QoS-Based Cloud ERP Selection Model for SMEs

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***Abstract*—The roles played by Enterprise Resource Planning (ERP) systems in any organizations in achieving operational excellence and competitive advantage cannot be underestimated. However, the cost of implementing traditional ERP has been observed to be a bane for most Small and Medium Enterprises (SMEs) which are globally known as the major drivers of most agile economies. Cloud computing is a paradigm technology concept that affords the SMEs opportunities of affordable services in which ERP can be Cloud-hosted and rented on pay-per-use basis, which does not require a great deal of initial capital to ensure business continuity in a highly competitive market. There are a lot of providers offering ERP as Software-as-a-Service (SaaS), the SMEs therefore is being faced with the challenge of selecting a provider with Quality of Service (QoS) suitable enough to meet the customized requirements of the organizations. A model is presented in this paper which seeks to address this selection challenge. Apart from the suitability efforts, the model also further attempts to select the cheapest among a few selected providers already found suitable for the SMEs.**

***Index Terms*—ERP Systems; SME; Cloud Computing; Provider; QoS; Selection.**

I. INTRODUCTION

Existence of traditional enterprise resource planning (ERP) systems dates back to over two decades. Under this situation, organizational data reside within the premise of the organizations [1]. ERP Systems is crucial to the business operations in the SMEs to improve productivity, efficiency and overall business performance [2]. However, traditional ERP has been observed to be too costly for most Small and Medium Enterprises (SMEs) [3] which are known to be the major driving force of any thriving and agile economy globally [4][5].

Fortunately, with the emergence of cloud computing which is a paradigm concept of accessing a network of remote servers via the Internet for the purpose of managing, processing and storing data, instead of using the local servers or one's personal computers, many enterprises have seized the opportunity based on its many advantages over the traditional model to move their businesses to the Cloud [6]. Consequently, Cloud-based ERP systems which are basically provided using the Software-as-a-Service (SaaS) architecture, now offers the SMEs with opportunity of a situation where users rent the software and use, rather than buy it [7]. Hence, it is seen as a viable answer to the high cost challenge for SMEs [4].

Selection of suitably fitted solutions remains a challenge and stumbling block to a widespread adoption of this paradigm technology yet by many organizations [8]. However, research, as well as observation, has proved that adoption of cloud computing was found to be higher in Small and Medium Enterprises (SME's) than in Large organizations apparently due to two major reasons namely, the reduced and affordable capital expenditure to access a pool of incredible computing resources at pay-per-use [9] and the fact that they have not as much assets to lose as the large enterprises in case of any possible eventual breach of data migrated to the cloud [4]. Also, the financial capability of the Large Enterprises (LEs) to implement the conventional traditional technologies has been found to be another reason why cloud adoption rate is greater in the SME's than in the LE's.

In a research report released in the European Union in 2014, though both large enterprises and the SMEs express concern about risk of a security breach as this scored highest among several limiting factors of adopting the Cloud with 57% and 38% respectively, however, Large enterprises and the SMEs express a considerable disparity regarding other factors. Statistics show that a whopping 32% regard high cost as one of the prominent limiting factors as compared to 17% in the large enterprises [10].

Yet, there's no one-size-fit-all solution among cloud services, while also, cloud service providers offer varying quality of service (QoS) at different costs as requirements differ from one organization to another. Therefore, selecting the most suitable service providers for the SMEs, and at the most affordable rate, remains key to the survival of the SMEs in the Cloud as several project failures have been reported due to wrong decision making in the process of selecting a service.

The rest of the paper is organized as follows: In section 2, we briefly analyze a few existing works that are related to this research. Section 3 discusses the methodology adopted to achieve our objectives. We discuss quality of service and service measurement index in session 4. In section 5, we describe the proposed selection model. Section 6 concludes the paper with a hint on projection for future work.

II. RELATED WORKS

There are numerous reports of cases where traditional ERP systems implementation projects persistently suffer poor fit between ERP systems and organizations, most of the times, causing project failure [11]. The Cloud environment witness even much more challenges in overcoming misfit between organization's requirements based on best practices and the ERP systems to be adopted. Although there have been ample challenges for organizations to select suitable cloud service providers for

themselves as interest in adoption of Cloud services is noticeably on exponential increase by the SMEs in recent times [12,16] consistent and concerted efforts both by researchers and Information Technology practitioners toward addressing these challenges have produced a handful research reports. One of the most common evaluation and selection criteria when it comes to Cloud Service Providers (CSP's) is the Quality of Service (QoS) criteria, such as usability, performance, agility, reliability, availability, accessibility, trust etc., while some others exclusively handle specific criteria such as security and privacy requirements [13,14] or other quality parameters.

