Decision Model for Selecting a Cloud Provider: A Study of Service Model Decision Priorities

Completed Research Paper

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ABSTRACT

This article describes a methodology to support the decision-making process for Cloud customers, using the Analytic Hierarchy Process (AHP). For this purpose, we present a decision model to select an appropriate Cloud provider. Despite its success in the industry, Cloud Computing still struggles with fulfilling customer expectations regarding provider characteristics. Due to limited transparency of existing Cloud providers, the evaluation and selection becomes a key issue. With the help of this decision model Cloud providers can be selected on the infrastructure, platform or application level. Subsequently, seven IT executives were interviewed and the decisions related to each level are discussed. Furthermore, differences and similarities between the infrastructure, platform and application levels are presented as most companies have similar requirements for basic systems and standard Cloud use cases. We enrich existing research on Cloud Computing adoption and present a systematic approach to assess Cloud providers and to apply a prioritization of selection criteria for all Cloud models.

Keywords

Cloud Computing, Cloud adoption, Decision model, AHP, Provider selection.

INTRODUCTION

Recently the number of Cloud Computing adopting companies has been rising. The increased flexibility and its simple provisioning model affect the decision process of the customer and have a lasting effect on the IT landscape (Koehler et al. 2010). While in its early state Cloud Computing was mainly technology-driven, the focus is now gradually shifting towards the business perspective (Hoberg et al. 2012; Son, Lee 2011; Iyer, Henderson 2010). Recent studies focus on company use cases mainly limited to non-critical or stand-alone business services, like sales automation or office applications (Marston et al. 2011). Others identify a strategic relevance and requirement of a comprehensive understanding of Cloud Computing as decision parameters (Martens et al. 2011; Kaisler et al. 2012). Nevertheless, also Cloud experienced companies are confronted with various conflicting decision criteria, which need to be compared among several alternatives using imprecise and incomplete information available (Saripalli, Pingali 2011; Martens et al. 2011). Due to limited transparency of existing Cloud providers, the evaluation and selection becomes a key issue (Godse, Mulik 2009; Hetzenecker et al. 2012). Furthermore, it is usually difficult to judge the quality of the services offered and to decide between various providers (Martens et al. 2011).

This paper intends to focus on the decision problem by investigating Cloud Computing from customers' perspective. Therefore, a decision model to select Cloud providers using the Analytic Hierarchy Process (AHP) is presented, which has proven to be an effective methodology for decision making support (Lee et al. 2012). Seven experts from three different companies were interviewed to prioritize relevant decision criteria for the service models Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The criteria are prioritized for service use cases non-critical (like back-office services or human resource applications) in order to ensure a universal validity, because most companies have similar requirements for such use cases (Iyer, Henderson 2012). Section 2 starts with the state of art regarding Cloud provider selection and Cloud Computing adoption. The next section describes the AHP methodology. The results regarding the decision priorities between the service models are presented and discussed in section 4. The last section summarizes the key findings and implications.

STATE OF THE ART CLOUD ADOPTION AND PROVIDER SELECTION

Adopting new technologies, such as Cloud Computing is a complex phenomenon with high ambiguity and a variety of opportunities and challenges (Luoma, Nyberg 2011). The adoption of cloud computing is affected by factors on both the client and provider side. Factors on the client side describe capabilities, processes, and resources which are essential for adoption. Specific IT capabilities, organizational readiness, or customer attitude towards cloud computing are some of them. The decision to adopt Cloud Computing is closely linked with the general consideration (Make-or-Buy decision) whether information and communication technology and services should be kept in the enterprise or be sourced from external providers (Leimeister et al. 2010). This decision process focuses on factors on the client side and represents the first Cloud adoption step. Subsequently, an appropriate provider need to be selected based on its capabilities (second adoption step). For instance, these factors can be the provider's reputation, promised service level agreements or the offered support (provider side factors). The key aspects relevant for the decision to adopt Cloud and select a provider are presented in Table 1.

