A Summer Internship Project Report

On

"Evaluating Cloud Services Using DEA, AHP and TOPSIS model"

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Submitted by

SAURABH KUMAR

Roll No. – 13114022

Master of Technology [Industrial and Management Engineering] [2013-15]

Indian Institute of Technology, Kanpur

Under the Guidance of

Dr. G. R. Gangadharan

Assistant Professor

IDRBT, Hyderabad

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CERTIFICATE

This is to certify that the summer internship project report entitled "**Evaluating Cloud Services Using DEA, AHP and TOPSIS model"** submitted to **Institute for Development & Research in Banking Technology [IDRBT], Hyderabad** is a bonafide record of work done by "**SAURABH KUMAR", Roll no. – 13114022, IME-M.Tech., 2013-15, Indian Institute of Technology, Kanpur"** under my supervision from **"15th May, 2014**" to **"17th July, 2014"**

Dr. G. R. Gangadharan

Assistant Professor,

IDRBT, Hyderabad

Place: Hyderabad

Date: 17th July, 2014

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SAURABH KUMAR

IME-M.Tech., 2013-15, IIT Kanpur

Evaluating Cloud Services based on DEA, AHP and TOPSIS

Abstract:

With the revolutionizing of cloud services many cloud service are now commercially deployable like Amazon, HP, Azure, Google Compute Engine etc. These services have comparable functionality are available to cloud customers at different prices and performance. Often there is a trade-off between different functional and non-functional requirements as provided by different Cloud Providers. This makes difficult to evaluate the relative performance and their ranking based on user specific Quality of Service attribute.

The aim of this paper is to develop is to evaluate cloud services based in DEA, AHP and TOPSIS. The objective of the framework is to rank the cloud services according to the performance taking price also into the consideration. This not only enables customers to choose a cloud service that is most suitable to their requirement but also create a healthy competition among the Cloud Service Providers which makes them to find the areas where they are lacking and innovate ways to improve them.

The Objectives of paper is to Analyse and evaluate cloud services using Data Envelopment Model (DEA), Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model.

Keywords: Cloud Computing, Multi-Criteria-decision-Method, Ranking Technique, Evaluation of cloud service, DEA, AHP, TOPSIS

1. Introduction

Cloud Computing is a network based model whereby shared resources, software and Information are provided to computers and other devices on-demand, like a public utility. A user can access technology enabled services from the cloud through internet without owning the technology infrastructure that supports them [B.Hayes]. The ideology behind development of the cloud computing is that information processing can be done more efficiently and centrally on large firms of computing and storage systems accessible via Internet. The technology is now successfully embraced and commercialised by the companies such as Amazon, Apple, Google, HP, Microsoft and others. There are broadly three delivery models that are provided: Software-as-a-Software (SaaS), Platform-as-a-service (PaaS), Infrastructure-as-a-Service (IaaS) that are deployed as Public, Private, Community and Hybrid Clouds. The cloud offers enormous benefit to businesses by providing various services at reduced cost (pay for what you use) and they no longer needs to spend large amounts of capital on buying expensive application software or sophisticated hardware that they might never need.

With many public cloud services being deployed, several services with comparable functionality are now available to the cloud customers at different prices and performance. Often, there may be trade-offs between different functional and non-functional requirements fulfilled by different Cloud Providers. This make difficult to evaluate service levels of different cloud providers [Garg, SK]. Thus, a framework is required to evaluate relative performance and for their ranking based on user specific Quality of Service (QoS) attributes. Evaluation will provide the solution to customers to select most worthy cloud services that can satisfy their needs. Moreover, this enables a provider to know the potential improving areas to meet the customer demand and be competent with the needs of market.

This Paper address and discuss the relative evaluation of the cloud service performance for the cloud service providers including Amazon, HP, Azure, Rackspace, Google Compute Engine, Century Link and City-Cloud. For each service provider two service levels which differ in virtual cores and Memory are considered for the performance evaluation. The parameters considered for evaluating the QoS is user specific with a relative preference value. The following calculated Benchmark values are used for performance evaluation, though it can be any user specific.

- CPU Performance
- Disk I/O Consistency
- Disk Performance
- Memory Performance

Price of a service is dependent on number of virtual cores and Memory, so only Price of service is considered during the evaluation process. The two service level for each service provider is selected based on number of virtual cores in which we considered virtual core-2,virtual core- 4 and virtual core-8 for each service provider which among themselves differs on price and memory.

