USABILITY EVALUATION OF SOME POPULAR PAAS PROVIDERS IN CLOUD COMPUTING ENVIRONMENT

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ABSTRACT

This paper aims to focus on the usability evaluation of two interactive and popular cloud PaaS (Platform as a Service) providers namely Microsoft Azure and Appharbor. Usability evaluation has been carried out in two stages: Performance evaluation is carried out by taking CPU Utilization, Memory Usage and Disk Seeking Rate as essential parameters and in next stage customer satisfaction is measured by considering user feedback mechanism based on Interview and Questionnaire method.

Keywords: *PaaS service, Usability evaluation, Cloud computing, Questionnaire method*

1. INTRODUCTION

In the current trends of the IT world, usability plays an important role for a user in order to achieve their goals and satisfaction in different applications. Nowadays in different fields of computing such as cloud computing, web computing, usability engineering etc. usability evaluation [1, 2] is carried out in order to determine ease-of-use, customer satisfaction, clear visual consistency and evaluation process [3, 4, 5]. Usability testing plays a key role in assessing the usability of different applications by considering different factors such as task time, ease of use of the product, users' perception while performing specific tasks on the application [6, 7]. So far, web sites employ usability engineers to ensure user-friendliness, ease, and satisfaction in order to ensure positive customer experience [8, 9]. But recently, usability measurement is not only confined to web-based application only, but it has expanded its limit to Cloud Computing Environment also.

Cloud service creates a huge interest and attracts the end users because of its elasticity, robustness, and provides on-demand services to users. The greatest challenge of cloud computing is that it is cost-effective in the sense that it has the capability to run large applications without actually owning or maintaining the powerful and scalable hardware. In this competitive market, cloud providers should offer high quality and satisfactory services to the customers in order to distinguish from the other service providers. It is considered to be an image for the Internet that is used to perform computation and provides infinite storage virtually over the Internet where resources seem to be enormous. Cloud computing is mainly divided into three categories: Software as a Service (SaaS), Platform as a service (PaaS) and Infrastructure as a Service (IaaS). PaaS is a category of cloud computing services that provide a computing platform where the provider provides the networks, servers, storage, and other services on demand basis [10]. PaaS offerings facilitate the deployment of applications without the cost and complexity of buying and managing the underlying hardware and software and provisioning hosting capabilities [6]. PaaS vendors offer higher level services and, therefore, have many more opportunities to offer specialized services [11, 3]. The motivation and objective of the work is to estimate the usability of the PaaS providers by measuring the performance level after completion of certain task in the PaaS environment as well as to measure the user satisfaction through user feedback based on specific usability attributes. The questionnaires have been prepared for feedback through pilot study.

This paper has been organized as follows. Section 2 provides related work on the usability evaluation carried out in different cloud computing environment. Following which section 3 provides different PaaS cloud providers commercially available. Section 4 provides the main objective of the paper i.e. the performance and usability metrics in PaaS environment. Analysis and experimental study are carried out in section 5. Finally, section 6 concludes our study.

2. RELATED WORKS

Boniface et. al. [1] states that the PaaS architecture developed in the EU IST IRMOS project aims to provide real-time Quality of Service (QoS) by using certain tools and techniques in order to guarantee modelling, simulation and monitoring of real-time multimedia applications. The architecture covers all the aspects starting from service engineering, service level agreement design, provisioning and monitoring which helps in improving the usability, maintainability and efficiency of cloud services.

Ganesh Iyer [12] proposed a new architecture Progress Cloud Test Framework (PCTF) in his research work which is used for testing various cloud testing dimensions. The framework contains some components which are required for managing different test environment, a data repository and different modules for testing cloud features.

Claudio A. Ardagna [13] in his research work gave importance on scalability issues which he considers as an essential requirement for a Platform-as-a-Service infrastructure. In his paper he analyzed some of the scalability patterns applied to PaaS infrastructure to implement SOA which has a greater impact on the performance of SOA security standards.

Chakraborti, Roy and Pattnaik [14] in their paper focus on the various usability techniques, evaluation assessment and issues while evaluating the usability of different services in CCE. Usability is considered to be a vital attribute in CCE in order to perform a task efficiently, effectively and with least navigation time, which further increases customer satisfaction.