Key Aspects	Perspective	Author(s)
Organizational capabilites, performance, relationship, deployment model and contract	Client	Janssen & Joha 2011
Strategic value, complexity, uncertainty, specificity, attitude (perceived benefits, risks), control	Client	Nuseibeh 2011
Competititve pressure, complexity, compatibility, technology readiness, firm size , and management support	Client	Low et al. 2011
Specificity, uncertainty, strategic value, inimitability, attitude, subjective norm	Client	Benlian et al. 2009
Announcements, attitude (perceived benefits, risks, expectations), organizational learning capacity, IT capabilities, competetive pressure	Client	Son & Lee 2011
Expectancy (effort, performance), social influence (subjective norm), infrastructural and organizational readiness	Client	Luoma & Nyberg 2011
Uncertainty, organizational readiness, IT capabilites, large user numbers, strategic value, cost of capital	Client	Xin & Levina 2008
Uncertainty (availability or resources), IT capabilities (efficiency), switching costs, organizational readiness	Client	Sarkar & Young 2011
Economic, compatibility, privacy, security, scalability, technology	Provider	Kaisler et al. 2012
Alignment, management & control, legal, deplyoment, financial, functional	Provider	Geczy et al. 2012
Suitability, economic value, control, usability, reliability, security	Provider	Saripalli & Pingali 2011
Economic, migration effort, performance (QoS, satisfaction), cost, security, data control, flexibility	Provider	Lee et al. 2012
Certificates, SLAs, scalability, interfaces, data centers, compliance, auditability, security, support	Provider	Martens et al. 2011
Reputation, pricing tariffs, support, migration effort, organizational readiness (required skills)	Provider	Koehler et al. 2010
Information security, performance & usability, legal & privacy & compliance, cost, support & cooperation, transparency & provider capabilites	Provider	Hetzenecker et al. 2012
Functionality, architecture, usability, reputation, cost	Provider	Godse & Mulik 2009

Table 1. Adoption and selection factors from two perspectives

Most research examining the adoption and the sourcing decision on client side are based on various theories (Xin, Levina 2008). Common theories are the Transaction Cost Theory, the Resource Theory, the Agency Theory or the Relationship Theory (Dibbern et al. 2004). Thus, the adoption of Cloud Computing is based on common sourcing theories. Decision aspects often taken into account and related to Cloud adoption are uncertainty, organizational readiness, and client attitude.

Unfortunately, empirical studies have not been able to provide consistent evidence regarding the effect of environmental uncertainty on firms' sourcing choices so far (Xin, Levina 2008). Hence, Cloud Computing decisions can be correlated both positively and negatively regarding environmental uncertainty. The environmental uncertainty for Cloud Computing is influenced by a non-transparent and large market, with a lack of legal clarity and no common understanding of Cloud Computing.

The organizational readiness of a company is related to its IT capabilities and is divided into three subsets: infrastructure, IT personnel and IT-related knowledge (Mata et al. 1995). The decision to adopt Cloud solutions does have a long-term and strategic impact due to changes in the governance and structure of IT in order to manage the new delivery models (Janssen, Joha 2011). The organizational readiness is positively correlated with the maturity of the enterprise architecture and the level of organizational IT capabilities (Son, Lee 2011; Zhu, Kraemer 2005). Due to an increased use of standardized infrastructure, business processes and data management, it is easier to integrate Cloud services and make use of best practices (Xin, Levina 2008).

Cloud Computing is a topic discussed controversially and separating IT managers in proponents and adversaries. The adoption decision may not always result from an evaluation and comparison of alternative sourcing options (Benlian et al. 2009). Furthermore, it can be influenced by third party (consulting, market researchers) opinions and other organizations (Benlian et al. 2009).

The adoption decision is followed by the provider selection as a subsequent step. A customer evaluates the provider based on defined requirements. This evaluation and selection process involves various parameters and can barely be solved with mere judgment or intuition (Godse, Mulik 2009). Existing literature focuses on this issue and provides several decision frameworks (see Saripalli, Pingali 2011; Godse, Mulik 2009; Lee et al. 2012) and selection criteria (see Hetzenecker et al. 2012; Kaisler et al. 2012; Geczy et al. 2012; Martens et al. 2011; Koehler et al. 2010) a customer can take into account. A consensus opinion among most researchers is that security and legal aspects, functionality coverage, economic factors (costs, prices) and abilities to interact with and manage the provider are relevant to make a vendor selection.

