An Enhanced Quality Model for IaaS Provider with Non-Quantifiable Key Performance Indicators

Jugal Harshvadan Joshi, Ali Naser Abdulhussein Abdulhussein, Atwine Mugume Twinamatsiko, Arash Habibi Lashkari, and Mohammad Sadeghi

***Abstract*—Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources Cloud computing is significant because it encapsulates a range of different technologies that have developed through the history of commercial computing. The model analyzed is known as Service Measurement Index (SMI) Model, which is a set of business-relevant Key Performance Indicators (KPI's) that provide a standardized method for measuring and comparing a business service regardless of whether that service is internally provided or sourced from an outside company. The SMI model analyzed is only applicable to the quantifiable attributes, thus in this research, we have concentrated on the Non-quantifiable attributes (KPIs) which, once incorporated, would not only enrich the customer experience but also provide more accurate customer results together with improved customer satisfaction.**

***Index Terms*—Cloud, cloud computing, cloud system, IaaS, key performance indicators.**

I. Introduction

Before Cloud Computing evolved, there was Grid Computing; Grid computing makes use of middleware to organize unrelated resources across a network, permitting them to work as a lump sum. The goal of grid computing is to deliver the clients with access to the resources, which they require, when they require. Grids provide two dissimilar but related goals, offering remote access to IT assets and combining processing power. It requires the use of software to distribute and work out pieces of a program as one large system image to a huge number of computers, cloud computing evolves from grid computing, which provides on demand resource provisioning [1].

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g networks, servers, storage, applications, and services) that can rapidly provisioned and released with minimal management effort or service provider interaction [1].

Manuscript received November 4, 2013; revised January 25, 2014.

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There are many types of cloud functionality provisioning, which include: platform, software, and infrastructure [2]. Clouds are pools of easily usable and accessible virtualized resources, which can be dynamically reconfigured to a variable load, allowing optimum resource utilization [3]. The cloud has many participants:

- **The end user / client**: this is the person that is least concerned with the technicalities of the system. They simply use the system without knowledge of what is happening in the background.
- **The business management:** these are the people that govern how the system works, they make sure the system is running and providing acceptable standard services to the clients. The management must aim at providing top-notch services in order to satisfy the growing base.
- **The cloud service provider**: this is the part of the cloud that is responsible for maintenance and the assets of the business. They are the technical team of the cloud system [4].

II. Related Works

Saeid *et al*, in his article namely SMICloud mentioned that, the first challenge we discovered is how to measure various SMI attributes of a Cloud service. To tackle this problem, SMICloud is used, which uses historical measurements and combines them with promised values to find out the actual value of an attribute. The second challenge is how to rank the Cloud services based on these attributes. There are two types of QoS requirements, which a user can have: functional and non-functional [5]. To address this problem, we propose an Analytical Hierarchical Process (AHP) based ranking mechanism to solve the problem of assigning weights to features considering the interdependence between them, thus providing a much needed quantitative basis for the ranking of Cloud services [6], [7].

Currently, there is no framework that can allow customers to evaluate Cloud offerings and rank them based on their ability to meet the user's Quality of Service (QoS) requirements. In this work, they propose a framework that measures the quality and prioritizes cloud services [8].

They proposed the Service Measurement Index Cloud framework SMICloud that helps Cloud customers to find the most suitable Cloud provider and therefore can initiate SLAs. The SMICloud framework provides features such as service selection based on QoS requirements and ranking of services based on previous user experiences and performance of services. It is a decision making tool, designed to provide assessment of Cloud services in terms of KPIs and user

DOI: 10.7763/IJCCE.2014.V3.298

requirements. Cloud computing services can be evaluated based on qualitative and quantitative KPIs. Qualitative are those KPIs, which, cannot be quantified and are mostly inferred based on user experiences. Quantitative are those, which, can be measured using software and hardware monitoring tools.

J. Siegel *et al.* on 2012 formed the Cloud Services Measurement Initiative Consortium (CSMIC) to address the need for industry-wide, globally accepted measures for calculating the benefits and risks of cloud-computing services. The CSMIC developed a measurement framework called the, Service Measurement Index (SMI). SMI involves the application of consistent, meaningful measures that are designed to enable comparison of current cloud-based services with non-cloud services or cloud services available from multiple providers. Cloud services characteristics where measures are being documented and tested include: Accountability, Agility, Assurance, Financials, Performance, Security and Privacy, and Usability. The SMI addresses a total of 51 attributes [9].

The CSMIC members have made two assumptions: (1) the measures need to be relatively simple; (2) measures must be clearly defined for each attribute. As experience is gained with using SMI, this will make the weighting system easier to use over time, and help to drive industry consensus on the relative importance of certain measures. While the SMI framework contains 7 characteristics and 51 attributes in total, it is not expected that the decision makers will want or need to use measures for all of the attributes. Rather, typical users will select the framework components of the greatest importance in their decision process and may consider a small number (5 to 7) of measures to be most relevant to their research. This allows the users to choose how much information they want to consider without constraining their options. The SMI is a multi-year initiative; the measures are being developed, reviewed and tested in industry and government settings as well as in university-based laboratories [9].

