A cloud virtualisation service quality survey platform with an IPA discrimination index

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ABSTRACT: Cloud computing has been utilising computing resources via a high bandwidth network to facilitate the execution of complicated multi-tasks that require large-scale computing. In this article, the authors propose a novel cloud multiple-function service quality survey system. The survey system will allow users to either choose one option with one category or spread their super multiple options with multiple categories for each question with results in a multi-level scale. To analyse service quality performance, the system proposed here has adopted a new importance-performance analysis (IPA) model discrimination index, which will reflect a more accurate quantity than the original IPA model proposed by Hollenhorst. Further, the proposed index has been implemented to compare and distinguish between the effects of different types of research event. Adopting this proposal to compare the homogeneous service quality of education activity, the results demonstrate that the new scheme has better information for performance comparisons. Furthermore, the IPA discrimination index will identify extra information to improve quality, and will determine a proper means of comparison.

INTRODUCTION

Cloud computing involves the distribution of a computing service rather than a computing product; i.e. to share resources, software and information provided via computer and other devices as a quality service utilising the Internet. The cloud provides computation abilities, software, data access and storage resources without requiring cloud clients to know the details of IT infrastructure. Therefore, cloud is a virtual resource environment for end-users. Cloud clients can get any amount of these resources without having first to acquire servers or other computing equipment. To provide a ubiquitous service, some cloud-based or Web-based services have also been discussed in the literature [1-4].

The IPA, first proposed by Martilla and James in 1977 [5], can be used to analyse the importance and performance of service quality [6][7]. The analysis process can be implemented in the following four steps [8][9]:

- Defining each attribute of the service that will be used in the questionnaire.
- Ranking all the attributes and arranging them according to their importance and performance level. The importance-performance scale requires participants to rate how important each attribute is to them (i.e. need for courses or seminars). Participants were then asked to rate how well they performed on each of the respective attributes. The word *perform* denotes satisfaction with user participating.
- Placing each attribute into a two-dimensional coordinate with *performance* as the X-axis, *importance* as the Y-axis and *ranking levels* as the coordinates.
- Dividing the two-dimensional coordinate into four quadrants (A, B, C and D) with a middle point.

Quadrant A: the service attributes in this quadrant are represented as *concentrate here*, with high importance and low performance.

Quadrant B: the service attributes here are marked *keep up the good work*, with high importance and high performance.

Quadrant C: the service attributes located in this quadrant are *low priority* with low importance and low performance.

Quadrant D: the service attributes in this quadrant are referred to as *possible overkill*, with low importance and high performance.

Generally, the IPA is a useful and powerful technique for identifying service quality that provides remedial and strategic actions. The IPA has been deployed in different research and in practical domains in many fields. Moreover, there are many research topics, where the IPA proved its usefulness, such as telecommunications [10], service quality of transportation [11] and as a case study in the education arena [12].

Generally, a Web-based questionnaire is characterised by speed, asynchrony and lack of intermediaries. Consequently, it has been widely accepted in academic and business domains. It further improves the efficiency in the collection of questionnaires. The cloud service meets the flexible survey requirements for a huge number of concurrent users from answering questions on-line. In this article, a novel cloud virtualisation service quality survey platform with an IPA index is proposed. It improves survey face validity, in which the discrimination index of the IPA model will reflect a more accurate quantity comparison. Applying the IPA model will generate potential information for customer satisfaction surveys. In order to evaluate the effectiveness of user satisfaction and resource allocation, a more valid and reliable instrument is needed. The new IPA discrimination index will show differences, as well as identify and compare to other multiple surveys. It is a useful, enhanced and novel tool for performance discussion with the IPA model. The performance analysis has demonstrated that the proposed new IPA discrimination can effectively show the differences.

CLOUD VIRTUALISATION SERVICE QUALITY SURVEY PLATFORM

The cloud computing structure improves the scalability of the traditional Web-based questionnaire system to facilitate high-speed interactions and accommodate a large number of concurrent on-line users. The design of the cloud virtualisation survey platform includes an IPA analysis model to provide useful analysis results about user satisfaction for managers. The cloud survey platform can not only provide the cross-platform user with on-line feedback, but also can provide loading shares based on concurrent users' requests. Furthermore, the advanced IPA analysis model both judges and identifies homogeneous survey results. There are three units in the proposed cloud virtualisation platform: a management service, a questionnaire computing service and a Dbase service. The management service can allow survey managers or users to maintain or answer questionnaires on-line. To support the large number of concurrent user responses to the questions, the management service can distribute system loading for different questionnaire computing services, meeting the requirement for computing resources by the virtualisation platform of the Dbase service. To provide consistent user feedback results, the questionnaire computing service temporarily saves all the answers and individually inserts the feedback to the Dbase service all at once when all the users' questionnaires are complete. The detailed functionality of the three services is as follows.