S.Roy et.al [15] in their research work aims to evaluate the usability and accessibility of web-based services namely three popular academic websites based on human perception. Performance based evaluation is done by considering task success rate, task completion time, the number of mouse clicks as the parameters of assessment. Questionnaire based evaluation was considered in order to collect feedback and to assess post-task satisfaction ratings. Accessibility evaluation was also done based on WCAG guidelines by testing the degree of compliance of the different websites.

Dikaiakos et. al. [16] states that cloud computing provide huge data centers and servers for performing high computation on the public domain. The system provides huge resources and delivers services to the customers over Internet on a pay-on-demand basis. The three utility service providers IaaS, PaaS & SaaS provides services to the users by purchasing and utilizing it as and when needed. But at the same time, several challenges are faced in order to accomplish and fulfill all the issues. Parallel processing, one of the greatest challenges needs to be fulfilled by increasing the number of CPU cores and threads per chip. Solid-State Drives (SSD) should be given higher priority than hard disk drives for better storage technologies. Moreover, security and privacy of the user is also considered as a greater challenge because it is stored as an untreated host. Similarly, data management is also considered as a higher challenge because of distribution of data in different geographical locations.

3. COMMERCIALLY AVAILABLE CLOUD PAAS SERVICE PROVIDERS

PaaS providers are responsible for installing integrated development environment, configuring and maintaining application server with the database to run a software project with efficiency and accuracy [17, 12]. PaaS service reduces the cost overhead and increases the flexibility in designing and deploying software project. An interesting feature of PaaS services is that it offers the combination of IaaS (Infrastructure as a Service) and SaaS (Software as a Service). PaaS act as an IaaS when it is used for developing the mobile application or Web computing and acts as a SaaS, by maintaining and configuring the components and by offering multi-tenancy services. For example, some PaaS providers offer their customer well-integrated application server, management tools with source code etc. Other PaaS providers might attract consumer by providing multiple languages support and server side technologies (e.g. PHP, Ruby, Python, Perl, .NET, Java). The increasing importance of cloud applications presents different areas of PaaS service and user has the opportunity to choose their desired PaaS [10].

Cloud computing has a greater impact on business applications and PaaS is a proven model

with a hassle free maintenance of the hardware and software infrastructure. In this paper, two PaaS based cloud environment namely Microsoft Azure and Appharbor are chosen for comparison based on their popularity and preference.

Microsoft Azure is used for deploying, building and managing services and different applications globally while maintaining their data center throughout the world. Azure provides flexible and an open cloud platform that satisfies the user need and enables the user to reliably host and scale out their application code. A robust feature of Windows Azure lies in enabling scalable applications in distributed environment and distributed caching services while reducing latency and delivering great application performance anywhere in the world. Here we consider minimal performance [3, 13] metrics provided by Azure such as CPU percentage, memory Consumption, Disk read/write for analyzing the performance of different PaaS environment. Windows Azure Cloud Services allows the user to construct virtual machines without the headache of maintaining OS.

Appharbor is a .NET hosted Platform as a Service which helps in deploying and scaling any standard .NET applications. Here, the developers push code to Appharbor using Git repository or Bit bucket or Codeplex. AppHarbor then builds the code and runs unit tests. If everything checks out, the code is deployed to AppHarbor's cloud platform. Appharbor is equipped with many infrastructure features and add-on programs (New Relic) to attract user with installing, configuring and maintaining facilities of users own VM. It provides a multi-tenant environment. In addition, Appharbor provides some specific characteristics [3, 18] such as Low start-up costs, automatic deployment of code from repository such as GitHub, Bitbucket, etc. support for compiling and running project tests and ability to integrate popular applications and monitoring them very easily.

4. PAAS PERFORMANCE AND USABILITY MEASUREMENT

Performance measurement of PaaS based cloud service providers is done by considering performance metrics which involves certain factors such as CPU Utilization, Memory usage, and Disk Seeking Rate [19, 20]. The increase in the performance rate will lead to an increase in user satisfaction which leads to a better usability factor.

