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DESIGN AND IMPLEMENTATION OF A COMMUNITY PLATFORM FOR THE EVALUATION AND SELECTION OF CLOUD COMPUTING SERVICES: A MARKET ANALYSIS

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Research-in-Progress

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Abstract

The large number of available Cloud Computing Services makes it hard for companies to keep an overview of the market and to identify the services that best fit their needs. Also, the search for the most suitable Cloud Computing Services often takes too much time and money. The community platform presented in this article was designed to assist companies and users in solving this problem by enabling them to identify relevant Cloud Computing Services. Furthermore, users have the option of evaluating individual services and get access to the evaluations submitted to the community platform by other users. The paper describes the design and the prototypical implementation of the platform and introduces a maturity model for the quality assessment of Cloud Computing Services listed in the platform's underlying database. The authors also provide recommendations for further action based on a first analysis of the market situation. Our research can be characterized as a design-oriented research approach that focuses on the design of IT artifacts (i.e. community platform and underlying maturity model). Both IT artifacts are evaluated by means of expert interviews and by users giving us feedback when testing our community platform.

Keywords: Cloud Computing, Cloud Computing Services, Maturity Model, Community Platform

1 Cloud Computing – Market Situation

Companies implement Cloud Computing Services in order to reduce the costs incurred by their IT infrastructure and to increase its flexibility at the same time. Therefore, Cloud Computing has been a hot topic for practitioners during the past few years (Martens et al., 2011). The most important distinctive features of Cloud Computing are: scalability, the use of virtualization technologies, pay-per-use payment models and the use of the internet as transmission medium (Leimeister et al., 2010). The business model of Amazon Web Services has had a strong impact on the development of Cloud Computing Services since 2006. At the beginning, the discussion concentrated on aspects of technical implementation, as e. g. virtualization, scaling, Grid Computing and service-oriented architectures (Mei et al., 2008). Meanwhile, the focus of the debate has shifted towards the field of security and data protection, for the utilization of Cloud Computing Services in a business context requires a high security level (Weinhardt et al., 2009). There is also a growing interest in added value activities (like consulting services, for example) (Leimeister et al., 2010). Cloud Computing Services may be categorized according to the different service models, as e. g. Software, Platform and Infrastructure as a Service (SaaS, PaaS, IaaS) (Youseff et al., 2008). Therefore, the service types may divide the clustering of the Cloud Computing meta-market (Pring et al., 2009). Due to the rapid development of Cloud Computing technology the number of available Cloud Computing Services has grown very fast during the last couple of years. Potential users need to conduct intense research to gain an overview of the providers of a particular service type, which is further complicated by the inconsistent naming of the services. For example, the provision of data storage capacity is both described as "Storage Service" and as "Data-Storage-as-a-Service" (Youseff et al., 2008; Weinhardt et al., 2009). Furthermore, it is usually impossible to judge the quality of the offered services. At present, a comprehensive evaluation of service providers that accounts for all aspects mentioned above is only possible on the basis of information given by the providers themselves.

2 Systematic Literature Review

To rely on the current state of the art, we conducted a systematic literature review to reveal the market requirements for the implementation of a platform for selecting and evaluating Cloud Computing Services (http://www.uwi.uni-osnabrueck.de/martens/2011_ECIS_Literature_Review.pdf). Heinle and Strebel (2010) state, that with every sourcing decision the problem of the selection of an appropriate vendor or, as it is the case in Cloud Computing, an appropriate Cloud Computing Service arises. Based on the literature review we defined Cloud Computing Services by means of a morphological box and characterized a service with the help of selected criteria to create a foundation for the platform's underlying Entity Relationship Model (ERM). Both the morphological box and the ERM were developed on the basis of a systematic literature review and iteratively improved through information gained in expert interviews. The interviewed experts have previous experience with Cloud Computing and come from IT consulting firms whose main customers are small and medium-sized companies. Table 1 illustrates the morphological box which contains the most important characteristics of Cloud Computing Services. These distinctive features occur as entities and attributes in the platform's database. During the identification of a particular Cloud Computing Service the parameters may sometimes take on several different values: for example, Cloud Computing Services can be scalable both horizontally (e.g. creation of a new service through the combination of an IaaS and a PaaS) and vertically (e. g. option of obtaining additional storage capacity). Both the results of the literature review and information gained in expert interviews emphasize the importance of decision support in selecting Cloud Computing Services (Heinle and Strebel, 2010) and the need for an internet platform that provides an overview of the Cloud Computing market situation. To the best of our knowledge, we did not find an internet database which supports companies by means of decision support in Cloud Computing.