- Management service: the management service model is shown in Figure 1. It provides an on-line graphical interface for users with different capacities to use the PHP and JSP programming language to operate and manage the cloud survey platform throughout the main program and to use the MySQL database to store survey system configurations. Considering concurrent on-line users, the management service will automatically assign the appropriate computing in response to users' requirements and then cooperate with the Dbase service.
- Dbase service: the Dbase service model is shown in Figure 2. To provide dynamically computational images of the virtual machine utilising Oracle VirtualBox software, the Dbase service can create a virtual machine client from the questionnaire computing service when the management service allocates the computing resources. To manage the virtual machine images, the Dbase service maintenance program with Java RMI can access, replace and create images via the NFS protocol. It also can share computing loading and control connection performance.
- Questionnaire computing service: the questionnaire computing service model is shown in Figure 3. The questionnaire computing service is a simple virtual machine system via NFS protocol with a Java program. The physical hardware of the questionnaire computing service would provide computational resources in response to the management and Dbase services' allocations. There are many real servers with CPU, memory and a high bandwidth network connection that could utilise this questionnaire computing service for computing requirements.

The real-time management and performance condition of the proposed cloud virtualisation survey platform can be shown on-line as in Figure 4. The state monitor can display each system resource of the questionnaire computing service, such the CPU usage, memory and disk capacity. Moreover, the state control functionality can be controlled manually by the system manager. The manager can use the state monitor control panel to quickly identify problems and find corresponding solutions.

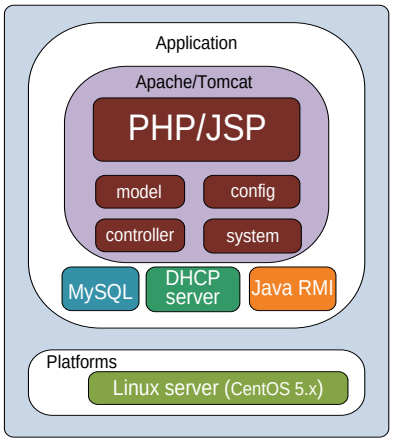

Figure 1: Management service model.

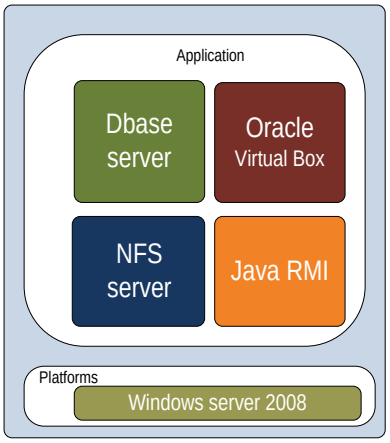

Figure 2: Dbase service model.

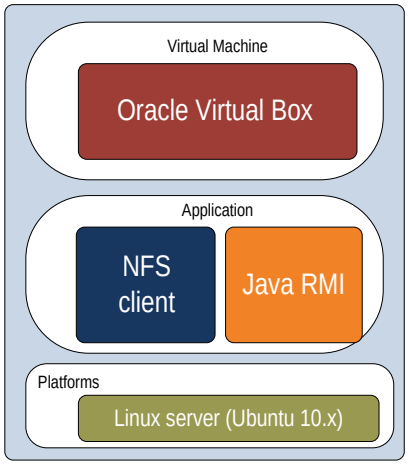

Figure 3: Questionnaire computing service model.

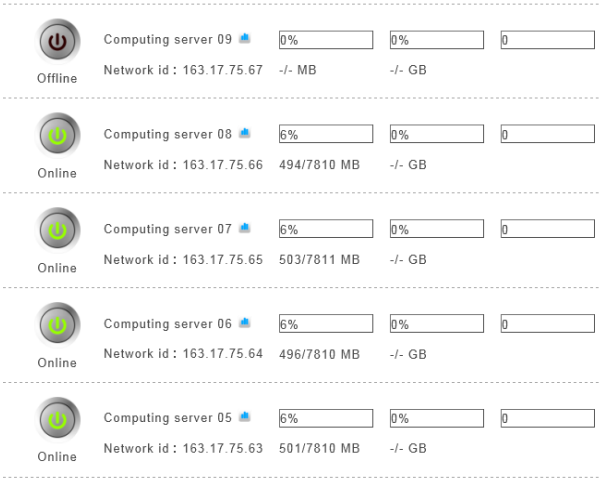

Figure 4: State monitor of the cloud virtualisation survey platform.