Following three models are used to analyse their relative performance and ranking-

- Data Envelopment Analysis (DEA) Model
- Analytic Hierarchy Process (AHP) Model
- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) Model

In the next section Literature Review of the existing model is discussed. In the section 3, we present Data Collection Methodology and Data Set Description. In section 4, Introduction to DEA Model analysis and its application and result in the evaluation of problem related to our case is discussed. In Section 5, Application of AHP in evaluation of cloud service and its result is discussed. In the section 6, Introduction to TOPSIS for evaluating cloud services and its application on our problem case is discussed. In subsequent section 7, we discuss the conclusion and future work followed by references.

2. Literature Review

In the following section we briefly describe existing model to evaluate the relative performance and ranking of the cloud services.

With the increasing popularity of cloud computing many research has been done to compare the cloud services for different types of application such as scientific computing, web services based on attributes such as security, accountability, assurance performance, cost etc, however there are papers which have done comparison based on properties of the alternative without the comparison of performance[Buyya R, Yeo CS, Venugopal S].

Another methodology for service selection of middleware in cloud computing environment is by using ELECTRE [Silas et al]. It IS based on multi-criteria decision making model. Parameters influencing the process of service selection were considered such as flexibility, time, service cost, scalability, trust, capability, etc. Metrics for measuring load handling, fault tolerance, scalability and cost is proposed in one of the research [Binning et al.]

Selection of product service based on Fuzzy- AHP and TOPSIS proposed in a paper [Chen et al] for aiding the customers in selecting product on the e-shop. It is based on multi-criteria decision making model.

A framework to find reliable cloud service providers using recommendation from reliable sources is proposed in a paper [Bedi]. Fuzzy Inference System (FIS) is used to address the uncertainty feature present in the recommendation.

In other work a framework CloudCmp was proposed to compare the performance of various cloud services [Li, Yang, Kandula]. In another paper [Garg, S.K] for calculating Iaas's QOS value and comparing performance of different cloud services, there is proposed framework by developing Key Performance Index metrics (KPIs) which are based on certain attributes such as Accountability, Agility, Assurance, etc.

3. Data Collection Methodology and Data Set Description

For the purpose of analysis with the models we have considered 7 cloud service provider including Amazon, HP, Azure, Rackspace, Google Compute Engine, Century Link and City-Cloud. Data are taken for the standard generation of cloud services offered by them. For each service provider two types of service offered by them are considered based on number of virtual core. The services with 2-virual core are specified as large cloud services, services with 4-virtual core are specified as extra large cloud services and services with 8-virtual core are specified as 2x-extra large cloud service. For each service, specified data for Price/Hr (cents), Virtual core, Memory (GB) are taken from their respective website. For evaluating the performance of the cloud services calculate benchmark values for CPU Performance, Disk I/O Consistency, Disk Performance and Memory Performance are considered from the benchmark evaluation site [www.cloudharmony.com].

The Dataset for the analysis is listed in Table 1.

The Cloud Service providers are coded as C1, C2....., and C7. The services provided by each are further coded as S1, S2 so on. The price for per hour usage is in Cents, the next column indicates number of virtual core and Memory (in GB) offered in the service. The next four columns are the benchmark values. Higher the value indicates better the performance for a service under that attribute.

Providers	Service	ce/Hr (cen	Virtual core	Memory	CPU Performa	Disk IO Consistency	Disk Performance	Memory Performance
C1	C1S1	28	4	15	25.86	92.89	110.33	129.03
	C1S2	56	8	30	48.23	53.28	67.22	131.79
	C2S1	14	2	7.5	13.89	114.44	97.38	144.86
C2	C2S2	28	4	15	23.66	119.63	100.55	131.81
	C2S3	56	8	30	51.7	77.46	73.44	125.59
C3	C3S1	16	4	4	7.21	70.29	125.48	54.28
	C3S2	32	8	8	15.33	57.11	111.18	55.68
	C4S1	18	2	3.5	8.83	67.87	83.73	52.27
C4	C4S2	36	4	7	16.07	67.97	78.49	61.8
	C4S3	72	8	14	28.4	78.72	70.91	27.33
	C5S1	12	2	4	16.41	23.43	40.23	80.67
C5	C5S2	45	4	15	32.4	29.07	42.47	90.83
	C5S3	90	8	30	52.82	35.35	55.07	83.92
	C6S1	8	2	4	17.34	43.02	141.23	51.71
C6	C6S2	16	4	8	37.05	36.15	102.74	132.87
	C6S3	32	8	16	71.11	39.66	99.15	135.88
	C7S1	10.132	2	4	23.43	89.31	173.49	89.84
C7	C7S2	20.8624	4	8	42.05	59.63	174.5	97.16
	C7S3	34.6528	8	16	75.89	64.64	174.12	100.14

Table 1 Dataset for analysis

4. Evaluation of Cloud Services using DEA

4.1 Introduction to Data Envelopment Analysis (DEA)

Data Envelopment Analysis is a linear based Multi-criteria Decision making model. DEA accords name Envelopment because the way it envelops the observations in order to identify "frontier" that is used to evaluate relative performance of all peer entities [cooper]. It was introduced by Charnes, Cooper and Rhodes as a "mathematical programming model applied to observational data that provides a new way of obtaining empirical estimates of relations ".