An ERP model meant for supplier selection was proposed by [15] in 2011. The model successfully combined three multi criteria decision analysis (MCDA) techniques namely Analytic Network Process (ANP), Technique for Order of Preferences by Similarity to Ideal Solution (TOPSIS) and Linear Programming (LP) to select suppliers in electronic industry. ANP is used to calculate weights of the criteria while TOPSIS is used to give suppliers a ranking. LP is used to effectively allocate order quantity to each vendor. Though this research basically deals with ERP selection in the traditional setting, the concept is applicable in the Cloud environment.

Kilic et al [8] uses combination of two MCDA techniques to select the "best" ERP systems in their work. The framework presented works in three phases: pre-evaluation, weighting and ranking phases. Framework synergistically combines the strengths of ANP and PROMETHEE (Preference Ranking Organization METHod of Enrichment Evaluations). After the pre-evaluation stage during which the criteria are determined, ANP is used to assign weights to the criteria while ranking is done by the second MCDA technique, PROMETHEE.

Though many MCDM techniques can be used for the dual purpose of determining weights of criteria as well as ranking them, study has shown over time that separating the two and using suitably combined techniques produces better results. According to [8], "The ERP system studies that successfully combined more than one MCDM method seemed to be the ones that have reported the most satisfying results".

III. Methodology

This study is being carried out in order to come up with a model which will help in selecting best fitting or most suitable and the most affordable Cloud ERP services for the SMEs. The study takes its origin in the existing literatures which have reported several misfits between ERP systems and the requirements of the organizations, as well as the numerous models and frameworks that have been proposed by various researchers in efforts to address these challenges.

Systematic Literature Review (SLR) methodology serves as a source of secondary data collection from which a preliminary framework is developed. A confirmatory study with experts in SMEs will be carried out via a pilot test to validate the criteria identified in the literature.

To achieve the objectives of this paper, the study adopts a four phase methodology. The four phases involved are pre-evaluation, AHP, PROMETHEE and Cost comparison phases (as shown in figure 1 below) in a linear process as the output of one phase feeds the next in line. In the pre-evaluation phase, the selection criteria identified from literature are confirmed via consultation with a group of ERP experts. The next two phases, namely AHP and PROMETHEE techniques, which also have experts input, constitute the core area of the methodology.

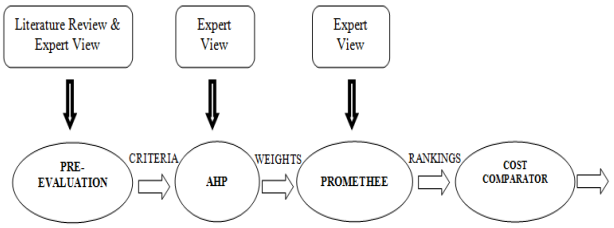

Figure 1: Methodology of the proposed model

IV. Quality of Service (QoS) and Service Measurement Index (SMI)

Quality of Service, often called as QoS, in web service selection, represents a set of criteria that is employed in ranking and selecting the best service candidates for the end users among a catalogue of service providers [17][18]. In web services, QoS is composed of both functional and non-functional attributes of a given service. The end users or client organizations formulate their customized QoS requirements based on the QoS criteria used to compare various service providers. However, literature reports how increasingly difficult and challenging it has become for these organizations to take decision on which among myriads of service providers can satisfactorily fulfill their QoS requirements [19][20][21][22].

In order to create a standard of measurement of QoS in Cloud, a body called the Cloud Services Measurement Initiative Consortium (CSMIC) was founded in 2010 in Carnegie Mellon University. This body is composed of a group of globally renowned organizations. Experts from these various organizations came up with the idea of standard measurement framework popularly referred to as SMI (Service Measurement Index) [19][33] which offers a platform for comparative evaluation of Cloud services. This framework, which is hierarchical in nature, is constituted by seven identified categories that provide holistic coverage of the QoS which the customers would need to select a cloud service provider (CSP). These categories are Performance, Assurance, Cost, Agility, Accountability, Usability and Privacy/Security [23].

A. Performance

In a situation where a number of service providers offer varying solutions to meet the client's IT needs, there is a need for pedestals to measure the performance of each of these solutions as they are less likely to perform at same degrees. As such, performance can be measured in terms of service response time, functionality, throughput and efficiency, suitability, accuracy, interoperability, etc.

B. Assurance

Service Level Agreement (SLA) is part of a contract service where the expectations of the end user are defined. Assurance is the attribute that indicate the likelihood of CSPs to perform as stated in the SLA. Therefore, the end user considers such attributes as service stability, reliability, availability, reputation, etc, in selecting a service provider.