INTEGRATION OF THE STATISTIC IPA MODEL AND THE CLOUD MULTIPLE-FUNCTION SURVEY SYSTEM

When it is on-line, the cloud service quality survey platform can design the main survey content as a blue block (as shown in Figure 5); the multiple-category and flexible scale range for each question as a red block; and the survey management and statistics report as a green block. The format of the questionnaire for this research is based on the basic framework of the Web-based multiple-option questionnaire proposed by Chen in 2010 [13], the enhanced version was proposed in 2014 [14]. It is a highly interactive Web system and is designed with the PHP and AJAX functionality.

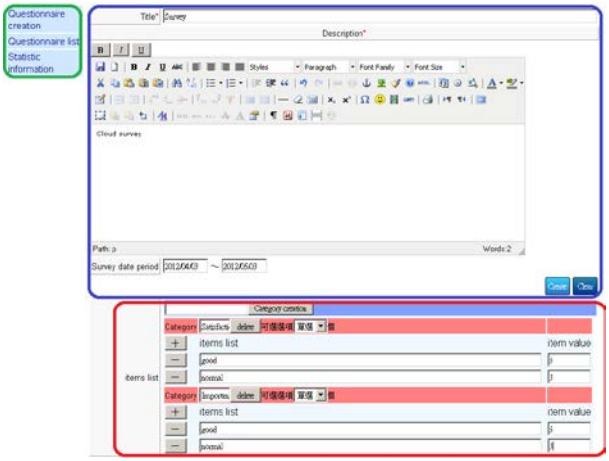

Figure 5: Cloud virtualisation service quality survey platform basic interface.

INTEGRATION OF THE STATISTIC IPA MODEL AND THE CLOUD MULTIPLE-FUNCTION SURVEY SYSTEM

The IPA model can present some potential information between different portions of a questionnaire for decision making, so by supporting the inter-survey performance analysis, this will improve the scalability of survey analysis. There is an extension viewpoint of the importance-performance mapping, which is a 45-degree line; namely, the iso-rating or iso-priority line to show the equal value of two importance-performance categories in the article [15]. By mapping the score of question items against the iso-rating line, when the points are above the line, it is an indication that importance exceeds performance, whereas the points below the line indicate otherwise. To adopt the line can provide extra concepts with two classes for IPA model discussion. Though the IPA and the IPA iso-rating line can divide items for several classes, the quantity can be identified.

Considering further comparisons with the IPA model, the proposed index can be implemented to compare and distinguish the differences between IPA results. It is well known that there are four individual quadrants in an I-P matrix, if any item is located inside Quadrant B or C, then it means positive service. Otherwise, it must be improved. However, there is no quantitative method to determine the performance between any two IPA models. In the authors' previous work, a discrimination index of the IPA model was proposed as Formula (1) [16]. The diagonal line across the importance-axis and performance-axis intersection with slope = 1 is the best location of the IPA model, and the contributing value of each point in Quadrant B or C is positive. In addition, it is a negative value when the paint marks on Quadrant A or D.

However, if $(x_i-\bar{x})(y_i-\bar{y})=0$, then $\left|(x_i-\bar{x})(y_i-\bar{y})\right|=0$ and $D_{index\text{-}ori\text{-}1}$ is undefined; hence, the above mentioned discrimination index must be amended. Moreover, $\left[(x_i-\bar{x})-(y_i-\bar{y})\right]^2$ is more sensitive than $\left|(x_i-\bar{x})-(y_i-\bar{y})\right|$, therefore, an improved discrimination index of IPA model is shown in the paper by Chen et al [17] as Formula (2) as follows:

$$D_{index-ori-1}=\frac{1}{n}\sum_{i=1}^{n}\left[\frac{1+\frac{(x_i-\bar{x})(y_i-\bar{y})}{\left|(x_i-\bar{x})(y_i-\bar{y})\right|}}{2}-\frac{\left|(x_i-\bar{x})-(y_i-\bar{y})\right|}{\max\limits_{1\le i\le n}\left|(x_i-\bar{x})-(y_i-\bar{y})\right|}\right] \tag{1}$$