Characteristic	Value										
Type of Cloud	Public Cloud			Private Cloud			Hybrid Cloud			Community Cloud	
Business Focus	Collabo-ration	Content Mngt.	Office	CRM	HR	BI	ERP	SCM	Manufac-turing	Engine-ering	IT
Service Category	Infrastructure as a Service			Platform as a Service			Applications				
	Storage		Computing	Business		Development	Software as a Service		On-demand Web Services		
Contract Model	Fixed Rate			Pay per Use			Licensing		Spot Market		
Billing Metric	Data Transfer			Used Storage Capacity			Computing Hour		Number of Users		
Configuration	Storage Capacity			Number and Type of Processors			Network Connection		Software/Operating System		
# of Providers	One						More than one				
Scalability	Vertical Scalability						Horizontal Scalability				

Table 1. Morphological Box (cf. Mei et al., 2008; Benlian et al., 2009; Weinhardt et al., 2009).

3 The Platform's Underlying Database and Maturity Model

Database Model: The ERM (cf. Figures 1 and 2) shows the main database tables and provides a (simplified) illustration of the platform's database by using a min/max notation. For reasons of clarity and comprehensibility, the model is split in two parts. Figure 1 shows the entity clusters "technical implementation", "maturity model", "Service Level Agreements" (SLA) and other characteristic features of Cloud Computing Services. The central table "Cloud Computing Services" contains basic product information such as the service and vendor name, website, publication date or current status of the service (for example, "open beta version" or "fully implemented"). We did not include the current price of a Cloud Computing Service, since volatile market development and heterogeneous pricing models. The cluster "maturity model" was also implemented in the database. In this way, users are enabled to judge each service's level of maturity and gain a clearer picture of its quality. So far, a general maturity model for Cloud Computing Services has been implemented, which provides a basis for the integration of further maturity models (cf. section 3).

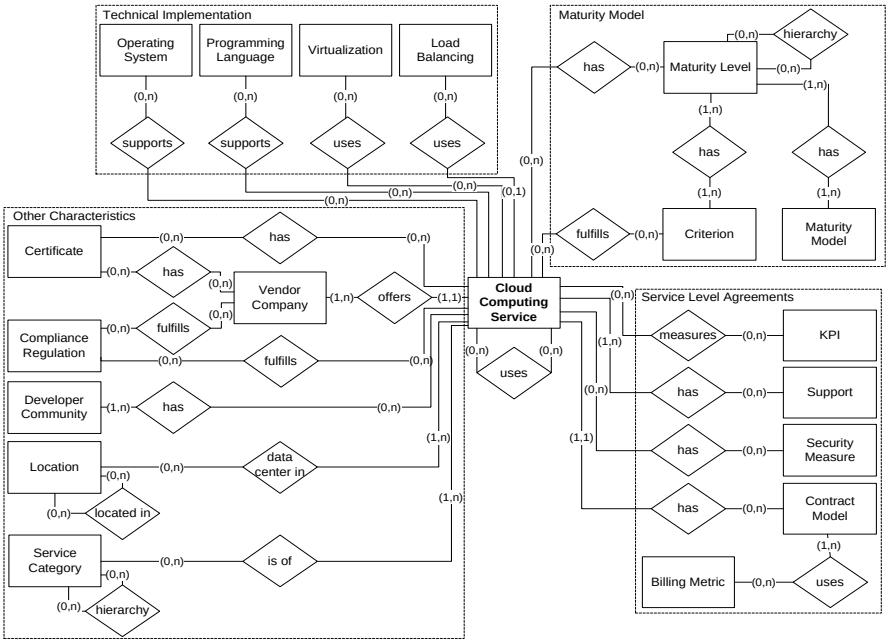

Figure 1. ERM for Cloud Computing Services

Also, it seems reasonable to extend the database by integrating maturity models for the different service categories. In view of existing compliance regulations it is necessary to know the location of the data center. Therefore, the database contains the entity "location" which makes it possible to model a hierarchy of locations: for example, San Francisco is located in California, which in turn is

part of the United States. Within the database, similar hierarchies exist for service categories, maturity levels and the Cloud Computing Services themselves.