In the model each entity is represented by "Decision Making Unit" to represent operations or processes which convert multiple inputs to multiple outputs. There is same number of input and output for each DMU. The model maximizes the efficiency of a DMU subject to constraint that efficiency of all DMU's should be less than or equal to 1. Through the performance evaluation, the model determine "Efficient Frontier" that represents the relative best practices followed and inefficient strategy can be improved with suggested directions of improvement [Zhu Joe]. If a DMU is inefficient, then a combination of other efficient DMU's can either results in greater output for the same level of inputs or use fewer inputs to produce the same level of outputs or some combination of both.

There are two approaches to determine efficient frontier.

- Input Oriented
- Output Oriented

Input Oriented: The DEA model will be Input Oriented when Inputs are minimized keeping output as fixed at their current value. The objective function of input-oriented model subject to the constraint is given below. The purpose of objective function is to increase efficiency of a DMU by decreasing input while keeping output at the same level.

$\theta^* = min\theta$

Subject to

$\sum_{j=1}^{n} \lambda_j x_{ij} = \theta x_{io} \quad i = 1,2,3 \ldots, m;$

$\sum_{j=1}^{n} \lambda_j y_{rj} = y_{ro} \quad r = 1,2,3 \ldots, s;$

$\sum_{j=1}^{n} \lambda_j = 1$

$\lambda_j \geq 0 \quad j = 1,2,3 \ldots, n$

where DMU_o is one of n DMU's under evaluation and x_{io} and y_{io} represent the i^{th} and r^{th} output of DMU_o respectively. The efficiency score of a DMU_o is represented by θ^*. If θ^*=1, then the current input level cannot be reduced which indicate that DMU_o is on the "efficient frontier". Otherwise, if θ^*< 1, then DMO_o is inefficient and there is scope for increasing efficiency by reducing input with output kept at same level.

Output Oriented: It is complement of Input oriented model where outputs are maximized while keeping input level as constant. The objective function of output-oriented model subject to the constraints is given below.

$\theta^* = max\theta$

Subject to

$\sum_{j=1}^{n} \lambda_j x_{ij} = x_{io} \quad i = 1,2,3 \dots, m;$

$\sum_{j=1}^{n} \lambda_j y_{rj} = \theta y_{ro} \quad r = 1,2,3 \dots, s;$

$\sum_{j=1}^{n} \lambda_j = 1$

$\lambda_j \geq 0 \quad j = 1,2,3 \dots, n$

where the symbols have their usual meaning. If the efficiency score θ^*=1, then the current output level cannot be increased further without changing present input and that DMU is said to be on "efficient frontier". Otherwise, if θ^*> 1, then DMO_o is inefficient and there is scope for increasing efficiency by increasing output with input kept at same level.

Concept of Slack Variable:

There is also the possibility of improvement of a DMU which are located at same level as of another DMU of the efficient frontier. It can be done by either decreasing input or increasing output level. This either reduction in individual input or increase in individual output is called Input Slack or Output Slack respectively. In fact it is possible that that both input and output slack exist in model. We have

$$s_i^- = \theta^* x_{io} - \sum_{j=1}^{n} \lambda_j x_{ij} \quad i = 1,2, \dots, m \qquad \text{(INPUT SLACK)}$$

$$s_r^+ = \sum_{j=1}^{n} \lambda_j y_{rj} - y_{ro} \qquad r = 1,2,3 \dots, s \qquad \text{(OUTPUT SLACK)}$$

So in the step 2 after calculating θ^* in equation----, is to use following linear programming model to determine the possible slack for each input and output.

$$max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta^* x_{io} \quad i = 1,2, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro} \quad r = 1,2,3 \dots, s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,2,3 \dots, n$$

If for a DMU, θ^*=1 however $\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \neq 0$ then that DMU is said to be ***weak efficient DMU.***

4.2 DEA model for cloud services

For the set of user specific performance attribute, not only it is necessary to determine which one is performing better with perspective of client but for a service provider they need to know the areas where they were lacking and need improvement in the efficiency. DEA model can address these problems by considering a cloud services as Decision Making Unit (DMU) and Price per hour as Input and Performance Benchmarks as Output parameters. DEA model will locate which among the cloud services lie on the efficient frontier that is they are performing relatively high, however there is still chance of improvement for these services if Slack Variable in non-zero. The DEA model gives the projected value, for improving the performance of a service which does not lie on the efficient frontier. To give preference to the QOS attribute for measuring the performance of the cloud services we do slight modification in the model shown below:

$\theta^* = min\theta$

Subject to

$\sum_{j=1}^{n} \lambda_j x_{ij} = \theta x_{io} \quad i = 1,2,3 \dots, m;$

$\sum_{j=1}^{n} \lambda_j y_{rj} = w_r\, y_{ro} \quad r = 1,2,3 \dots, s;$

$\sum_{j=1}^{n} \lambda_j = 1$

$\lambda_j \geq 0 \quad j = 1,2,3 \dots, n$

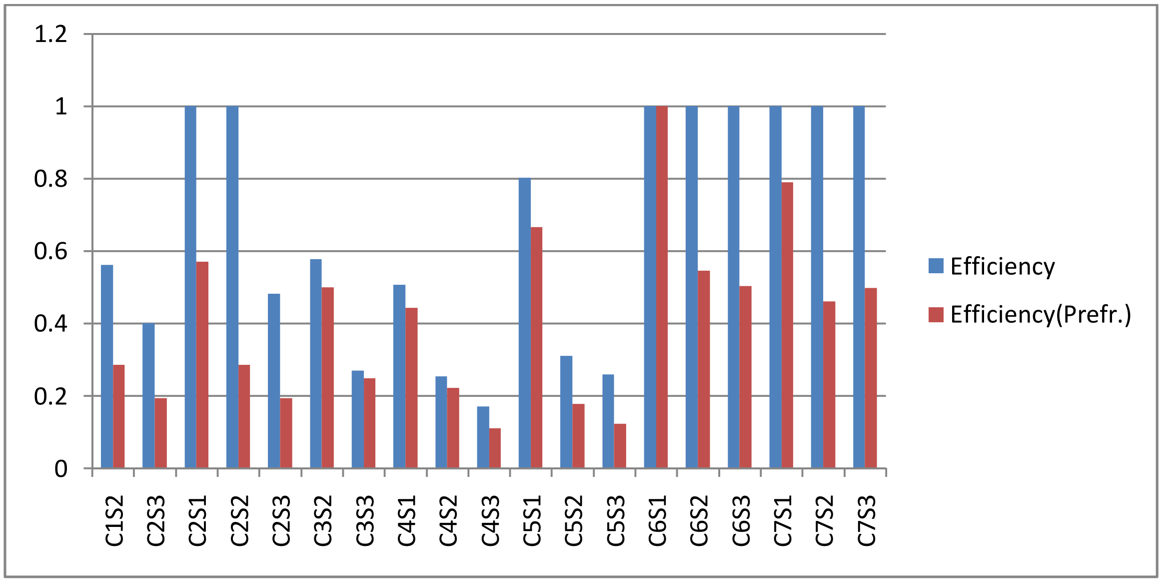
where w_r is the relative preference weights for a output parameter "Output r". Other notations have their usual meanings.

4.3 RESULTS and Discussion

This analysis is based on the input-oriented DEA models as described above, which addresses the problem "By how much can input parameter (Price/Hour) be proportionally be decreased without changing the output parameter (Performance Benchmark values)". The Input parameter that was considered for the analysis is Price/Hour charged by the cloud service provider for a cloud service. We employed four output parameters; however any number of parameter can be included for both output and input. The output parameters were Performance Benchmark which includes CPU Performance, Disk I/O consistency, Disk Performance and Memory Performance. The performed DEA is carried out with variable return to scale assumption by giving the constraint to the model:

$$\sum_{j=1}^{n} \lambda_j = 1$$

This variable return to scale approach gives technical efficiency scores.



PROJECTED VALUE USING SLACK VARIABLE CONCEPT

Providers	Service	ce/Hr (cents)		CPU Perf.	)isk IO Con	Disk Perf.	1emory Per	Total Slack
C1	C1S1	1.2E-10		8.84E-12	4.11E-11	6.775443	-1.3E-11	6.775443
	C1S2	8.979747		-6E-11	-5E-10	39.84286	-4.6E-10	48.82261
	C2S1	0		0	0	0	0	0
C2	C2S2	0		0	0	0	0	0
	C2S3	4.411081		0	0	0	0	4.411081
C3	C3S1	0		0	0	0	16.01	16.01
	C3S2	9.335628		0	0	0	1.43	10.76563
	C4S1	0.971797		0	0	0	15.6	16.5718
C4	C4S2	11.08352		0	0	0	6.17	17.25352
	C4S3	28.10646		0	0	0	51.39	79.49646
	C5S1	0		0	0	0	0	0
C5	C5S2	11.2942		0	0	0	0	11.2942
	C5S3	27.17352		0	0	0	0	27.17352
	C6S1	0		0	0	0	0	0
C6	C6S2	0		0	0	0	0	0
	C6S3	0		0	0	0	0	0