$$D_{index-ori-2}=\frac{1}{n}\sum_{i=1}^{n}\left[\frac{1+\mathrm{sgn}(x_i-\bar{x})(y_i-\bar{y})}{2}-\frac{\left[(x_i-\bar{x})-(y_i-\bar{y})\right]^2}{\max\limits_{1\le i\le n}\left[(x_i-\bar{x})-(y_i-\bar{y})\right]^2}\right] \tag{2}$$

To emphasise the effect of positive and negative parts of the quadrants, the points inside Quadrant A and B (the red block shown in Figure 6) should have higher impact than the other location points. It can be assumed that each point of Quadrant B has twice the weight of Quadrant C's point, otherwise the points of Quadrant A also have twice value. The new IPA discrimination index is shown as Formula (3). The value of D_{index} is between 0 and 1, $0 \le D_{index} \le 1$. The higher the value is, the better performance of IPA is.

$$\begin{aligned}
&D_{index}=\frac{1+D_{index}}{2}=\frac{1}{n}\sum_{i=1}^{n}\left[a_i-b_i\frac{\left|(x_i-\bar{x})-(y_i-\bar{y})\right|-d_m}{d_M-d_m}\right]\\
&(a_i,b_i)=\begin{cases}(1,0.5) & if\ (x_i-\bar{x})\ge 0,(y_i-\bar{y})\ge 0\Rightarrow 0.5\le D_{index}\le 1\\ (0.75,0.25) & if\ (x_i-\bar{x})\le 0,(y_i-\bar{y})\le 0\Rightarrow 0.5\le D_{index}\le 0.75\\ (0.5,0.5) & if\ (x_i-\bar{x})\le 0,(y_i-\bar{y})\ge 0\Rightarrow 0\le D_{index}\le 0.5\\ (0.5,0.25) & if\ (x_i-\bar{x})\ge 0,(y_i-\bar{y})\le 0\Rightarrow 0.25\le D_{index}\le 0.5\end{cases}\\
&d_M=\max_{1\le i\le n}\left\{\left|(x_i-\bar{x})-(y_i-\bar{y})\right|\right\}\\
&d_m=\min_{1\le i\le n}\left\{\left|(x_i-\bar{x})-(y_i-\bar{y})\right|\right\}\\
&\Rightarrow 0\le D_{index}\le 1
\end{aligned} \tag{3}$$

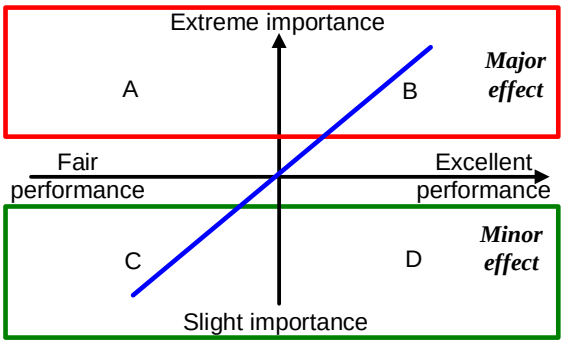

Figure 6: The effective value of IPA area.

COMPARISON OF DISCRIMINATION INDEX AMONG EDUCATION SERVICE QUALITY SURVEY RESULTS

To identify the new IPA discrimination index of the proposed service quality survey system, the survey results of the performance analysis are shown as follows. The reliability of this statistical analysis can be shown on-line via the proposed cloud virtualisation service quality survey platform. A further example of the IPA analysis is shown by three categories with the same questionnaire. The IPA discrimination index can help in analysing the importance and performance of education seminars, such as *IT Applications for Teaching*, *IT Ethics*, and the *Free Software Application*. Moreover, the proposed IPA discrimination index can show the difference between IPA results with the same or a similar survey concept.