C. Cost

Cost-effectiveness is one vital factor in the plan of the organizations, most especially, the SMEs, when considering which service providers to go for. Though Cloud services are based on pay-per-use, and cost, a function of resources required, such as Central Processing Unit (CPU), virtual machines (VM), memory, etc, yet pricing of services varies from one provider to another.

D. Agility

Agility is the ability of an organization to move quickly and easily. Cloud computing increases the agility of an organization, in that it affords the organizations the capability of changing and expanding within a very short time without incurring much expenses. When these new capabilities are activated to meet IT's urgent needs, the rate of change metrics can be measured. Agility is measured in form of adaptability, elasticity, scalability, etc.

E. Accountability

The attributes of this criteria offer the customers the privilege of being able to evaluate the level of trust with the providers before deployment of their critical data. This includes compliance, data ownership, auditability, sustainability, transparency, etc.

F. Usability

It is an obvious fact that when a system is easy to use, adoption rate is faster. To measure the usability of a service, such factors as learnability, operability, accessibility and installability, are major factors which can be measured.

G. Security and privacy

How data are protected in the Cloud is of paramount importance and concern to the end user. Different service providers provide different security apparatus to ensure that clients' data are safe and secured. There are arrays of attributes to measure this criterion, such as, Data integrity, data segregation, data availability, network availability, backup Strategy, provider's transparency, data protection, legal compliance and physical Security.

V. Proposed Model

We propose a Cloud service selection model in this paper, which is aimed at enabling the SMEs to find a suitable service provider, as well as selecting the most affordable amongst a group the best fit providers that meet the organizations' customized QoS requirements based on best practices. The model is a modification of CERRA model of Chen et al, 2013 [24]. CERRA model is a cost-efficient and reliable resource allocation model meant to schedule cloud project based on cellular automaton entropy. Figures 2 and 3 illustrate the proposed model of this paper and the flow diagram for the model design respectively.

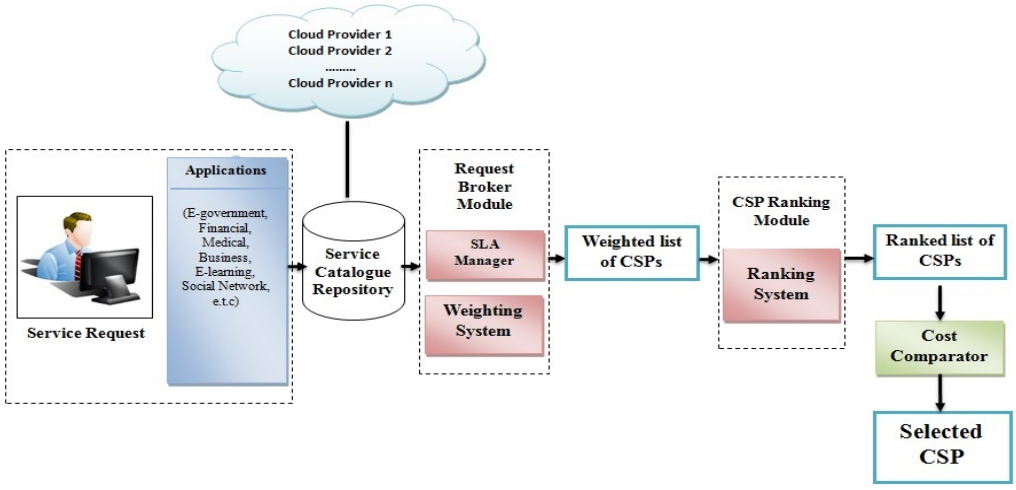

Figure 2: Cloud ERP selection model

A. Service request

(From figure 2 above) Several requests for various types of resources (deployment of certain applications) coming from heterogeneous backgrounds worldwide are made.

B. Service catalogue repository

This component is responsible for the storage of a list of available cloud service providers with the information supplied (advertized) by them. There is a constant self-updation of this component with time due to the fact that the Cloud environment is dynamic in nature.

C. Request broker module

This component collects a detailed QoS criteria as requirements from the customers and the details of Cloud Service Providers from the repository. Customers' application requirements are usually classified into 2 categories: essential and non-essential. Essential requirements must be met, non-essential ones can be compromised depending on the organization needs. The broker also consists of the Service Level Agreement (SLA) Management component which keeps track of customers' SLAs with service providers and the history of how they have been satisfied. It calculates the various Key Performing Indices (KPI's) which are used to determine the weights of the criteria which are in turn used for ranking of cloud services. This phase uses Analytic Hierarchic Process (AHP), a Multi Criteria Decision Making (MCDM) technique.