In general, security and reliability remain important issues for consumers and the relative novelty of Cloud Computing brings up a number of legal challenges (Koehler et al. 2010; Geczy et al. 2012). Additionally, when using Cloud services it is important to properly manage data between updates and backups and to make sure that the provider offers appropriate support (Hetzenecker et al. 2012). Nevertheless, when implementing Cloud Computing the cost efficiency is a relevant decision criterion to select a provider (Lee et al. 2012). The costs of Cloud services have to be compared to a traditional (internal) solution within the company and can result in considerable cost savings (Koehler et al. 2010).

AHP METHODOLOGY

Several methodologies for decision-making support exist, but AHP emerges as the most popular and prominent methodology due to its effectiveness and ease of use (Lee et al. 2012). For vendor selection problems the AHP approach is suggested by many researchers, mainly because of its inherent capability to handle quantitative and qualitative criteria (Tam, Tummala 2001; Narasimahn 1983; Nydick, Hill 1992; Partovi et al. 1990). Additionally, it can be easily applied and understood, and provides a systematical support to identify and prioritize relevant criteria. The AHP model was developed by Saaty in 1990 in order to solve multi-criteria decision problems and to provide a structured and systematical approach (Saaty 1990). When formulating the AHP model, the hierarchical structure can enable single or multiple persons to visualize the problem systematically in terms of relevant criteria and sub-criteria (Tam, Tummala 2001). The AHP modelling process involves four phases (see Figure 1). For this purpose, a complex problem is decomposed and modeled as a hierarchical structure, divided into sub-problems. Elements of this hierarchy can be divided into groups and are compared pairwise on each level of the hierarchy. The results will be translated into the corresponding pairwise comparison judgment matrices and the eigenvector with the highest eigenvalue is calculated.

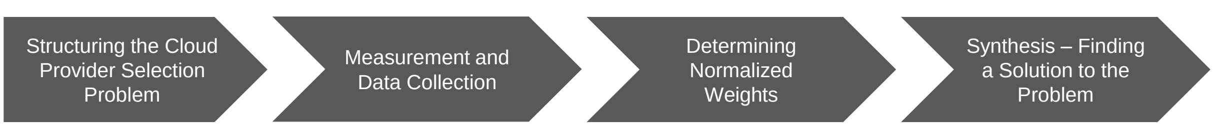

Figure 1. AHP modelling process involves four phases (Tummala, Wan 1994)

In order to structure the decision problem, the motivation (1^{st} level) is defined. Assigned to the motivation there are several target dimensions on the second level. Each target dimension is broken down into abstract requirements (3^{rd} level) and further evaluation criteria (4^{th} level). For the weighting of an element (criterion) all sub-criteria on the level below are compared pairwise, whereby the calculated importance behaves reciprocally. If element i is twice as important as element j, then element j is only half as important as element i. For reasons of complexity, more than seven elements per hierarchy level should be avoided. Then the column entries for each column sum c_i are added. The matrix is then normalized which involves that each entry (a_{ij}) is divided by the sum of its column (a_{ij} / c_i). The last step is to form the row sums from the normalized entries and divide these by the number of elements, resulting in the eigenvector. Using the AHP, decision makers can systematically determine the priorities of the criteria and are able to compare several providers effectively in order to select the best provider (Tam, Tummala 2001).

DECISION MODEL DESIGN FOR SELECTING CLOUD PROVIDERS

Structuring the Provider Selection Problem for Cloud Computing

In the scope of a pre-study, relevant criteria for a Cloud provider selection are identified. The research method was based on the design science paradigm (Hevner et al. 2004). A systematic literature review on Cloud adoption and provider selection is conducted. For the literature review the systematic approach of Webster and Watson (2002) is used, considering common IS databases (AIS Electronic Library, EBSCO, SpringerLink, Science Direct) and journals of the AIS ranking (Webster, Watson 2002). In total, 313 articles were identified, of which 55 could be assessed as relevant for the research question. Additionally, data from 60 IaaS providers, 82 PaaS providers and 651 SaaS providers was evaluated and available characteristics were gathered. The derived selection criteria were refined and evaluated using semi-structured interviews with cross-sectional business and IT representatives (provider, mediator and customer). The interviews with experts were structured and conducted referring to Glaeser and Laudel (2006) (Gläser, Laudel 2006). Two additional studies, each with 20-30 German executives and IT decision makers were conducted to examine the relevance of the target dimensions and the completeness of the criteria. Following the AHP approach, the criteria are structured hierarchically on four levels, containing six target dimensions, 21 abstract requirements and 62 evaluation criteria (see Table 2).