Results of DEA model is shown in the figure, the result in 'BLUE' is the efficiency score of DMU's, it can be seen the services C2S1, C2S2, C6S1, C6S2, C6S3, C7S1, C7S2 and C7S3 have relative efficiency score of 1 and they lie on efficient frontier line. However, the ranking among the efficient services cannot be obtained directly using the DEA model.
For the ranking of non-efficient frontier relative efficiency score can be used. One Paper [Adler N.,Friedman L.] review to ranking of DMU's with the concept of super efficiency and cross-efficiency ranking. We slightly modified the DEA model to include additional preference weights for Qos Attribute (the weights are same as used in other models and is calculated by the use of AHP model explained later in the paper). The result is shown with Red in the Figure. C6S1 is performing relatively the beat among other. For other ranking can be done based on new efficiency score.

There is some Properties of DEA model:

- There is no change in the efficiency if there is same increasing the inputs and outputs level of a DMU.
- If a DMU is efficient under input-oriented then it will be efficient under output-oriented model also.

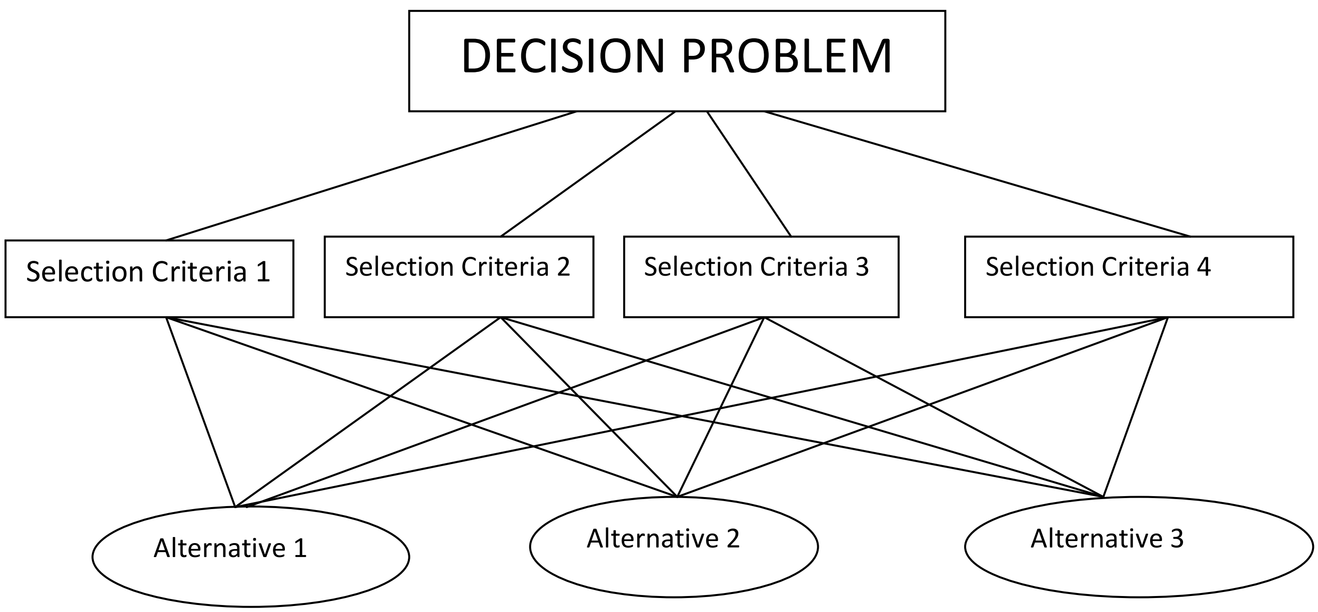
However,

- DEA model are heavily relied on the outliers and it does not smooth them away.
- There is no thumb rule which specify number of variables to use and whether model is consistent but as more variables are added, efficiency score increases and variability decreases which results in greater number of DMU's thus end up on efficient frontier. Although there should be enough peer available to make useful comparison.

5. Evaluation of Cloud Services using Analytic Hierarchy Process (AHP)

5.1 Introduction to AHP Model

Developed by T.L. Saaty, it is a tool for analysis and comparing complex application with multi-criteria decision making process. AHP model enables decision makers to set preferences and make decision accordingly [Saaty, T.L.].



A problem is represented in either hierarchic or network and pair wise comparison to estimate relative strength of preference on a ratio scale. The comparison is done based on the fundamental scale of comparison between the pair. The Table below is the fundamental comparison scale for AHP model.