The different performance measurement factors mentioned above are discussed below:

4.1 CPU Utilization (CU): CPU utilization may be defined as the percentage of CPU computed and how many instances are running in the cloud. Handling of workload is also indicated by CPU usage.

4.2 Memory Usage (MU): Memory usage is indicated by how much memory is consumed by the running process at any given time and how much is available for using by another process.

4.3 Disk Seeking Rate (DSR): Disk seeking rate is the amount of data read from and writes into disk on the host machine. Disk seeking rate is defined as the total number of bytes read/write divided by the total read/write time taken respectively during the collection interval. It is used to monitor average disk loads and to determine the trends in disk usage. It is measured in Kbps.

Moreover, usability evaluation is also carried out by taking into consideration the Questionnaires and Interviews method [3] which is one of the most popularly used usability testing method. The usability testing method is used in order to collect users performance and satisfaction level while performing a task in the cloud environment. Depending upon certain questionnaires, the satisfaction level is measured based on user feedback while performing a task in the cloud platform. Below are given the results and analysis of the performance rate and usability level of both Azure and Appharbor.

5. EXPERIMENTAL STUDY AND RESULT ANALYSIS

In this section, we present the experimental setup which is used to measure the performance rate and evaluate usability level of Azure and Appharbor. The technical specification of CPU, OS and RAM conducted are as follows:
CPU: Intel(R) Core(TM) i5-2540M CPU @ 2.60 GHz
OS: Ubuntu 14.o4 LTS
RAM: 4 GB
In next section, we have collected user feedback by interview and questionnaire method depending on their task performance and analyzed the results in order to evaluate the usability of the two PaaS providers.

5.1 Performance Analysis

The performance appraisal of both Azure and Appharbor are based on the following parameters:

5.1.1 CPU utilization:

Two web applications are uploaded on both cloud service providers namely Azure and Appharbor in order to analyze the CPU utilization. The post launching of the applications involves certain operations such as monitoring CPU utilization while performing certain task on the applications by the users and recording the values at different time instance on both PaaS service providers [22, 23, 24].

The recorded values are observed on different times of a day such as: peak network traffic time, moderate network traffic time and low network traffic time. Comparing both the above CPU utilization as recorded in Azure and Appharbor we make a comparison study of both PaaS services. Table 1 shows the estimated CPU Utilization (Te) calculated using Equation 1 shown below, on at three different network times by using Optimistic CPU usage (To), Pessimistic CPU usage (Tp) and most likely CPU usage (Tm). The estimated time (Te) consumed for PERT [21] is shown in equation 1 below:

$$Te = (To + 4Tm + Tp)/6 \qquad \textit{Equation 1}$$

Table1: Estimated CPU Utilization (Te) on Three Different Network Times

PaaS Cloud	Peak Network Time	Moderate Network Time	Low Network Time
Windows Azure	6.38%	3.65%	0.93%
Appharbor	0.16%	0.052%	0.093

Figure 1 below shows the CPU utilization of Azure and Appharbor PaaS Cloud at different network times.
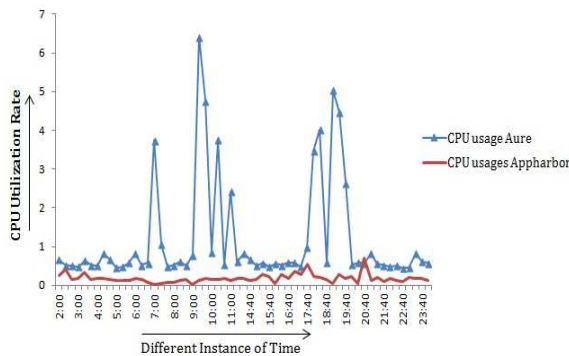

Figure 1. CPU Utilization in Azure PaaS and Appharbor PaaS

Based on the above results, we draw a conclusion that the CPU Utilization rate of Azure

PaaS is better in comparison to Appharbor PaaS. Hence, an increase in the CPU Utilization rate improves the performance level and also the efficiency of the PaaS Cloud.