Selecting a Cloud provider is mainly influenced by six requirement perspectives on the customer side (target dimensions). Additionally, each target dimension can be linked to similar aspects of related research (see chapter 2). One perspective covers the functionality and performance of the Cloud service (“Scope and Performance”) (see also Saripalli, Pingali 2011; Lee et al. 2012; Godse, Mulik 2009; Geczy et al. 2012; Hetzenecker et al. 2012; Kaisler et al. 2012). Another perspective describes the ability to respond quickly to changing capacity requirements and competition pressure (“Flexibility”), see also (Lee et al. 2012; Kaisler et al. 2012). When a customer is migrating in-house services or infrastructure to a Cloud environment, its security must be assured (Che et al. 2011). Hence, everything related to protection and safety of the services and data is considered in the target dimension “IT Security and Compliance” (see also Saripalli, Pingali 2011; Lee et al. 2012; Martens et al. 2011; Hetzenecker et al. 2012; Geczy et al. 2012). The certainty that the service from the Cloud has a guaranteed availability and the provider fulfills the quality as promised is considered by the perspective of “Reliability and Trustworthiness” (see also Saripalli, Pingali 2011; Lee et al. 2012; Hetzenecker et al. 2012; Martens et al. 2011; Koehler et al. 2010; Godse, Mulik 2009). The costs for setting up and maintaining a Cloud can lead to favorable monetary aspects like small capital commitment or low acquisition costs (Lee et al. 2012). These economic benefits or challenges are represented by the perspective of “Costs” (see also Godse, Mulik 2009; Lee et al. 2012; Hetzenecker et al. 2012; Geczy et al. 2012; Kaisler et al. 2012; Saripalli, Pingali 2011; Koehler et al. 2010). The target dimension “Service & Cloud Management” includes aspects necessary for the Cloud management and the maintenance of the relationship between customer and provider (see also Kaisler et al. 2012; Geczy et al. 2012; Saripalli, Pingali 2011; Lee et al. 2012; Hetzenecker et al. 2012).

1. Level (Motivation)	2. Level (Target Dimension)	3. Level (Abstract Requirement)	4. Level (Evaluation Criteria)
Provider Selection Problem For Cloud Computing	Flexibility	Interoperability	Interfaces
			Internal Integration Degree
			Compatibility
			Transparency and Documentation
		Portability	Portability of Data
			Service Portability
		Delivery Model	Scalability
			Contract Flexibility
			Provisioning Time
			Set Up Time
		Automatization Degree	Automatic Resource Booking
			Contract Renewal
			Usage Limits
	Costs	Pricing Model	Price Transparency
			Price Granularity
			Price Stability
		Payment	Time of Payment
			Payment Method
		Service Charging	Volume Based Costs
			Account Based Costs
			Time Based Costs
			Booking Concept
	IT Security & Compliance	Data Center Protection	Building Safety (internal)
			Building Safety (external)
		Network Protection	Connection Opportunities
			Communication Security
		Operations Protection	Application Access (Identity Management)
			Application Protection
		IT Compliance	Data Center Location
			Data Protection
	Scope & Performance	Service Characteristics	Functionality
			Usability
			Service Bundles
			Customizability
			Operating Platform
			Add-On Services
		Service Optimizing	Maintenance / Service Cycles
			Continual Service Innovation
			Customer Recommendation
		Hardware [IaaS]	Server Type
			CPU Cores
			Additional Hardware Features
			Network Access
		Hardware Perfomance [IaaS]	Computing Quality
			Connection Quality
			Instance Capacity
	Reliability & Trustworthiness	Service Level Agreements	Availability
			Liability
			Resource Guarantee
		Reliability	Network Redundancy
			Data Center Redundancy
			Disaster Recovery Management
		Trustworthiness	Provider Profile
			Reporting
			Auditing
	Service & Cloud Management	Provider Relationship Management	Support
			Contact
			Internationality
		Service Management	Monitoring
			Operation and Controlling
		Transformation Management	Consulting Services
			Implementation Support