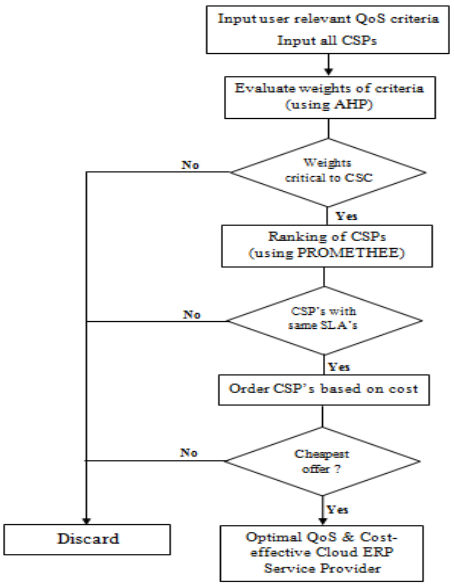

Figure 3: Flow diagram for the proposed model (based on CERRA model of Chen *et al*, 2013)

D. *Cloud service ranking module*

This component receives output, which is the weighted CSP list from the Request Broker Module and performs a pairwise comparison of the weighted criteria. The already shortlisted service providers are re-arranged such that they can now be compared on number of quality parameters. The output is the priority ranking of the service providers which is passed to the next phase for final selection. This module employs Preference Ranking Organization METHod of Enrichment Evaluation (PROMETHEE) technique.

E. *Cost Comparator*

In this phase, this component simply selects the provider with the cheapest offer among the service providers on the list of those that best meet the QoS requirements from the preceding filtering and ranking processes.

F. *Analytic hierarchical process (AHP)*

Analytic Hierarchy Process (AHP) is a multi-criteria decision making (MCDM) technique discovered by Thomas L, Satty in 1980. The technique works to solve the problem of decision making using three major elements namely, goal, criteria and alternatives. The problem - which is to select and rank competing Cloud services - is the "goal". The "criteria" are represented by the QoS requirements while the "alternatives" are the various Cloud services available [17]. The top-to-down hierarchical relationship structure of this method allows effective mapping of the clients' customized requirements to the various QoS capacities of the alternatives to accomplish iterative pairwise comparisons determining corresponding weights which will facilitate eventual ranking and selection of the best alternative with detailed consideration of each attribute. AHP carries out these pairwise comparisons iteratively using a scale provided by Satty. The proposed model under consideration uses this (AHP) method to assign corresponding weight to each attribute.

G. *Preference ranking of organizations method enrichment evaluation (PROMETHEE)*

The MCDM technique developed in the 80s by Brans [25], and later taken steps further by Brans and Vincke [26] in 1985. After determining the importance weights of the criteria being considered in the selection of Cloud ERP services using AHP, this technique, PROMETHEE, which is another family of outranking methods, is employed to select the preferred services based on the suitability of the service provider with the QoS requirements of the client or users. This method which has been successfully applied in several selection efforts in both past and recent literature [27,28,29,30,31] functions in a five-step process that culminates in the determination of outranking flows for each of the alternatives (Cloud service providers).

VI. Conclusion and Future Work

In most of the various frameworks and models designed for selection of Cloud service provider, it is observed that it principally involves a few phases or stages, which is three in most cases. First is gathering of relevant information on the concerned parameters of interest from both the service providers and the client organization in form of Quality of Service requirements. Secondly is assignment of weights to the identified criteria and possible discard of some CSPs. Finally, ultimate selection and recommendation of the best or suitable providers based on ranking of the CSPs on their ability to meet most, if not all, the quality of service requirements and needs of the client organizations depending on their priority concerns.

However, several studies on ERP systems selection show that there seems to be more satisfying results in the approaches where more than one multi-criteria decision making analysis techniques are successfully combined [8] in selecting a suitable provider. This has been demonstrated in such works as those of [32] which used fuzzy Analytic Hierarchy Process (AHP) and Technique for Order of Preferences by Similarity to Ideal Solution (TOPSIS) for ERP selection; [15] used the combination of ANP, TOPSIS and LP to select ERP system; [32] which used fussy AHP and TOPSIS for selecting ERP software for Turkish airlines, and many more.

Measurements show that there can be amazing results when two or more best complementary MCDA techniques are combined for selection purpose as this brings together the strengths of unique features of these techniques [18]. The area of strength of this model, which is the part that makes it unique and different from previous or existing ones, is that, apart from the fact that it combines two MCDM techniques to overcome misfit between organizations' customized requirements and the functionalities of the systems being adopted, it also additionally provides solution to the challenge of procuring the most cost-effective Cloud service provider among those which can meet the organization's QoS requirements.

In our future work, we plan to conduct a confirmatory study of the criteria identified in this work on the SMEs and also prioritize them based on the level of importance or relevance. Finally, we would like to develop a prototype from the model which would be validated via case study involving two selected SME organizations.

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