario, the project demands and the Cloud services delivered lead to the alternative solutions scenarios. Like within the models of Klems et al. (Klems, et al. 2009) and Matros et al. (Matros, et al. 2009) it is necessary to analyse the project relating to its demands in the context of the project scope and different solutions. To compare it with the previous project solution of the company the framework needs a defined reference model, like the hosting at the data center of the customer.

4.3 Analysis Phase

After setting the project scenario and scope there are several analyses necessary, e.g., benefit, cost, risk, security and accounting analysis, which are explained below. The final evaluations of the results are part of the next phase. The combination and enhancements of different analyses and approaches from the models of Henneberger et al. (Henneberger, et al. 2010), O'Neil et al. (O'Neil, Dubowski, 2010), Kram (Kram, 2010) and Klems et al. (Klems, et al. 2009) allow this comprehensive step.

Cost Analysis. In the cost analysis the cost of each alternative scenario in the complete project period are measured and summed up. Therefore table 2 shows possible cost drivers within a project period. The sum of all costs over the complete project period is the total cost for the respective alternative scenarios.

Table 2: Cost driver.

Cost driver	Amount
Hardware costs Server, network, infrastructure, maintenance	Complete project
Software costs Operating system, applications, database, maintenance	Complete project
Communication cost Delivery, utilisation	Project quota
Operational cost Power, cooling, fire security	Project quota
Administration costs Imputed rent, security, facility management, access control	Project quota
Personal cost Installation (hard-/software), migration, monitoring, assistance	Project quota
Development costs	Complete project
Training costs	Complete project
Support/Service	Project quota
General administration costs	Project quota
External costs Development, service	Complete project

Benefit Analysis. For each alternative scenario the expected benefit has to be identified. Therefore table 3 shows possible benefit categories for each scenario. For each category the benefit is identified and measured on a monetary basis.

Accounting Analysis. Additional to the benefit analysis the account analysis identifies und measures the accounting opportunities for the customer over the complete project period. Based on the project scenario there are three general types of location for the Cloud and possible accounting parameters. Table 4 shows possible parameters similar to the pricing system of the Amazon Elastic Compute Cloud (Amazon EC2) (Amazon 2010).

Table 3: Benefit analysis.

Benefit	Description
Processes	Improvements of current and new business processes (through standardisation or efficiency)
Finance	Reduction of investment costs
Product and service	Improvements of the product and service quality, competitive advantages
Relation to customer and supplier	Improvements in relation to customer and supplier , cost reduction through better connection

Table 4: Accounting analysis.

Cloud location	Accounting parameters
Customer	Maintenance (per period) Monitoring (per period) Support (per period)
Provider/ Third party	Processing power (per hour) Storage (per GB) Virtual server instances (per instance) Data transmission (per GB)

Risk Analysis. Every project or investment has its own risks and the according impact. With the risk analysis they are be identified and analysed. Therefore every risk and the incidence rate are calculated and the possible loss documented. Table 5 shows possible risk categories within an IT project.

Table 5: Risk analysis.

Risk category	Risks
Organisation	Changes in organisational structure or processes
Management	Lack of support by the management
Market	Dependence on third party, changes in market conditions
Project management	Lack of requirements, wrong project scope, budget or delays, lack of responsibilities or communications
Staff	Lack of know-how, shortage of staff
Technology	Delivery bottleneck, development problems
Customer	Cancellation of a contract, changes in requirements or project scope, insolvency

Security Analysis. In addition to the risk analysis a security analysis is also required. For each alternative scenario and through the specific contract with a customer all possible security issues (e. g. data privacy) have to be identified and documented.

4.4 Evaluation Phase

All identified parameters of the analysis phase are evaluated in this phase. With such an evaluation the management can assess the different solutions. The following approach is based on the models of Kram (Kram, 2010), Klems et al. (Klems, et al. 2009) and Lacity et al. (Lacity, et al. 1996) and continued.

Investment Evaluation. The investment evaluation helps companies to compare the total costs of each solution scenario over the complete project period. Therefore all costs of the cost analysis for each scenario (alternative or reference scenario) are summed up and compared.

ROI Evaluation. The ROI evaluation is the central evaluation of this framework. For each scenario the costs are summed up as total costs for the complete project period. These costs are the total cost of investment and the ratio to the sum of all monetary benefit. This ratio is the ROI of each solution. In this case the financial benefit is the combination of the results of the benefit and account analysis. This evaluation allows a conclusion of the used capital and its cash flow. The ROI evaluation gives an exact key figure for the profitability of each scenario and an ROI of more than 100 percent is cost-covering.

Risk Evaluation. The risks detected in risk analysis are compared with the incidence rate and the business influence into a rating table. According to their priority they are monetarily assessed. The framework provides an overview for each scenario with all risks and their financial business influence on the project and the company.

Security Evaluation. Like to the risk evaluation the security issues are ranked with their relevance and compared with a monetary value. The monetary values are the cost of security violations, sabotage or contract penalties.

Scenario Evaluation. The final evaluation is the comparison of the different solution scenarios and the reference model. All perceptions of the evaluation phase are summed up in the final step to lead the company management to the most profitable decision in a concrete IT project scenario.

5 CONCLUSIONS AND FURTHER STEPS

This approach provides a framework to evaluate Cloud Computing from the view of a company which wants to provide Cloud services to their customer. The framework is based on previous approaches from literature but enhances these with further Cloud Computing specific aspects e.g., a business IT alignment fit or data privacy. For an evaluation with the business model of an IT provider there are several analyses required e.g., a business strategy analysis.

Further steps for the development of this framework in practical use are:

The framework has to include analyses to measure the business alignment and strategic impact of each Cloud solution within the project scenario. This analysis can be part of a strategic phase and contains the identification of the business strategy and objectives of the IT provider. Beside this, the framework has to include detailed practical instructions and criteria for a company. In further steps this developed guideline helps IT provider to do the evaluation with a standardised approach to measure the value of Cloud Computing within a specific customer-driven project.

Finally the framework approach of this paper has to be evaluated in an actual business scenario with specific customer demands and business requirements. With the findings of this practical implementation of this framework the approach can be adjusted to the common business scenario of IT providers.

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