The proposed new IPA discrimination index can identify classifications of the service quality survey results to check the quality of the inter-seminars. The overall mean of the I-P matrix for the basic performance of the three education seminars is shown in Table 1; IT Ethics has the highest overall mean value and the IT Application for Teaching has the lowest overall mean value. Based on the results of the overall mean value, the IT Ethics seminar might have the best performance. However, the IPA model can provide more information than just the basic overall mean value. The three

I-P matrixes are shown in Figure 7, Figure 8 and Figure 9, and the calculation of the question items is shown in Table 2. According to Table 2, the IT Ethics seminar has two question items in Quadrant A, but the Free Software Application only has one item in this quadrant. The IT Ethics seminar has only 12 items in Quadrant B, which is less than the 14 items for the Free Software Application. The result of the IPA model indicates that the Free Software Application is better than the IT Ethics, which contradicts the result suggested by the overall mean value of importance and performance. Based upon this finding, Hollenhorst's IPA model might perform poorly in comparison to the different types of importance and performance results [6].

The traditional IPA model only can provide a qualitative analysis across different results for the same questionnaire sample and a different distribution of questions. To improve the analysis of the IPA model and check both the quality and quantity of the inter-seminars, this novel cloud survey platform utilises its new IPA discrimination index to identify the characteristics of the different types of education seminars. Based on the results, the distribution of questions in the three seminars is different. If Quadrant A is the most important part of the user satisfaction results, the Free Software Application seminar might have the best performance since there is only one item inside this quadrant. However, the rough quadrant analyses of these surveys were identical and the I-P matrixes were similar. The IPA discrimination index can be applied to re-check and identify the surveys from homogeneous inter-seminars and the results can, then, meaningfully suggest which seminar might have a better performance in the IPA model.

Table 3 is based upon the comparison of I-P matrixes from these three types of seminars. The Free Software Application has the highest performance value (0.7613), so the index value has corresponded to the I-P matrix analysis and supplied a quantitative demonstration. It can, therefore, be argued that the Free Software Application has the best performance and that the participants recognised the greater value of this type of education training seminar.

Table 1: The overall mean of three seminars.

	IT Application for Teaching	IT Ethics	Free Software Application
Importance	4.684	6.3685	6.3187
Performance	4.6519	6.2493	6.2409

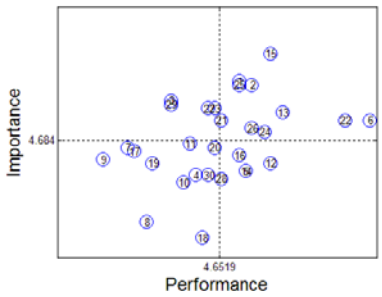

Figure 7: I-P matrix of IT Application for Teaching.

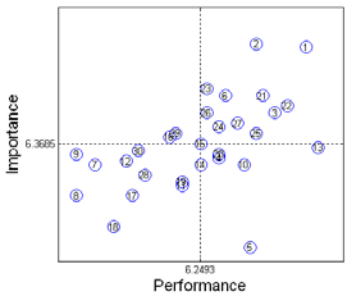

Figure 8: I-P matrix of IT Ethics.

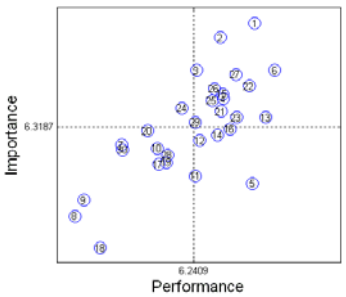

Figure 9: I-P matrix of Free Software Application.

Table 2: Number of questions distribution of three seminars.

Quadrant	IT Application for Teaching	IT Ethics	Free Software Application
Quadrant A	4	2	1
Quadrant B	10	12	14
Quadrant C	11	10	10
Quadrant D	5	6	5

Table 3: The discrimination index of three seminars.

	IT Application for Teaching	IT Ethics	Free Software Application
D_{index} value	0.6293	0.7373	0.7613

CONCLUSION

In this article, the authors asserted that the cloud virtualisation service quality survey platform with a new IPA discrimination index can provide a better assessment of user feedback. Based on an analysis of education seminars, the performance of similar seminars can be studied in detail by comparing the IP matrixes. In addition, the discrimination index can alert researchers to practices or approaches that should be implemented in order to improve the

performance of the education training seminars; thereby, ensuring a better allocation of resources and more effective budget planning. Adopting the authors' new IPA discrimination index not only allows a comparison between service quality survey results, but also allows the results to be based on the same criterion. The practical experiments carried out by the authors demonstrate that this IPA index performs better and can provide some extended, useful service quality information. The IPA model with the IPA discrimination index, therefore, might be a useful, flexible and large scale performance tool for many working areas (e.g. education, business, industry) with survey requirements.

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