Also, S. K Garg *et al*. on 2011 gave precise metrics for each measurable attribute within the SMICloud, with the growth of Cloud Computing, more and more companies are offering different cloud services. From the customer’s point of view, it is always difficult to decide whose services they should use, based on users’ requirements. Currently there is no software framework, which can automatically index cloud providers based on their needs. In this context, the Cloud Service Measurement Index Consortium (CSMIC) [9] has identified measurement indexes that are combined in the form of Service Measurement Index (SMI) and important for evaluation of a Cloud service.

These measurement indexes can be used by customers to compare different Cloud services. In this paper, we are taking the work of this consortium one step further by proposing a framework (SMICloud) that can compare different Cloud providers based on user requirements. The SMICloud would let users compare different Cloud offerings, according to their priorities and along several dimensions, and select whatever is appropriate to their needs. However, without having precise measurement models for each attribute, it is not possible to compare different Cloud services or even discover them [10]. Therefore, SMICloud uses historical measurements and combines them with promised values to find out the actual value of an attribute. We also give [10].

SMICloud framework provides features such as service selection based on Quality of Service (QoS) requirements and ranking of services based on previous user experiences and performance of services. It is a decision making tool, designed to provide assessment of Cloud services in terms of KPIs and user requirements. Customers provide their application requirements (essential and non-essential) to the framework, which gives a list of Cloud services where the customer can deploy his/her application.

III. Analysis of Previous Models

Whilst analyzing the previous model, we found out the Service Measurement Index (SMI) is a set of business-relevant Key Performance Indicators (KPI's) that provide a standardized method for measuring and comparing a business service regardless of whether that service is internally provided or sourced from an outside company (see Fig. 1). Designed to become a standard method to help organizations measure business services based on their specific business and technology requirements, the SMI enables individual preferences to be the basis for what defines a good service [11].

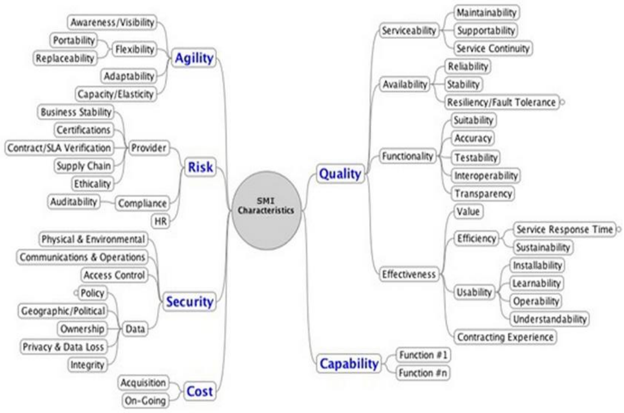

Fig. 1. SMI characteristics.

Users of the SMI Framework can not only compare cloud service vendors based on their specific business and technology requirements, they can also make dynamic, real-time decisions on where to best migrate or deploy an application. The Framework provides a single, standard way to evaluate, monitor and implement services demanded by the business [11]. The framework was created by CA. and is independently developed and run by the Cloud Service Measurement Initiative Consortium (CSMIC).

IV. New Proposed Model

After carefully studying the SMI Characteristics, we removed all the quantifiable attributes and only those which are non quantifiable are taken into account, since the study for quantifiable attributes has been done and it is out of the scope of this project. Below shows an amended SMI Characteristics diagram to show which attributes/KPIs have been taken into consideration (Fig. 2).

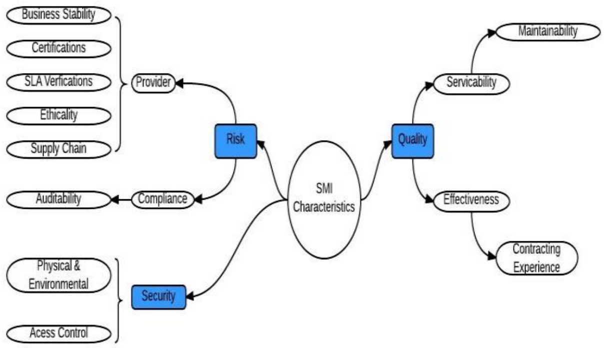

Fig. 2. SMI characteristics.

We used a three-phase process, that is, three rounds of questionnaires were used corresponding to the Delphi [12]-[14] study, each phase included a survey to identify the expert analysis and take them into account (Fig. 3). For the first phase (round), respondents were identified using a nominating process. These participants were then contacted by electronic mail to determine if they would be interested in participating. Other rounds were followed with some surveys, which were passed around to determine consensus. Below is a diagram that depicts the Delphi [15] process and the way it was conducted.