INENSITY of IMPORTACE	Definition
1	Equal Importance
3	Moderate Importance of one over another
5	Essential or Strong Importance
7	Very Strong Importance
9	Extreme Importance
2,4,6,8	Intermediate value between the two adjacent judgment

First, step is to establish priorities for the selection criteria by judging them in pair for their relative importance thus generating a pairwise comparison matrix. So number of pairwise comparison needed for a particular matrix of order n is n(n-1)/2 as it is reciprocal and diagonal elements are equal to unity. In the next step the alternatives are compared with respect to each of the criteria leading to three pairwise comparison matrixes. In the final step, Final priorities of the alternatives are obtained by weighting or synthesising by computing eigenvector of the matrix.

To validate the weighted result, next step is to validate using consistency matrix. Consistency ratio (CR) is calculated which indicate how inconsistent the matrix is. If CR is greater than 0.1 , then the calculated ratio matrix in too inconsistent for a trustworthy result. Consistency Ratio is ratio of Consistency Index (CI) to Random Index (RI).

$$\text{Consistency Ratio (CR)} = \frac{\text{Consistency Index (CI)}}{\text{Random Index(RI)}}$$

Where, Consistency Index (CI) is

$$\frac{\lambda_{max} - n}{n - 1}$$

λ_{max} is principal Eigenvalue of the reciprocal n x n matrix. Consistency index basically tells about how far the principal eigenvalue is from consistent case.

And, Random index (RI) for a size n is the average CI calculated from a large number of reciprocal matrixes.

5.2 AHP model for cloud services

First, in order to determine the relative importance of the QOS attribute, we use AHP model to give weights. The importance is specific to user requirement. In the matrix weights are assigned based on pairwise comparison. The diagonal value is 1. Only upper triangular part of the matrix is needed to be filled up, lower triangular is reciprocal of upper triangular part. The attribute in the table column is given weights relative to the attribute of table row.

$$\begin{array}{c} \\ \text{Attribute1} \\ \text{Attribute2} \\ \text{Attribute3} \\ \vdots \\ \text{Attribute n} \end{array}
\begin{array}{c} \begin{array}{ccccc} \text{Attribute1} & \text{Attribute2} & \text{Attribute3} & \cdots & \text{Attribute n} \end{array} \\ \left\{ \begin{array}{ccccc} 1 & W_{12} & W_{13} & \cdots & W_{1n} \\ 1/W_{12} & 1 & W_{23} & \cdots & W_{2n} \\ 1/W_{13} & 1/W_{23} & 1 & \cdots & W_{3n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ 1/W_{1n} & 1/W_{2n} & 1/W_{3n} & \cdots & 1 \end{array} \right\} \end{array}$$

In the next step, the resultant matrix is normalized, averaged to obtain weights for the QOS attributes. Consistency Ratio (CR) is obtained to check whether the matrix is consistent and weights are valid. If obtained CR<= 0.1, then the weights are valid as the Ratio tell how inconsistent the matrix is.

Next, in order to compare the cloud services are compared with respect to each of the attribute by normalizing the data with respect to a particular attribute, and then resultant rank based on benefit for the attributes in preference is computed by summing weighted normalized attribute ratio for each cloud services. Final ratio and ranking is computed by taking Price into consideration and calculating Benefit to Price ratio.

5.3) Results and Discussion

In our analysis for evaluation of cloud services using AHP, we took seven cloud service providers which include Amazon, HP, Azure, Rackspace, Google Compute Engine, Century Link and City Cloud.

The Table below shows the relative importance of among QOS attribute. For example, relative importance of CPU performance is 5 times as that of Disk I/O consistency and relative importance of Disk Performance is 0.25 (1/4) times as that of Memory Performance, and its reciprocal is in lower triangular matrix i.e. Memory Performance is 4 times as important parameter as Disk Performance.

	CPU Perf	Disc I/O	Disc Perf	Mem Perf
CPU Perf	1	5	4	2
Disc I/O	0.2	1	0.5	0.33
Disc Perf	0.25	2	1	0.25
Mem Perf	0.5	3	4	1

In the next step, after normalizing the resultant matrix and averaging the value, we get following weights