Table 2. AHP model for selecting a Cloud provider

The decision of selecting a Cloud provider depends on context specific customer requirements (e.g. project focus, use case). This includes the prioritization and weighting of decision parameters. For instance, due to unpredictable and large capacity variation for marketing related activities, the weighting of the scalability may be significantly different compared to the use case of IT provisioning for a PC workplace, with low scalability according to predictable number of employees and workplaces. Conversely, for the PC workplace use case, the portability would be more important than for a marketing campaign. However, unweighted criteria are independent of the use case and can be used as a general decision structure prior to the context-sensitive prioritization. In order to ensure a universal validity the measurement, including the prioritization, was conducted for standard and standard Cloud use cases.

Measurement and Data Collection

Basically, Cloud Computing consists of three service models: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Leimeister et al. 2010; Vaquero et al. 2009; Low et al. 2011). A company can either obtain complete software (SaaS) applications, programming platforms (PaaS) or only the necessary IT infrastructure (IaaS), depending on the depth of vertical integration. For all of these three levels a lot of positive success stories in practical communities exist. In the majority of cases companies obtain uncritical services and services which are not directly related to core business capabilities. Most companies have similar requirements for basic systems and stand-alone applications such as customer relationship management (CRM), human resource (HR) management or back office applications (Iyer, Henderson 2012; Marston et al. 2011). For instance, companies rather migrate stand-alone solutions (like CRM, HR) or general-purpose applications (like office, e-mail, collaboration technologies) into the Cloud than an interconnected business critical Enterprise Resource System (Benlian et al. 2009).

A total of seven IT executives from three different companies were asked to weight the criteria regarding a provider selection either for SaaS, PaaS or IaaS. The executives were selected based on their decision-making power, their knowledge in cloud computing and experience in the IT vendor selection. Additionally, the selection was influenced by the target dimensions and the specific IT landscape of the customer. In order to consider these differences, the setting is defined as follows. First, the Cloud service that should be implemented is not related directly to core competencies of the company. Second, the Cloud service can be a first time implementation or replace a legacy system or service. Last, the context in which the Cloud service is implemented (marketing, controlling, human resources etc.) is not examined in detail in this paper. Instead, general differences between the service models are collected and therefore, the weighting process considers the decision as universally valid as possible. To operationalize this context independency, the executives should consider several presented use cases (perspectives) and weight the criteria independently from one specific perspective. The results are seven rated comparison judgement matrices with at least two weightings for one service model. Based on the hierarchy structure of criteria a decision matrix for evaluation is formed in order to compare the criteria pairwise on each level. As suggested by Saaty, a nine-point rating scale is adopted and the priority weights of these nine scales are determined using pairwise comparisons (Saaty 1990).

Determining Normalized Weights

The geometric mean approach is used instead of the arithmetic approach, in order to consolidate the pairwise comparison judgment matrices for each Cloud model (Saaty 1990). These consolidated matrices (SaaS, PaaS, IaaS) are then translated into the corresponding largest eigenvalue problem, which is solved to find the normalized and unique priority weights for each criterion (Tam, Tummala 2001). In order to evaluate the coherence the *consistency ratio* (CR) is calculated. In order to determine the CR, the row vectors are multiplied by the priority vector, and divided by the eigenvector of the respective row, to get the maximum eigenvector (λmax). Starting from the maximum eigenvector, the *consistency index* (CI) can be calculated using the following formula, where "n" is the number of criteria:

$$CI = \frac{(\lambda \text{max - n})}{(n-1)} \tag{1}$$

Based on the CI the CR is derived, which is divided by the so-called *random consistency index* (RCI). In this paper, the calculated CR values for all comparison judgement matrices are below 0.08 and represent a consistent valuation by the experts. A random assignment of ratings can be considered if the CRs are above 0.10 (Saaty 1990; Coyle 2003).

