

Cloud Enterprise Application Provider Selection Model for the Small and Medium Enterprise: A Pilot Study

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Abstract—Enterprise Applications (EAs) aid the organizations achieve operational excellence and competitive advantage. Over time, most Small and Medium Enterprises (SMEs), which are known to be the major drivers of most thriving global economies, use the costly on-premise versions of these applications thereby making business difficult to competitively thrive in the same market environment with their large enterprise counterparts. The advent of cloud computing presents the SMEs an affordable offer and great opportunities as such EAs can be cloud-hosted and rented on a pay-per-use basis which does not require huge initial capital. However, as there are numerous Cloud Service Providers (CSPs) offering EAs as Software-as-a-Service (SaaS), there is a challenge of choosing a suitable provider with Quality of Service (QoS) that meet the organizations' customized requirements. The proposed model takes care of that and goes a step further to select the most affordable among a selected few of the CSPs. In the earlier stage, before developing the instrument and conducting the pilot test, the researchers conducted a structured interview with three experts to validate the proposed model. In conclusion, the validity and reliability of the instrument were tested through experts, typical respondents, and analyzed with SPSS 22. Results confirmed the validity of the proposed model and the validity and reliability of the instrument.

Keywords—Cloud service provider, enterprise applications, quality of service, selection criteria, small and medium enterprise.

I. INTRODUCTION

MAKING of optimal decisions on problems with a multi-criteria dimension is one of the most fundamental challenges managers face either in the public or private sector, whether in large or small enterprises. EAs are software systems that help organizations to run their businesses effectively by way of adding a degree of automation to business process implementations and also providing support to such tasks as planning, data analysis, and data management [1] in their traditional state, have been around for over four

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decades. In such state, organizational data reside within the premise of the organizations [2].

EAs have been known to be crucial to the business operations in the SMEs to improve productivity, efficiency and overall business performance [3]. However, implementing traditional EAs have been observed to be too costly for most SMEs [4], which are known to be the major driving force of any thriving and agile economy globally [5], [6].

However, the emergence of cloud computing, which is a paradigm concept of accessing a network of remote servers to perform business operations via the Internet in place of the local servers or one's personal computers, have afforded many enterprises, most especially the SMEs, the opportunity of engaging their large counterparts in fairly competitive market [7]. Consequently, cloud-based EA's are basically provided using the SaaS architecture in such a way that users rent and use the software, rather than buy [8]. Hence, it is seen as a viable answer to the high cost challenge for SMEs [6].

In a research report released in the European Union in 2014, though both large enterprises (LEs) and the SMEs express concern about risk of a security breach which ranks highest among several limiting factors of cloud adopting rates, with 57% and 38%, respectively, they express a considerable disparity in other factors. Statistics show that a whopping 32% of SMEs regard high cost as one of the prominent limiting factors as compared to 17% in the LEs [9].

In the midst of this, the fact remains that there's no one-size-fit-all solution among cloud services, while also, CSPs offer varying 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.

This paper is structured as follows: firstly, we highlight, in the introduction, the main challenges faced by the SMEs decision makers in selecting cloud EAs in a way that will help them maximize the benefits that come with cloud computing; Secondly, we briefly review some previous works that are related to the study. Thirdly, we present our conceptual model that is proposed; fourthly, the research methodology. The results and discussion take the final part before concluding with the future research areas.

II. RELATED WORKS

One of the most common evaluation and selection focuses

when it comes to CSPs is the QoS criteria. It has been observed as becoming increasingly challenging to make a decision on which CSP can satisfy the QoS requirements of cloud customers [10]. While some research work have considered such QoS attributes as usability, performance, agility, reliability, availability, accessibility, trust, etc. [11]-[14], some others however exclusively have focused on specific criteria such as security and privacy requirements [15], [16] or other quality parameters.

Quite a number of researchers have already applied different techniques in solving CSP selection problems. But not many of the research are focused on SMEs, while the facts remain that certain selection criteria are particular to SMEs, which are not relevant to their LE counterparts, owing to the unique characteristics of the small business [17]. Aside, most of the research work involved application of single multi-criteria decision-making technique, whereas, it has been argued that successful combination of two or more multi-criteria decision-making analysis (MCDM) techniques tend to yield more satisfying results when it comes to seeking suitable

service providers for the client organizations [18].

An ERP model meant for supplier selection was proposed by [19]. The model successfully combined three MCDM 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. Though this research primarily focuses on ERP selection in the traditional setting, the concept is applicable in the cloud environment. Kilic et al. [18] uses a combination of two MCDM techniques to select the “best” ERP systems in their work though with not much emphasis on the cost-benefit feature.