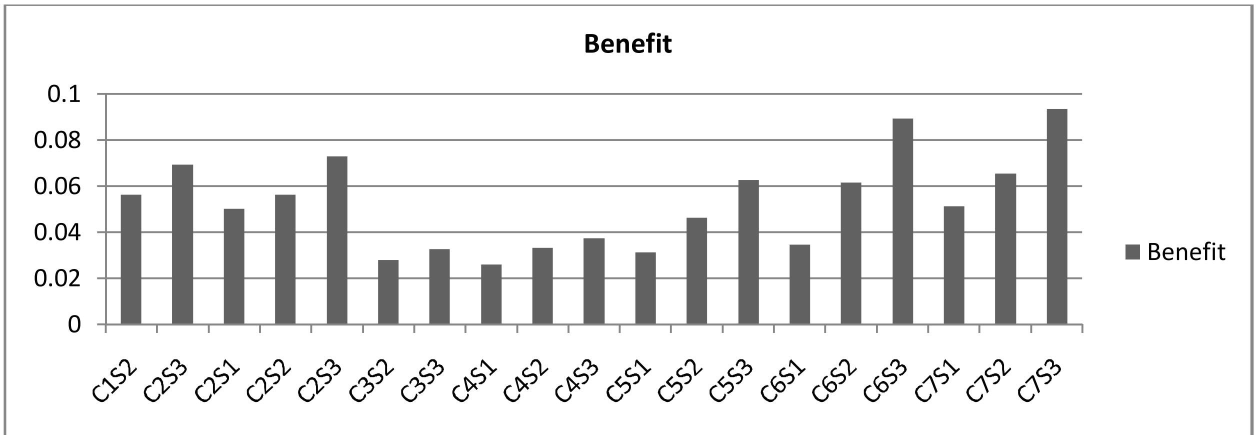
CPU Performance -	48.66%
Disc I/O Consistency-	8.48%
Disc Performance-	12.13%
Memory Performance-	30.73%

To check the consistency of the calculated weights, Consistency Ratio (CR) is obtained which is 0.040291. As Consistency Ratio tell how inconsistent the matrix is, and the result is acceptable if CR <= 0.01. So our matrix is consistent and weights are valid.

These Weights were also used in DEA, TOPSIS and AHP model.

The result with Benefit Ratio based ranking and Benefit to Price ratio based ranking is shown in figure.

In terms of Benefit cloud service C7S3 and C6S3 which is provided by the service provider C7 and C6 respectively are relatively has highest performance. When taking price factor also in consideration still cloud service provider C7 and C6 are relatively performing best however the services C7S1 and C6S1 have the highest ratio. So for a user having intensive dependence on the cloud can opt for either C7 or C6 with service S3 which is with virtual Core 8 processor. Whereas for those with less intense work load on cloud can opt for Cloud service C7 or C6 with service S1 which is processors with virtual core 2.



6. Evaluation of Cloud Services using TOPSIS

6.1) Introduction to TOPSIS model

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is introduced by Chen and Hwang. It is a Multi Attribute Decision Making (MADM) technique that sorts the alternatives for a decision problem in order of distance from the ideal solution and negative ideal solution. The best solution is the one which has minimum distance from the ideal solution and maximum distance the negative ideal solution. The ideal solution is the one with each criteria value having the optimal value when comprehensively evaluated. Similarly, the negative ideal solution is the one with each criteria value have least optimal value.

In briefly the procedure for TOPSIS model described below:

Step 1: Determine the Decision Problem and identify the relevant evaluation criteria

Step 2: Develop the preference for the criteria by assigning them weight.

Step 3: Construct the Decision Matrix for the alternative based on the criteria, where each row represent one alternative and column allotted to each criteria. So element S_{ij} refer to i^{th} alternative and j^{th} criteria.

Step 4: Find the normalized decision matrix for the above Decision Matrix.

Step 5: Compute the weighted normalized decision matrix by multiplying weights of criteria with the corresponding alternatives value.

Step 6: Determine the ideal solution i.e. best performance from each criteria.

Step 7: Determine the negative ideal solution i.e. least performance from each criteria.

Step 8: Compute separation of each criteria value for each alternative from both ideal and negative ideal solution.

Step 9: Determine for each alternative, the ratio R equal to separation of criteria value from negative ideal solution to the sum of separation of criteria value from negative ideal solution and ideal solution. Value of R refer relative closeness to the ideal solution

Step 10: Ranking the alternatives based on the value of R.

6.2) TOPSIS model for Cloud Services

For the analysis of cloud services, we can use benchmark values and also Price per hour for the usage of cloud services as criteria. So in this case, ideal solution is maximum value of performance-oriented benchmark under each criteria and minimum value of price data and time-oriented benchmarks are considered. Whereas in case of negative ideal solution is minimum value of performance-oriented benchmark and maximum value of price data and time-oriented benchmark are considered.

6.3) Results and Discussion

For the analysis of cloud services, we use Price per Hour, CPU Performance, Disk I/O Consistency, Disk Performance and Memory Performance as criteria and cloud services C1S1, C1S2,……, C7S3 as the alternatives. For giving the preference to the criteria we use same that we developed using AHP.