Synthesis – Finding a Solution to the Problem

After calculating the normalized priority weights for each comparison judgement matrix of the AHP hierarchy, the next step is to synthesize the solution for the Cloud provider selection problem (Tam, Tummala 2001; Saaty 1990). Based on the hierarchy and the local preferences, the global priorities of the criteria are calculated from the weighted criteria. The ten most important criteria with the highest weights for each Cloud model are highlighted (see Table 3). Additionally, the unique characteristic for each service model is calculated based on the highest difference to the other models. By means of the global priorities, the relevant decision factors for each Cloud service model regarding a provider selection can be distinguished. This paper examines the decision priorities for highly standard non-critical use cases, which are mostly independent of the company's structure and requirements (e.g. staff training, software testing, back office applications, standard HR services).

Generally speaking, the decision-making process for the selection of a Cloud provider is shaped by different factors. Regardless of the Cloud model providers are selected particularly with respect to the existing price transparency. Less important are reliability and trustworthiness. For enterprises this dimension is often difficult to assess and to obtain reliable information from the provider (Martens et al. 2011). Additionally, a failure of the provisioned Cloud service is expected as a prerequisite and therefore considered only slightly important as a decision factor. Especially, SaaS providers are rarely selected for their reliability, whereas IaaS providers should consider having at least a second (redundant) data center.

Furthermore, IT security and IT compliance are considered as critical for the decision (Subashini, Kavitha 2011). At lower Cloud models (IaaS and PaaS) the customer has more possibilities to control and monitor the Cloud services. In this context, corporate policies and structural requirements have to be considered, especially in relation to network safety and data protection. Decisions regarding the IT infrastructure are largely affected by the IT departments, which usually prioritize IT security and data protection higher than the business units. The decisions related to SaaS may be initiated by business units or management and therefore be less affine to security risks.

Cloud Computing enables a demand-driven access to IT resources. Companies can benefit from a high degree of flexibility. Accordingly, they usually pursue this goal in Cloud Computing (Armbrust et al. 2009; Rawal 2011). However, as evaluated by IT executives, flexibility is rated low and is not that important for provider selection. Flexibility benefits, due to short contract agreements and on-demand provisioning, are common sense within Cloud Computing and may have a decreasing effect on the decision significance. More important, particularly for IaaS providers, are the capabilities of automatic resource allocation (automatic resource booking). SaaS providers as well should consider offering adequate data transfer opportunities (portability of data).

The pricing model is considered relevant for all three service models within Cloud Computing. Especially for IaaS and PaaS a high pricing differentiation is important due to the high level of standardization of these services (Commodity services). The pricing model directly influences the cost saving potential of the IT department. For this reason, granularity, stability and transparency of the prices are necessary to estimate cost savings. For the PaaS service model volume based service charging and usage-dependent booking are named as relevant.

