User Satisfaction Metrics for Cloud Computing Environment

Chakraborti Bratati[1], Roy Sharmistha[2], Pattnaik Prasant Kumar[3]

[1]School of Computer Engineering, KIIT University,
Bhubaneswar, India
bratatikiit@gmail.com

[2]School of Computer Engineering, KIIT University,
Bhubaneswar, India
sharmistharoy11@gmail.com

[3]School of Computer Engineering, KIIT University,
Bhubaneswar, India
patnaikprasant@gmail.com

Abstract: In the field of service computing, cloud computing provides a scalable services and promising delivery platform. Although the specific future of cloud computing is hard to pin, but it has a vital impact in the present world of Information Technology and digitalized business world. The more usable the cloud is the more efficient will be its task performance and making a cloud usable is Usability. The usability aspect is an essential criterion to design services in an interactive way to support the task performance efficiently, effectively and with least navigational time, which increases user satisfaction level. Usability experts have carried out various usability evaluation techniques and metrics (or user satisfaction metrics) which play a significant role in cloud computing environment. Thus usability aspect became essential for designing cloud services and more interactive to support the user at their work. This paper mainly addresses the various usability techniques and evaluation assessment and issues that may be considered while evaluating the usability of cloud services.

Keywords: Usability Metrics, Usability Evaluation Techniques, Cloud Computing Environment

1. Introduction

Utility computing with cost-effective realization became the foundation of Cloud computing model which allows users and providers to access the resources easily in a self-efficient manner, with pay-as-you-go fashion, thus reducing initial infrastructure cost and improving resource utilization by maximizing the effectiveness of resource. Recently, the Global IT ecosystem and new markets economy are greatly influenced by the impact of cloud computing which can meet the fluctuating and unpredictable business demands because of its achieving coherence and economics of scale. Thus considering the benefits of end user, usability is considered to be a vital attribute for measuring user satisfaction level in cloud computing environment. So, usability can be defined as the process of increasing the effectiveness of shared resources with maximizing task efficiency, computing power so as to ensure user need and satisfaction. Effectiveness, efficiency, and satisfaction are considered to be the three main goals of cloud that encourages achieving specified goals to specified users. So we can say a usable cloud always support the Users' tasks in an efficient manner. Usability evaluation is defined as systematic process of collection of data and makes a better understanding of users that how a user can use the cloud service to perform a particular task. To create cloud service, scientific observation, measurement and design principles are applied. These processes helps user to use cloud service easily at lower cost.

2. Brief History of Usability Evaluation

The journey of usability was started in simple environment but proceed to a complex environment. The term "usability" was coined in the late 1980s, when J. Whiteside (Digital Equipment Corporation) and J. Bennett (IBM) published several articles about usability engineering [7]. In 2006 a study on usability testing done by Miller [1], [5] where he discussed about usability testing and quality assurance attribute. From his publication we came to know that usability testing should be performed at the initial stage to overcome the problems and good usability testing method can make the service faster. To measure a website in cloud, L.Fang [2], [5] proposed different usability evaluation methods. Evaluation methods such as heuristic evaluation, focus group cognitive walkthrough, and questionnaire can be adopted to measure the usability and in 2010, A. Lodhi [3], [5] described usability heuristics as an assessment parameter

Corresponding Author: Prasant Kumar Pattnaik, School of Computer Engineeirng, KIIT University,
patnaikprasant@gmail.com

for usability testing and several experiments was conducted to establish to justify his research. In 2012, L.Hasan [4], [5] performed experiment on usability evaluating in nine Jordanian university websites. Some usability attribute was taken into consideration to evaluate the usability such as easiness of usability, architectural design and informational content. 237 user were selected to perform a specific task on a particular website and provide feedback .From their feedback a report was generated to measure their satisfaction level of users. Google, Yahoo, Hotmail and IBM are continuously attempting to facilitate the users through more innovations.

3. Brief History of Usability Attributes, Benefits, Challenges of Cloud Computing Environment

3.1. Usability Attribute

According to J. Nielsen, usability is defined by the following five quality components [7], [8].