Apart from integrating the support services offered by the service providers in the database, it is also possible to enter information on existing communities of developers who give advice to other developers and users via websites or online exchange forums. Considering that issues of privacy and data protection are of particular relevance for Cloud Computing (Martens et al., 2011), security measures can also be recorded in the database to protect the stored data and applications. The evaluation of Cloud Computing Services is illustrated in Figure 2. Users can register anonymously and can evaluate services and providers. To improve the evaluation quality and address the problem of the evaluation reliability, other users can comment on evaluations and statements. Evaluations can be made in short form (written comment) or in the form of a comprehensive review (written comment and rating). Users who choose the latter form may evaluate services or providers in the following categories: Support/communication with the user, Scalability, Flexibility of the SLAs, Interfaces, Monitoring, Cost overview. In this way the users themselves generate and extend the content of the community platform, which are also meant to provide a solid basis for decision makers.

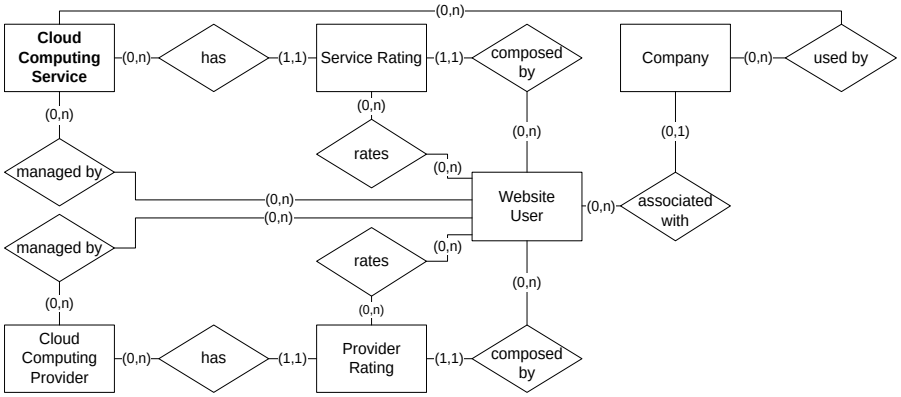

Figure 2. ERM of the Service Rating

Maturity Model for the Evaluation of Cloud Computing Services: Often, the quality (or maturity, respectively) of a Cloud Computing Service can only be assessed by conducting intense online research or by exchanging experiences with customers. The Cloud Computing Service Maturity Model introduced here is part of the platform's database model (cf. Fig. 1) and determines the maturity degree of Cloud Computing Services on the basis of the information stored in the underlying database. In this way, users are enabled to evaluate the quality of a service without further time-consuming research. The model serves to determine in how far the maturity object (i.e. Cloud Computing Service) meets the quality requirements defined for each degree of maturity (Becker et al., 2009). The degree of compliance with these requirements is measured by means of specific criteria listed in Table 2. It should be noted that the maturity model can be applied to all types of Cloud Computing Services. In contrast, most companies use maturity models to assess the maturity of their internal IT infrastructure in preparation for the implementation of Cloud Computing Services (e.g. GTSI 2009). In constructing the maturity model we followed the recommendations and the procedural model by Becker et al. (2009), developing the model on the basis of the results of our literature review and improving it with the help of expert interviews. The numerical value describing the maturity of a service is calculated on the basis of the weighted arithmetic average. It can be filled in by the users of our platform and published by administrators. The last column of the table contains an example of the evaluation of the Amazon Web Service (AWS) Elastic Compute Cloud (EC2), which has an average maturity degree of 3.7 (not weighted). Service providers receive a clearer picture of their position on market, since the model allows for direct comparison with competitors (external benchmarking). The degree of maturity can be determined by means of the following formula, with ML_i equaling the maturity degree of criterion i, n equaling the total number of criteria and WF_i equaling the weighting factor for criteria i:

$$\sum_{i=1}^{n=9} (ML_i * WF_i) / n$$

Degree of Maturity	1. Initial	2. Acceptable	3. Industry Standard	4. High Standard	5. High Quality	*Example: AWS EC2*
Certificates	None	1 certificate recognized through-out the branch	1 high-value certificate	2 high-value certificates	≥ 3 high-value certificates	*ISO 27001, SAS 70 Type II [4]*
SLAs	Rudimentary SLAs exist	SLAs with predefined, fixed KPIs	SLAs with predefined, partly fixed KPIs; KPIs can be monitored directly	SLAs with recommended, exchangeable KPIs	Measuring methods are individually negotiable and adaptable	*Predefined SLA [2]*
Scalability	Non-scalable, peak load oriented	Scaling via third party providers (may result in reduction of quality)	Manual scaling after renegotiation due to hardware extensions	Automatic scaling with prior notification of peak loads forthcoming	Automatic scaling and configuration, periodic monitoring of peak loads	*Manual Scalability, Auto Scaling [5]*
Interfaces	Specific interfaces of the service provider	Specific interfaces of the service provider with high standardization	Open interfaces that can be easily modified	easy to integrate and high interoperability interfaces (meet the branch standards); example code provided; high number of developer forums	After basic parameters have been entered, each service can be implemented automatically	*Standardized interfaces (branch standard;, example code; developer forums [4]*
Data Centers	One single data center	2 data centers without backup functionality	2 data centers (reciprocal backup); limited availability in case of failure; monthly backup	2 data centers with reciprocal backup and full resource availability in case of failure, weekly backup	Several computer centers, for each of which there is one backup computer center; daily backup	*4 data centers; no automatic backups; manual backup possible [3]*
Compliance	Compliance not tested	Limited compliance for data processing	Compliance for data storage in one area of application	Compliance for data storage in several areas of application	Full compliance for data processing	*e. g. HIPAA, PCI DSS Level 1 [4]*
Auditability (SAS 70 I+II, IDW PS 951)	Ad hoc audits of each customer's IT infrastructure are conducted	Basic documentation for the IT audit is at hand, but the procedural steps are not described in concrete	IT audits are based on frameworks which include a process, role, and data model; standards for audit reports are applied (e. g. SAS 70)	Interfaces for the automatic transmission of relevant documents, which, however, are not technically mature	It is made transparent which data are processed in which computer center; the IT review process is fully documented and automated.	*Adherence to SAS 70 Type II standards [3]*
Security	No security management; in case of security incidents ad hoc measures are taken	Active security management; no interface to the customer; measures are taken according to regulations; basic coding technology is applied	Security information is published on the provider's website; emergency plans have been generated and tested; complex coding technology is applied	Security information is provided via a web interface, but without notification function; a monitoring has to be implemented by the customer	Automated security management via web interface and e-mail notification; the security status of individual services is made transparent	*Comprehensive security management; transparent service status, no notifications [4]*
Support	Online documentation and FAQ	Help Line, Wikis	Developer and user forums, slow response to questions	response to questions takes a medium amount of time	quick response to questions; support channels are up-to-date	*Comprehensive documentation; response within a few hours [4]*

Table 2. *Cloud Computing Service Maturity Model* (Cloud Security Alliance, 2009; ENISA, 2009; Weinhardt et al., 2009; Martens et al., 2011)

4 Degree of Realization and Prototypical Implementation

A prototype of the community platform has already been implemented and is available online at www.cloudservicemarket.info. Additional elements of the platform are, for example, lists of services, providers with a search engine, research organizations, event calendar, assessment tools, user evaluation forums, regular polls on current issues in Cloud Computing and a configuration tool for IT architectures when using Cloud Computing Services. Currently, there are over 170 Cloud Computing Services and over 140 providers registered in the database (as of April, 2011). The services and providers were identified by searching press publications, professional publications (ENISA, 2009) and scientific articles for directories of services and providers or submitted by users. For the implementation of the platform, ASP.net was used on the basis of Visual Basic.NET (.NET framework 4.0). The MySQL Community Server 5.1 was used as database management system.

5 Market Analysis and Recommendations for Further Action

Preliminary Results: Figure 3 shows the first results of a preliminary analysis. The Cloud Computing market is still in an early phase of development and is continuously extended by new services and providers but also limited by services that have been taken off the market. However, focusing on certificates we found that they are very widespread yet: of all identified services, 118 Cloud Computing Services are certified by at least one certificate. The most widespread certificate is the SAS 70 Report. However, it is a common report, which has been applied in IT outsourcing arrangements already (Goodman and Ramer, 2007). Information on the availability of a service is provided by 50 providers and often set to 100%. Frequently providers promise a credit voucher for non-compliance to KPIs. On the other hand, we evaluated the overall SLA quality based on the presented maturity model (cf. Table 2). Overall we found 47 SLAs. Most often SLAs are added to maturity level 2, since KPIs are neither designed very flexible nor merged in monitoring cockpits. Finally, we evaluated the information quality on the providers' websites on a scale from 1 to 4 (cf. Figure 3) and found that certificates are currently very important (cf. level 2). Well described certificates and SLAs are mostly found on websites of large providers and thus not widespread.