Target Dimension	Abstract Requirement	Evaluation Criteria (Sub-criteria)	Global Weights IaaS	Global Weights PaaS	Global Weights SaaS	Unique-ness of IaaS	Unique-ness of PaaS	Unique-ness of SaaS
Flexibility	Interoperability	Interfaces	0.008	0.009	0.027	0.020	0.019	0.037
		Internal Integration Degree	0.007	0.014	0.012	0.013	0.009	0.007
		Compatibility	0.009	0.018	0.012	0.013	0.016	0.009
		Transparency and Documentation	0.012	0.025	0.020	0.020	0.017	0.012
	Portability	Portability of Data	0.008	0.009	**0.034**	0.026	0.026	0.051
		Service Portability	0.008	0.003	0.012	0.009	0.013	0.013
	Delivery Model	Scalability	0.026	0.011	0.012	0.030	0.016	0.015
		Contract Flexibility	0.009	0.016	0.014	0.012	0.008	0.007
		Provisioning Time	0.026	0.008	0.008	0.037	0.020	0.019
		Set Up Time	0.013	0.006	0.009	0.011	0.010	0.007
	Automatization Degree	Automatic Resource Booking	**0.040**	0.009	0.010	0.063	0.033	0.032
		Contract Renewal	0.009	0.004	0.003	0.011	0.006	0.007
		Usage Limits	0.013	0.007	0.005	0.014	0.008	0.009
Costs	Pricing Model	Price Transparency	**0.045**	**0.083**	**0.032**	0.051	0.089	0.065
		Price Granularity	**0.028**	**0.069**	0.016	0.054	0.095	0.066
		Price Stability	**0.058**	**0.029**	0.013	**0.073**	0.044	0.060
	Payment	Time of Payment	0.009	0.020	0.013	0.015	0.017	0.011
		Payment Method	0.009	0.011	0.026	0.019	0.017	0.032
	Service Charging	Volume Based Costs	0.015	**0.037**	0.012	0.026	0.048	0.029
		Account Based Costs	0.007	0.022	0.003	0.019	0.033	0.024
		Time Based Costs	0.006	0.017	0.003	0.014	0.025	0.018
		Booking Concept	0.007	**0.029**	0.009	0.023	0.042	0.022
IT Security & Compliance	Data Center Protection	Building Safety (internal) (e.g. fire protection)	**0.039**	0.024	**0.038**	0.017	0.029	0.015
		Building Safety (external) (e.g. area access)	0.027	0.007	0.009	0.038	0.023	0.020
	Network Protection	Connection Opportunities	**0.043**	**0.027**	0.025	0.034	0.018	0.020
		Communication Security	0.024	**0.027**	0.014	0.012	0.015	0.022
	Operations Protection	Application Access (Identity Mngt.)	0.019	**0.046**	0.026	0.033	0.046	0.026
		Application Protection	0.025	0.020	0.015	0.013	0.009	0.014
	IT Compliance	Data Center Location	**0.040**	**0.052**	0.023	0.029	0.041	0.047
		Data Protection	0.023	**0.074**	0.019	0.055	**0.105**	0.060
Scope & Performance	Service Characteristics	Functionality	0.011	0.014	**0.055**	0.047	0.044	0.085
		Usability	0.006	0.019	0.022	0.029	0.016	0.019
		Service Bundles	0.003	0.012	**0.028**	0.032	0.024	0.040
		Customizability	0.003	0.008	0.015	0.016	0.012	0.020
		Operating Platform	0.002	0.002	0.015	0.013	0.013	0.026
		Add-On Services	0.002	0.003	0.012	0.010	0.009	0.018
	Service Optimizing	Maintenance / Service Cycles	0.011	0.018	**0.073**	0.070	0.062	**0.116**
		Continual Service Innovation	0.010	**0.027**	**0.043**	0.050	0.033	0.050
		Customer Recommendation	0.005	0.013	**0.032**	0.035	0.027	0.045
	Hardware [IaaS]	Server Type	0.011	-	-	-	-	-
		Processor Type	0.006	-	-	-	-	-
		Additional Hardware Features	0.010	-	-	-	-	-
		Network Access	0.014	-	-	-	-	-
	Hardware Perfomance [IaaS]	Computing Quality	0.026	-	-	-	-	-
		Connection Quality	**0.032**	-	-	-	-	-
		Instance Capacity	**0.032**	-	-	-	-	-
Reliability & Trustworthiness	Service Level Agreements	Availability	0.015	0.015	0.013	0.003	0.002	0.003
		Guarantees	0.006	0.003	0.012	0.009	0.011	0.015
		Liability (e.g. compensation)	0.008	0.005	0.012	0.007	0.009	0.011
	Reliability	Network Redundancy	0.015	0.007	0.023	0.015	0.023	0.023
		Data Center Redundancy	**0.028**	0.010	0.017	0.029	0.025	0.018
		Disaster Recovery Mngt.	0.009	0.014	0.013	0.008	0.006	0.005
	Trustworthiness	Provider Profile	0.025	0.014	0.003	0.032	0.022	0.033
		Reporting	0.020	0.014	0.006	0.021	0.014	0.023
		Auditing	0.014	0.014	0.010	0.005	0.004	0.008
Service & Cloud Management	Provider Relationship Mngt.	Support	0.021	0.022	0.020	0.002	0.002	0.003
		Contact	0.012	0.005	0.006	0.014	0.008	0.007
		Internationality	0.005	0.007	0.007	0.004	0.002	0.003
	Service Management	Monitoring	0.012	0.010	**0.032**	0.022	0.024	0.042
		Operation and Controlling	0.004	0.007	**0.032**	0.030	0.028	0.053
	Transformation Management	Consulting Services	0.004	0.003	0.019	0.016	0.017	0.032
		Implementation Support	0.003	0.005	0.008	0.007	0.005	0.008
		Total	1.000	1.000	1.000			