The cost-efficiency apparatus fills the gap in the existing research by way of enabling decision makers to be able to select from a number of suitable service providers the one that is most affordable, so as to give the SMEs the benefit of enjoying one of the reasons for its cloud adoption – which according to [20], [21], is to cut business operational costs. A few of the reviewed work is given in Table I.

TABLE I
ANALYSIS OF SELECTION APPROACHES USED BY EXISTING WORKS

| Reference | Model/Approach | weighting | Ranking | Cost Efficiency apparatus |
|-----------|---|--|---|------------------------------|
| [18] | Combination of 2 MCDA techniques to select the “best” ERP systems | Analytic Network Process (ANP) | Preference Ranking Organization Method of Enrichment Evaluation (PROMETHEE) | None |
| [10] | SMICloud framework | | Analytic Hierarchy Process (AHP) | Value/cost ratio computation |
| [22] | Hybrid Methodology for ERP system selection | Fuzzy AHP | Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) | None |
| [19] | An ERP Model Supplier Selection. | Analytic Network Process (ANP) | TOPSIS and Linear Programming (LP) | None |
| [11] | QoS based CSP Selection | | Analytic Network Process (ANP) | Cost benefit analysis |
| [23] | Fuzzy Cloud Service Selection | Fuzzy-based | Analytic Hierarchy Process (AHP) | None |
| [16] | C.A.R.E approach | Assess requirement completeness, Audit required qualities, Report security information | | None |
| [24] | Optimal Selection Approach | Modified form of Elimination Et Choice Translating Reality (ELECTRE) | | None |
| [25] | Ranked Voting Method | Ranked voting | | None |
| [12] | QoS-Aware | Backward Cloud Generator Algorithm | Mixed Integer Programming (MIP) | None |
| [26] | CMfg-SME | Single Service Selection (SSS) algorithm | Genetic Algorithm (GA) | None |

III. THE PROPOSED MODEL

From the reviewed literature in cloud service selection, we found that many researchers developed several frameworks in selecting ‘best’ or ‘suitable’ service providers either by the use of single selection technique approach or by integrating two or more MCDM techniques. This research uses an architecture that synergistically combines two selection techniques, (AHP and PROMETHEE), (see Fig. 1), which, to the best of our knowledge, have not been combined by previous research to address cloud selection problems, particularly in the domain of the SMEs. Weighting of criteria is done by AHP, while PROMETHE is employed in outranking the alternatives [27]. The model does not only seek to select suitable service, but also one that is cost-efficient so that the SMEs can secure the cheapest of the suitable services available, based on its QoS requirements. This is achieved through a cost-efficiency

apparatus known as “cost comparator”. The model adopts the Service Measurement Index (SMI) (Fig. 2) [10] which provides a platform for comparative evaluation of cloud services.

A. Variables of the Proposed Model

1. Performance

To meet the client’s IT needs, a number of service providers compete to offer varying solutions. There is need therefore for pedestals to measure the performance of each of these solutions, as they are most likely not going to perform at same levels. As such, performance of a solution can be measured in terms of service response time, throughput and efficiency, functionality, suitability, accuracy, etc.

2. Assurance

The part of a contract service where the expectations of the

end user are defined is the Service Level Agreement (SLA). Assurance is the attribute that indicate the likelihood of CSPs to perform as stated in the SLA. The end user therefore can consider such attributes as service stability, availability, serviceability, reliability and reputation while choosing a service provider.

3. Cost

While shifting to the cloud, cost-efficiency is a major factor

for most of the organizations, most especially, the SMEs, in considering which CSP to settle 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. Acquisition and ongoing/on-demand costs are basic attributes usually considered by the end user.