5.1.2 Memory usage:

Memory usage measures the amount of memory used and available memory while performing a task on the application loaded in the PaaS Cloud providers. Figure 2 below shows the available memory while two applications are loaded simultaneously on both the PaaS cloud service providers.
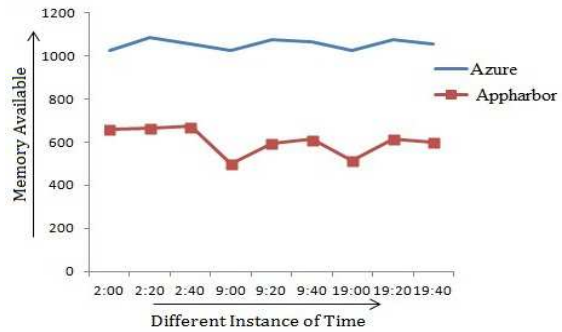

Figure 2. Memory Usage in Azure and Appharbor PaaS

5.1.3 Disk Seeking Rate:

Frequent variation of disk rate occurs due to different applications reading or writing into the disk, which determines the disk usage. Disk seeking rate determines the amount of disk read/write per total time taken for read/write respectively. A higher value indicates the better performance of the cloud services. Figure 3 below shows the disk seeking rate in both Azure and Appharbor PaaS cloud in different instance of time.
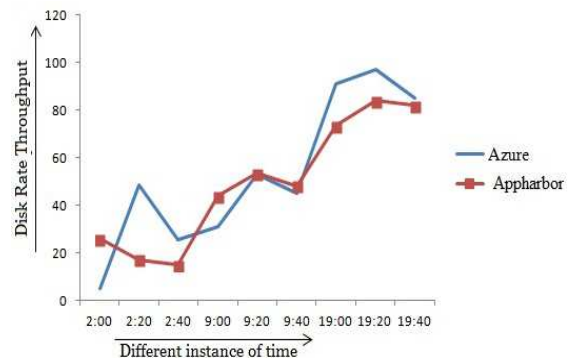

Figure 3: Disk Seeking Rate in Azure and Appharbor PaaS

5.2 Adaption of Questionnaire and Interview Methods

According various usability experts usability measurement is carried out based on certain usability attributes such as Learnability, Efficiency, Memorability, Consistency, Satisfaction, Memorability, Simplicity which are discussed below:

5.2.1 Satisfaction: In terms of cloud computing environment, satisfaction is one of the key attributes which measures users comfort level with the service provider. It also rates the flexibility level provided by the service providers.

5.2.2 Simplicity: Simplicity may be defined as the ease-of using the services i.e. the user friendliness quality which depends on the user interface of the cloud service providers.

5.2.3 Learnability: Learnability may be defined as ease of learning the features and functionalities of the different service providers.

5.2.4 Completeness: Completeness may be defined as the overall architecture of the cloud service providers so as to meet user's requirements while performing a task and working on them.

5.2.5 Consistency: Consistency may be defined as the level of performance achieved which does not vary greatly over a time period. Consistency is required in order to achieve user's trust and belief.

5.2.6 Memorability: Memorability may be defined as the capability to establish the proficiency with different cloud service providers so as to perform the task within the short span of time.

Based on the the above used attributes the usability test is conducted by selecting Questionnaire and Personal Interview of more than 100 expert users. Basically, there are two different Questionnaire Methods namely Pre-test Questionnaire and Post-test Questionnaire. The Pre-test Questionnaire contains questions on the personal information of a user. Whereas, the Post-test Questionnaire includes questions which are exclusively designed for measuring the functionality and usage of the different cloud service providers as well as to measure the satisfaction level of users. All the above-mentioned usability attributes are measured based on user's feedback and opinion. The set of questionnaires was designed to collect the users understanding and experiences, the different usability problems encountered by a user while performing certain task on Azure and Appharbor PaaS, the overall time spent by a user while completing each task and at last the satisfaction level of a user. Some sample questions are as follows: whether user is satisfied with the ease of uploading and completing task or not, amount of time it took to complete a particular task and supportive information by service providers to complete the task, whether it is helpful for user to meet their requirements and is it more effective and productive service provider, can user upload a new application successfully at every attempt and is the service reliable, secure and whether in overall the PaaS providers are satisfactory or not.