Table 3. Composite priority weights for critical decision factors per Cloud service model

The supplier selection for SaaS is largely determined by the scope of services and the performance (Benlian et al. 2009). Companies may benefit from innovations of the provider through an external purchase of SaaS. Otherwise, long maintenance cycles resulting in long downtimes are feared. For SaaS the IT executives assessed the optimization of the Cloud service and its functionality as essential, whereas the performance capacities (e. g. maximum memory of a virtual instance) and the transfer volumes are important for IaaS.

Providers of IaaS and PaaS are selected based on many similar criteria. For both models, the IT executives weighted the Service and Cloud Management as insignificant. In contrast, the service management takes a key role for SaaS. Especially, for the efficient use of SaaS, it is important to measure and control the services (Mell, Grance 2011). For this reason, monitoring and control options of a SaaS solution are prioritized higher than other criteria.

CONCLUSION

The presented AHP approach can be used to compare Cloud providers on all three service models, supporting teams or individuals in their decision process. In order to examine general priorities for decisions related to each Cloud model, standardized Cloud services are selected, which are mostly company-independent. Hence, the executives are asked to prioritize the criteria using the AHP approach for common or non-critical processes/services such as human resource management or sales force automation. Infrastructure resources (IaaS) are used to provide a testing environment or conducting a marketing campaign. Key priorities are a high price transparency and -stability, the possibility to use appropriate communication channels and the location of data. On the PaaS level, the price transparency, convenient encryption methods and adequate price granularity are considered as very relevant. The prioritized selection criteria for SaaS providers differ significantly from the other models. The IT executives assessed the functionality and a continuous service improvement and optimization as highly relevant.

Implications for science and research: For researchers we enrich existing research on Cloud Computing adoption, especially regarding the provider selection. This article presents general priorities for all three Cloud models related to standard services. The decision priorities are differentiated by the Cloud models. Nevertheless, it still has to be taken into consideration that the prioritization is dependent on whether an Office service or an ERP system is selected. For instance, it is crucial for which purpose a virtual instance of Amazon Web Service (AWS) is used for. The requirements for this virtual instance and the decision parameters are dependent on the applications and use cases. Accordingly, the criteria for selection can only be prioritized individually for a company or even just for a project.

Implications for business practice: As a practical contribution we developed a systematic approach to assess Cloud providers and apply a prioritization of selection criteria for all Cloud service models. Key criteria are price stability for the infrastructure level, data protection on the platform level and service maintenance on the application level. AHP implies a huge effort of paired comparisons, when a large number of criteria are considered. Also experts for this comparison are needed who are familiar with these services and providers in order to accurately make an evaluation. But for practitioners the decision-making can be enhanced by this systematic AHP approach and the defined set of criteria. On customer side the selection can be conducted more precisely and on provider side the service portfolio can be configured based on the criteria priorities.

Limitations: The decision priorities are differentiated by the cloud levels. Nevertheless, it still has to be taken into consideration that the prioritization depends on the service use case. Accordingly, the criteria for selection can only be prioritized individually for a company or even just for a project. The priorities for cloud services depend on experts input. However, the selection criteria can be used in general decision problems regarding a provider comparison. A minor shortcoming of AHP is the time-consuming process of paired comparisons, when a large number of criteria is considered. The use of a rating scale can prevent these efforts as each decision-maker can assign a rating to a provider's system avoiding pairwise comparison judgments (Liberatore 1989).

The overall outcome of the relationship between customer and provider depends not just on selecting a good provider, but also on various other decisions after the selection is made (contract design, or vendor relationship management). The non-transparent market and a missing provider database impede a provider comparison due to missing information. The correlation between the transparency of a provider and provider selection is rarely examined so far.

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