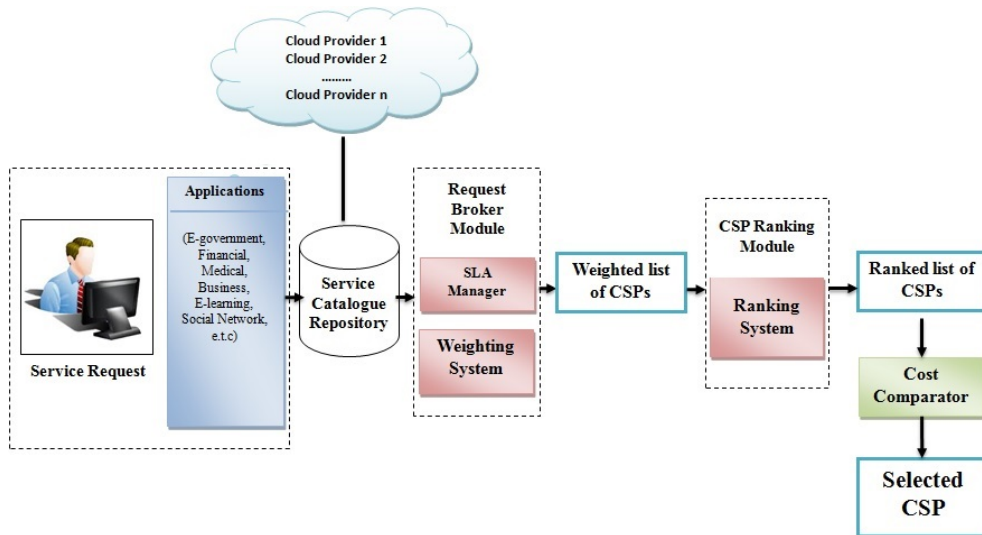


Fig. 1 Architectural Layout of the Cloud EA Selection Model

4. Agility

An organization is said to be agile when it possesses the ability to move and change quickly and easily. This easiness and quickness in change within an organization is aided by cloud computing, in that it affords the organizations the capability of changing and expanding within a very short time without incurring much expense. When these new capabilities are activated to meet IT's urgent needs, the rate of change metrics can be measured in form of adaptability, portability, elasticity, flexibility and scalability.

5. Accountability

The attributes of this variable afford the end user the privilege of being able to evaluate the level of trust with the providers before deployment of their critical data. This includes data ownership, auditability, sustainability and transparency.

6. Usability

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

7. Security and Privacy

Both in study and in the field, how data are protected in the cloud has been proven to be of paramount importance and concern to the end user. Different CSPs provide varying

security apparatus to ensure safety and security of clients' data. There are arrays of attributes to measure this criterion, but for the purpose of this study, only attributes such as data integrity, data segregation, backup strategy and physical security are considered.

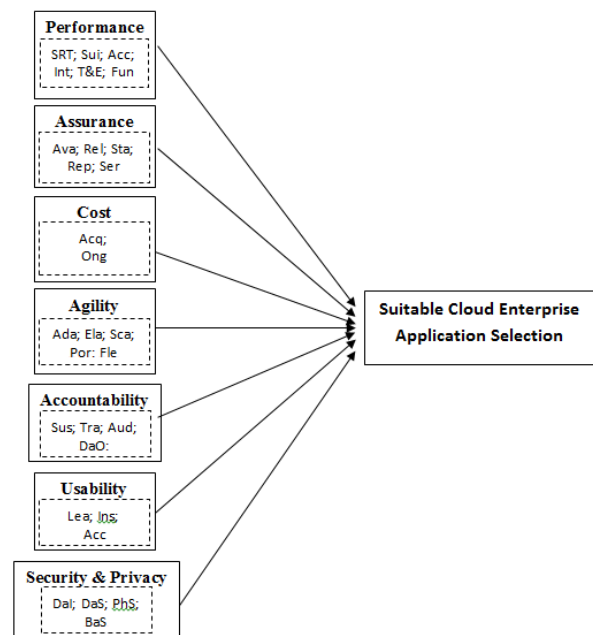


Fig. 2 Cloud EA Selection Model for the SMEs

B. Multi-Criteria Decision Analysis (MCDA) Techniques Employed

1. Analytic Hierarchy Process (AHP)

Developed by Thomas L. Saaty in 1980, Analytic Hierarchy Process (AHP), a MCDM analysis is a technique that has been successfully applied to solve decision making problems in many fields, which includes Manufacturing [28], [29]; Marketing [30]; Logistics [31]; Engineering [32]; Store location selection [33].

The technique works via three major hierarchies namely, goal, criteria and alternatives. The problem is the “goal”; the “criteria” are represented by the QoS requirements, while the “alternatives” are the catalogue of Cloud services available [22]. 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 in turn be used in ranking and selection of the best alternative, paying attention to all attributes. These pairwise comparisons are iteratively performed using a scale provided by Saaty. The AHP technique is based on three guiding principles: (i) Hierarchy construction, (ii) priority setting and (iii) logical constituency [34].