Compliance to	**%** (n=303)
SAS 70 Type II	45.61%
HIPAA	31.58%
SOX	27.49%
PCI DSS	21.05%
Safe Harbor	18.13%
ISO 27001	14.62%
SAS 70 Type I	7.60%
FISMA	5.85%
ITIL	5.26%

Availability	**%** (n=50)
100.000%	30.00%
99.999%	8.00%
99.995%	2.00%
99.990%	14.00%
99.950%	8.00%
99.900%	28.00%
99.0-99.8%	10.00%

SLA Quality	
Level*	**%** (n=47)
5	0.00%
4	8.51%
3	23.40%
2	46.81%
1	21.28%

*: cf. Maturity Model

Information Quality on Website	
Level	**%** (n=171)
4	8.77%
3	23.98%
2	46.78%
1	20.47%

Legend:
1: Marginal Information
2: Information on Certificates
3: Description of SLAs
4: Extensive Information

Figure 3. Preliminary Results of the Market Analysis

Implications for Business Practice: In view of the highly dynamic character of the Cloud Computing market, companies should take time to become familiar with current developments and future trends in the field in order to avoid precipitate decisions resulting in problems of security, confidentiality, lock-in-effects or other risks. Researchers and practitioners are currently discussing the development of consulting services, which increases the chance for user companies to receive external support in the development of a Cloud Computing strategy (Leimeister et al., 2010). In particular, the integration of a Cloud Computing Service into the enterprise architecture should be accompanied by a specialized consulting firm (Xin and Levina, 2008). First insights provide our tool for the configuration of Cloud Computing architectures on the platform's website. Companies with no previous Cloud Computing or outsourcing experience should start with selecting services of little strategic significance. In spite of the selection support provided by the presented database, it is highly advisable to conduct firstly an intense analysis and quality assessment of potential Cloud Computing Services in the context of pilot projects (ENISA, 2009). During this early stage, heterogeneous interfaces, SLAs and software applications are very likely to result in high switching costs and, as a consequence, in a vendor lock-in (Aron et al., 2005). However, this lock-in effect can be mitigated by developing and establishing standards, reference models and best practices for Cloud Computing Service Management. Existing standardization initiatives and activities are, for example: eurocloud.org (trade association of European Cloud Computing providers), cloudsecurityalliance.org (aims at increasing the security of Cloud Computing Services) or deltacloud.org (development of one API that supports several vendor-specific APIs). Finally, providers often do not offer extensive information on their services to maintain a personal contact (e. g. by an email form) and to discuss the requirements of the user company in detail.

Implications for Science and Research: Hevner et al. (2004) recommend the application of evaluation methods by means of utility, quality and efficacy. Subsequent expert interviews are planned to evaluate the implemented functionalities and to identify new requirements by means of iterative steps. As well, usability tests and experiments can reveal new insights into the improvement of the website. This evaluation step aims as well at an architecture adjustment to encourage corporate users for participation. For further exploration of the Cloud Computing market we are planning to conduct

statistical analyses of services, providers and their user evaluation. They will be possible as soon as the platform's database contains enough data to be sufficiently comprehensive. Further points of interest could be the diffusion of standardized interfaces, the analysis of answers to poll questions (e. g. by means of hypothesis tests) as well as distribution and content analyses (e. g. word analysis) of evaluations submitted to the platform. With regard to global harmonization processes of APIs (e. g.), we are planning to support with our platform my means of the documentation and direct comparison of APIs to each other. Furthermore we will develop a global marketplace for the formation of international Cloud Computing business networks. Regarding maturity models, we noticed that existing maturity models mostly take a user perspective, whereas there seem to be no maturity model specifically designed for providers. In order to further develop the community platform, it is possible to extend the maturity model by adding several new functionalities as, for example, the automation of the maturity level determination and the consideration of service evaluations submitted by other users of the platform in the calculation of the degree of maturity. Furthermore, we are planning to implement an analytical hierarchy process to determine the criterion weights. As regards aspects of Cloud Computing security and threats, the integration of a database of threats (e. g. by applying the Common Vulnerability Scoring System, for which only databases on internal threats exist to date (Sackmann et al., 2009)) in the community platform is ongoing work.

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