The questionnaires are prepared in order to measure the six usability attributes on both the cloud service providers. We have taken five different levels (A: Highly Agreed. B: Agreed C: Not sure D: Disagreed E: Strongly Disagreed) for measuring usability criteria. Each usability attribute is given different levels based on user's feedback mechanism. The usability analysis of Microsoft Azure PaaS provider based on the six attributes is shown in Figure 4 below:
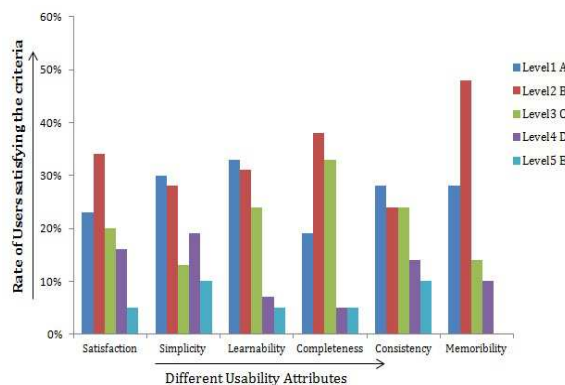

Figure 4: Usability Analysis on Microsoft Azure PaaS

For example, from the above figure we can analyse that in case of Azure PaaS, satisfaction criteria meets 23% of the highly agreed level(A) and meets 34% of the agreed level(B). Similarly level C,D and E are determined as 20%,16% and 5% respectively. Similarly, all other usability attributes are analyzed based on user's feedback and opinion.

The usability measurement on Appharbor PaaS provider is also carried out based on the above six usability attributes as shown in Figure 5 below:
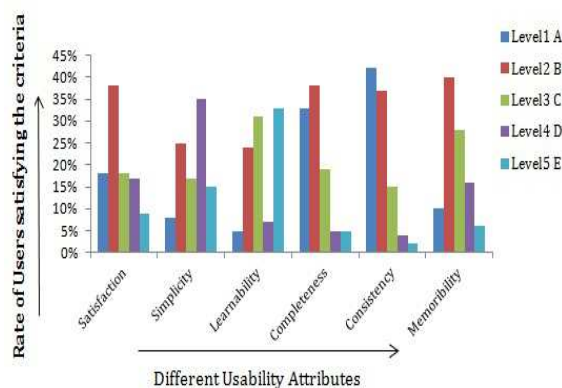
Figure 5: Usability Analysis on Appharbor PaaS

From the above figure we came to a conclusion that in case of Appharbor, satisfaction criteria meets 18% of highly agreed level (A) whereas, it meets the 38% of agreed level (B).Similarly level C, D and E are determined by satisfaction level 18%, 17% and 9% respectively.

Comparing the usability analysis of both Azure and Appharbor PaaS providers we came to a conclusion that except Completeness and Consistency rest all the four attributes are having more percentage of highly agreed level (A) in Azure than in Appharbor PaaS. So, finally we can conclude that the usability criterion is higher in Microsoft Azure PaaS provider than in Appharbor PaaS.

6. CONCLUSION

The purpose of this paper is to analyze the performance rate and usability of two different cloud frameworks namely Azure and Appharbor. Here we consider CPU Utilization, Memory Usage and Disk Seeking Rate, in order to rate the performance of these two different cloud frameworks. Moreover, usability evaluation has also been carried out to measure the user comfort and satisfaction level. Usability evaluation is carried by two groups of user namely, expert user and novice users in order to get the better result. The Questionnaire based method has been chosen in order to measure the user's rate of interest and evaluate user's satisfaction. Finally, we come to a conclusion based on the above findings that Azure PaaS cloud framework provides better performance, efficiency, and user satisfaction in comparison to Appharbor PaaS.

As a future scope of work, other usability factors and more additional number of tasks may be considered to improve the performance of the PaaS providers. Simultaneously, the increasing number of participants for feedback mechanism along with accurate test hypothesis gives outstanding insights to instant result analysis, user's trust level estimation and proportionate user satisfaction.

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