2. Preference Ranking of Organizations Method for Enrichment Evaluation (PROMETHEE)

Sequel to obtaining the importance weights of the selection criteria using AHP, PROMETHEE (Preference Ranking of Organizations Method for Enrichment Evaluation), another MCDM, developed by Brans in the 80’s [35] is employed to determine the most suitable Cloud EA choice for the firm 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 [36]-[38], [25], [26], functions in a five-step process that results in the determination of outranking flows for each of the alternatives (CSPs).

IV. METHODOLOGY

Prior to the development of the instrument used for the pilot study, a structured interview was conducted. This involved engaging five experts; three from the academic arena while two was from the industry. The purpose of this interview was to validate the proposed model. The results of the interview were analyzed while necessary refinement was effected based on the experts’ feedback. Before finally administering the developed questionnaire which was based on the model, it was tested in regards to both content and face validities.

The instrument developed was meant to verify which of the criteria identified by the researcher is considered relevant to the SMEs in the process of selecting a CSP for their organizations. Primarily, the main purpose of the pilot study was to if the respondents understood the questions clearly. In other words, it is to see if the questions were not confusing. In addition, it was meant to see if there was any trivial (or too

easy) aspect so as to either adjust or leave out in the final questionnaire.

Twenty one respondents from seven organizations in Klang Valley, Malaysia took part in the pilot study. This is in compliance with the recommendations by several researchers such as [39] which suggested 10-30 participants, [40] also advised using 10-30, [41] recommended that researchers should “use at least 12 observations in constructing a confidence interval”. Malhotra, in his work [42], submitted that “the sample size for pilot test is normally small, ranging from 15-30 subjects, but may be increased substantially if the test involves several stages”. Respondents consist of two IT executives, one computer operator, seven IS/IT staff, two system analysts, two system developers, one solution architect, one director, five IT/IS managers. The data collected were analyzed using Statistical Package for Social Sciences (SPSS 22), an IBM statistical analysis tool. The process took quite over seven months due to certain information access challenges encountered by the researchers during the data collection phase. The results of the reliability test are represented in Table II.

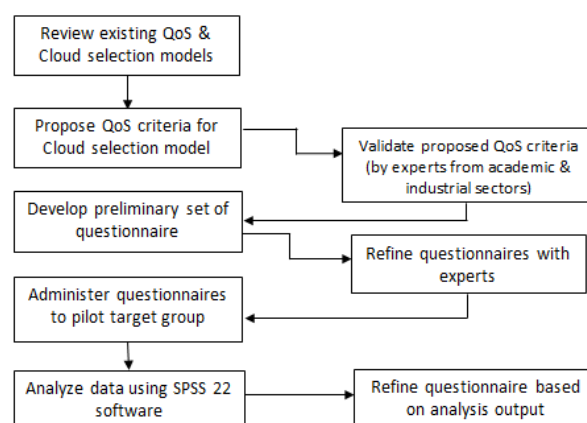


Fig. 3 Pilot Study Methodology

A. Measurement of Proposed Model Validity

As earlier mentioned, structured interview using formal standardized questionnaire was conducted with five experts. Three experts are drawn from the academic circle, while the other two are from the industry. The structured interview is made up to three parts: Part 1 consists of the expert’s background information, while part 2 consists of the introduction to the model. The last part comprises key concepts and general validation questions. Part three, which is the most important aspect of this phase, starts with obtaining remarks of the experts on each of the components of the model. This part also contains a set of questions to verify the feasibility and applicability of the proposed model in practice. Some of the experts were reached by physical visitation, while interview material was mailed to the experts that were overseas.

B. Measurement of Variables in Pilot Test

The questionnaire administered consists of multiple choice-questions. According to Miller (1991); Alreck and Settle

(1995), the Likert-type scale is considered to be most appropriate and reliable for a study of this nature. The instrument is meant to measure the degree of importance of key variables of the research using a 5-point Likert-type rating scale. The Likert-type scale ranges from unimportant to very important. The questionnaire of this study is made up of three parts all together forming 44 questions. Part 1 contains just two questions about the personal information of the respondents, which are sex and age. Part 2 comprises a set of nine questions targeted at gathering information about the professional background of the respondents as well as the company he represents. This includes area of expertise, category and size of enterprise, size of IT staff, layer of Cloud computing being used by the organization, level of satisfaction among others. Part 3 is a set of thirty-three questions which attempt to measure the level of importance of the identified QoS criteria for selection of Cloud EAs for the SMEs. These 33 questions come under the dependent variable and the seven different main cloud selection criteria (independent variables) which are Performance; Assurance; Cost; Agility; Accountability; Usability; Security and Privacy identified from the adopted SMI framework.