Ideal solution is obtained by considering maximum value under each benchmark attribute and minimum value under Price/Hour attribute. Similarly, Negative ideal solution is obtained by considering minimum values among Benchmark attribute and maximum value under Price/Hour attribute among the cloud services. The final result of calculated ratio for the cloud services is shown in the figure

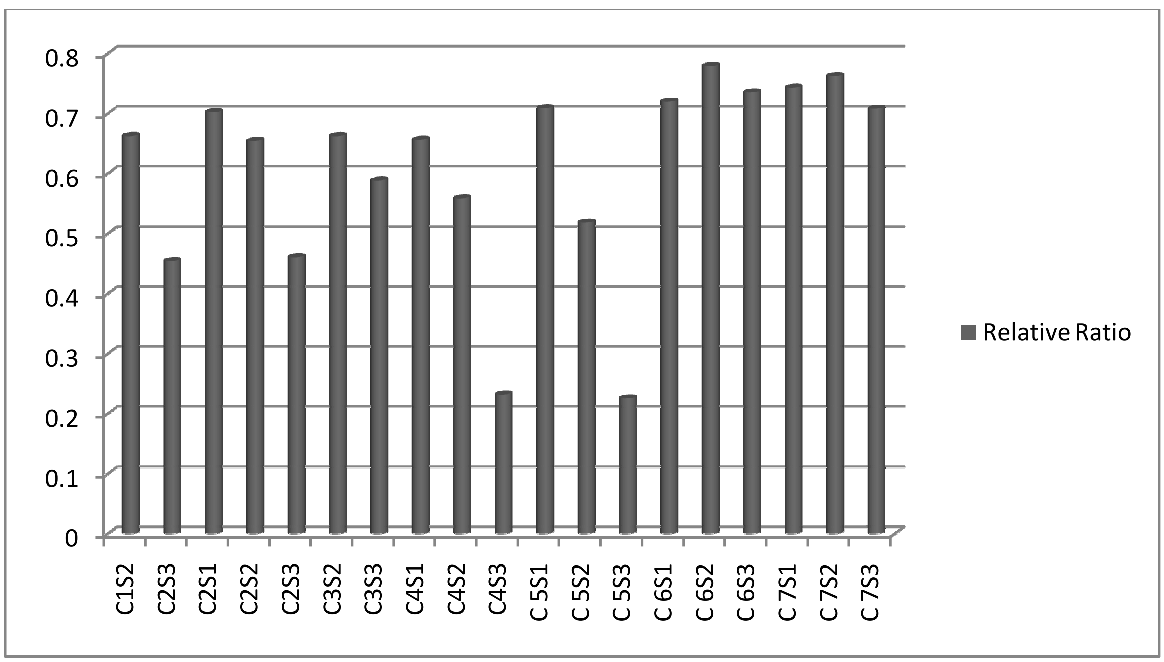


Figure 1 Cloud Service Evaluation using TOPSIS

According to TOPSIS model also, service provider C6 and C7 are performing relatively better. C6S2 service is relatively has best performance with Relative Ratio of 0.778, which indicates that the service is 77.8% of the ideal solution. Among the virtual core-8 service also service provider C6 with service C6S3 is performing the best with the ratio of 73.5%. For the service among virtual core-2, service provider C7 with service C7S1 is relatively performing better.

Interestingly, it can be seen that Service Provider C4 and C5 are performing well in the service with virtual-core-2 but the ratio decrease for their service with virtual-core-4 and 8. This may be because the ratio of providing high quality of service to price charged is very low which means that they are charging heavily for providing more quality service.

CONCLUSION AND FUTURE WORK

With the growing demand for the cloud service there are many cloud service providers are available with many cloud services with different prices and performance. It has now become challenge to for cloud customers to select the best cloud service which will satisfy their required QoS attribute. To select the best service customers need to have a framework to identify and measure key performance criteria according to their requirement in the applications.

The Study discussed how to select the best cloud service model among various service providers based on user specific QoS attributes. Although many frameworks exists to evaluate the performance of cloud service, the study introduced DEA model for the evaluation of cloud services which has added advantage that it give projected values for increasing the performance to a competing level. Other models that were used to evaluate the performance of cloud services were AHP and TOPSIS. AHP was used to evaluate the relative preference of QoS attribute. The consistency ratio for the developed attribute was 0.0402 which is less than 0.1 for valid weights for preference attribute. We used this preference weights in analysis with the other models

In future we will incorporate other performance benchmarks other than traditional High Performance Computing Benchmarks as these benchmarks focus primarily on static system specific to performance and cost. A Paper [Binning] propose metrics for measuring peak load handling, fault tolerance of cloud computing, scalability and cost.

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