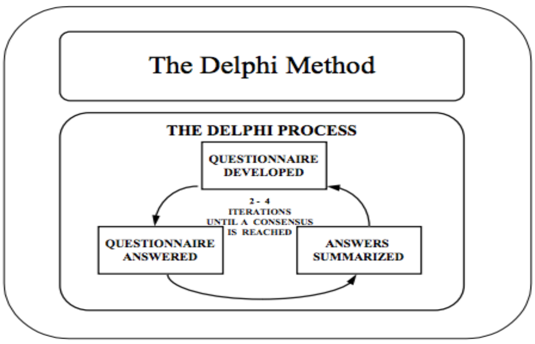

Fig. 3. The Delphi process.

Round 1: Respondents were called for an interview where broad knowledge was shared with them, analyzing different attributes, leading to a shortlisted version of some KPIs found influential.

Round 2: Responses to the first round were categorized or grouped by frequency or similarity of response in order to reduce the number to a manageable level but yet keeping the essential meaning of the responses. Participants were asked to rate the categorized responses from round 1 on a scale of 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree."

Round 3: The purpose of this round was to determine if there was a consensus. Responses from the round 2 were analyzed by determining the mode for each response. Participants were asked to review their response and the modal response, respond again using the same rating scale, and add any comments regarding the responses.

V. Results and Comparison

Firstly, we took the KPIs, which were shortlisted, from the SMI Model. The Table I below shows the qualitative attributes chosen in context of this research.

TABLE I: QUALITATIVE ATTRIBUTES

Attributes (KPIs)
Provider Business Stability
Provider Certifications
Provider Contract/SLA Verification
Provider Supply Chain
Provider Ethicality
Auditability
Contracting experience
Governance
Access Control & Privilege Management
Physical & Environmental Security
Maintainability

The following procedure was used in the second round of the Delphi survey [11], for this survey ten experts were contacted, and requested for their opinions on each KPI, their task was to rate each of the KPI on scale from 1-5, strongly disagree to strongly agree, respectively. The answers were then tabularized and analyzed. Below are the answers from the 10 expert respondents.

The total of each KPI score was added together, and then divided by the total number of respondents, to generate the median score, which is an approximation of the Average score, the formula being shown below.

$$\text{Total score for a } KPI \div \text{Total Number of Respondents} = \text{average score}$$
$$\text{Average score} \approx \text{median score}$$

The following procedure was used in the third round of the Delphi survey, the highest KPI score would be a maximum value submission by all the experts, since our highest scale mark is 5, and we have 10 experts, thus, the highest score achievable is ($5 \times 10 = 50$).

$$(\text{Total score for a } KPI \div \text{highest KPI score}) \times 100 = KPI \text{ percentage}$$

As seen from the table above, the approval rate, in terms of Percentage (over a 100%) and an Average Score over the highest score (5.0) is provided for all the Key Performance Indicators (KPIs). Below is a graphical view on the two rounds conducted?

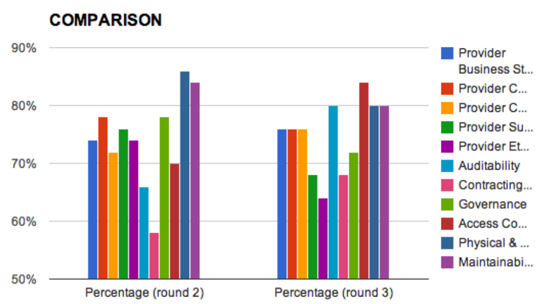

Fig. 4. Delphi round comparison.

After having a thorough readout, we decided that the consensus in this research is based upon 'Stability' of the KPI throughout the survey (Fig. 4). Stability in this context means, a KPI is able to maintain its score during the period of conducting the survey. As seen from the above diagram, most of the KPIs maintain a rough estimate of (+/- 10%), exceeding that range which in turn affects the median score; this KPI is noted as 'unstable'. From the diagram, it can be depicted that most of the KPIs hold a fluctuation rate of (+/- 10%) but not all.

VI. Conclusion

Before Cloud Computing evolved, there was Grid Computing, which made use of middleware to organize unrelated resources across a network, permitting them to work as a lump sum. It requires the use of software to distribute and work out pieces of a program as one large system image to a huge number of computers, cloud computing evolves from grid computing, which provides on demand resource provisioning. The major issue in this research was to identify the non-quantifiable KPIs, which could be incorporated later with the existing model to provide richer, accurate customer experience and results respectively. The idea was to shortlist the non-quantifiable attributes that would greatly increase the performance of the overall existing SMI Model. The whole process was carried out using a Delphi Survey. After carefully analyzing results from the survey we found that non-quantifiable KPIs shortlisted should be added to the already existing framework.

Acknowledgement

The special thank goes to our helpful supervisor Dr. Arash Habibi Lashkari from Postgraduate school for his unrivaled supervision and guidance in our dissertation and final project.

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