V. RESULTS AND DISCUSSION

A. Validity Test Results for Proposed Model

After the interview questionnaire meant for the experts' review was reviewed by experts in the English language as well as one in questionnaire and interview design, it was then sent to the selected experts. Responses were received and results analyzed. Initial responses indicated a level of little bit of variation in opinions of the experts. Questions were raised by the experts while the researchers addressed the inquiry. The results indicate that there is 96.55% agreement among experts on the relevance of the QoS attributes of the proposed model. Furthermore, in the applicability assessment, all the experts agree 100% with the usability of the framework in real life application. Recommendations were taken while necessary adjustments were made to refine the proposed framework.

B. Validity Test Results for Instrument

1. Face and Content Validity Tests

Face validity test: This is a subjective judgment on the operationalization of a construct. It is a form of 'Non-expert' judgments of individuals completing the instrument and/or executive who would approve the use of it. For this research, the questionnaire was administered physically to four typical respondents for face validity test. This process took about five days to complete, after which the researchers refined the instrument accordingly.

Content validity test: According to [43, p. 185], content validity is "a qualitative type of validity where the domain of the concept is made clear and the analyst judges whether the measures fully represent the domain". The initial set of questionnaire for this pilot test, was validated by five experts in the fields of Cloud computing, EAs, service quality and business management.

2. Reliability Test

Different types of reliability tests exist. The most common test is Cronbach's alpha [44]. After running the data using SPSS 22, it was found that all the measures ranges from 0.804 to 0.942. It could be seen from Table II that the result of the pilot test indicates that Cronbach's alpha values for the variables are all above 0.70. Consequently, therefore, we found no need to delete any item from the list. The Cronbach's alpha values for all criteria were as follows: Performance ($\alpha = 0.868$), Assurance ($\alpha = 0.894$), Cost ($\alpha = 0.942$), Agility ($\alpha = 0.894$), Accountability ($\alpha = 0.804$), Usability ($\alpha = 0.860$), and of course Security & Privacy ($\alpha = 0.924$). This finding indicates that all the identified criteria are valid. All the factor loading values are above 0.7 and suitable to proceed with the empirical study. The result of the analysis is as shown in Table II below:

TABLE II
 RELIABILITY TEST RESULTS

| | Selection criteria | Cronbach's alpha values of this study | Results | No. of Attribute |
|---|----------------------|---------------------------------------|-----------|------------------|
| 1 | Performance | 0.868 | Good | 6 |
| 2 | Assurance | 0.893 | Good | 5 |
| 3 | Cost | 0.942 | Excellent | 2 |
| 4 | Agility | 0.894 | Good | 5 |
| 5 | Accountability | 0.804 | Good | 4 |
| 6 | Usability | 0.860 | Good | 3 |
| 7 | Security and Privacy | 0.924 | Excellent | 4 |

In general, a commonly accepted rule used in describing internal consistency involving Cronbach's alpha has it that a score equals or above 0.9 (i.e. $\alpha \geq 0.9$) is considered "excellent". Furthermore, it is considered "good" when it is more than or equals 0.8 but below 0.9 (i.e. $0.9 > \alpha \geq 0.8$), and "acceptable" when above or equals 0.7 but below 0.8 (i.e. $0.8 > \alpha \geq 0.7$). Score is considered "questionable" when equals or above 0.6 but below 0.7 (i.e. $0.7 > \alpha \geq 0.6$). Result is "poor" when a value falls between 0.6 and 0.5 (i.e. $0.6 > \alpha \geq 0.5$). However, score is considered "unacceptable" when the value is below 0.5 (i.e. $0.5 > \alpha$).

VI. CONCLUSION AND FUTURE WORK

In this study, validation of the proposed model was carried out by experts, alongside the validity and reliability of the developed instrument which was tested for all identified criteria. This pilot test will aid the research to further investigation in the future. Combination of both online and face-to-face survey was conducted to achieve data collection. Results confirm the validity of the proposed model as well as the validity and reliability of the instrument. The validity and reliability test results indicate that empirical study can be expanded, which is expected to lead to final model development and validation. The next step in the study would involve collecting a considerably large data sample size from the SME companies and empirically run the study. Future research intends to establish the degree of importance of the various identified variables as far as cloud service selection is

concerned. Structured Equation Modeling (SEM) will be employed to validate the research model. Proposition of SEM is based on its ability to provide overall tests of model fit and also allows for the simultaneous running of individual parameter estimate tests of the research.

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