- Learnability: It defines that user's capacity of learning quickly and easily of the functionalities of a product to achieve goal of a certain tasks.

- Efficiency: It defines how fast users are accomplished different tasks and how effectively user can perform task to estimate the costs.

- Memorability: Memorability defines the recollection capability of user when they have not worked with the interface for a longer time.

- Errors: Users make many errors working with the cloud service. This attributes focuses on how often user can make error and can they cope with problem with ease and comfort. This attribute is related with the effort for error correction which greatly concern of recovery from error and robustness of device.

- Satisfaction: It defines how user is satisfied after working with the Cloud based application and how they are concerned with the time of execution. Satisfaction is measured by feedback of user's attitude, perceptions, and feelings about the service.

3.2. Benefits of Usability Evaluation

- Gaining Higher Level of Usage: Cloud services will be easy to use and meeting the expectations of their clients, and novice users can able to access the service offered [12].

- Lowering User Support Cost: Usable services help the customer to search the needed content and accomplish his/her goals with the application. The cloud application interface, operations should be understandable to the user without help of external intervention thus reducing user support cost. Accuracy is key components of the content. Accuracy will decrease the probability of customer's complain to the service provider about the quality of service offered [12].

- Impact on Usability Engineering Lifecycle: Usability evaluation should influence each step of usability engineering. In engineering lifecycle process, the usability activity is minimal in case of requirement analysis but increases during the development phase. The discovery process of usability reduces the cost of redesigning as modification is applied on prototype [12].

- Impact of Usability on Return on Investment: From an economical perspective, cloud-computing service allows users and providers access to resources in a self-service manner and pay-as-you-go fashion. Usability techniques can reduce costs (including development, support, training, documentation and maintenance costs), minimize the development time, and improve marketability (Cheskin: 1999). Usability-aware organizations maintain the thumb rule that the cost benefit ratio for the usability is $1:$10-$100. If they spent one dollar for implementing usability techniques, the organization will get a benefit between $10 and $100 (Gilb T: 1998). Developing high quality cloud applications enhance the credibility of the application manages the cloud service of various organization with full satisfaction of the users and clients [12].

3.3. Usability Challenges

The followings are some challenges that generally the usability area faces:

- Scalability: Scalability is one of the challenges of Cloud usability. For an example if any changes done by Face book (a social networking site), it will instantly affect large number of users. However, three years back that affected fewer users. So scalability is an issue to usability of cloud computing [11].

- Visual Design: Visual design plays an important role of application and communication with user. When user pays their taxes or purchases an airline reservation ticket, need simple application and do not want to concentrate about the mechanics of interpreting the application's screen. Clear and concise visual design will need to satisfy the user [11].

- Interactivity: One of the major challenges for cloud service provider is how the cloud service becomes more interactive to user [11].

- Dynamic Application: Dynamic Application is a most important challenge in usability. Designer can face serious negative outcome if changes are done incorrectly. The problems of changes mainly affect those users who use an application frequently [11].

4. Needs and Design Process on Usability of Cloud

On the cloud, usability is an essential condition. The useful method of usability is user testing, which are discussed here [9], [12].

At first, some users should be selected and then instruct the users to perform tasks in specific cloud platform. At last, evaluator observes whether user does the work successfully or not and where they face discomfort with the user interface.

Usability plays a vital role in each stage of the design process of creating cloud. Following steps are performed for

the design process:

Step 1. Prototyping a new requirement, the design engineer have to identify the requirement and satisfaction level of user.

Step 2. To get more quality product at low prices, developer makes a comparison with competitors' designs and develops more quality product based on user requirement.

Step 3. Then Evaluator should conduct a field study to observe user's behavior, their comfort and difficulties with the service.

Step 4.After that evaluator makes paper prototypes of new design ideas.

Step 5.Evaluator refines the design ideas with multiple iterations for best result.

Step 6. After implementation of the final design; test will be conducted to reduce the usability problems.

5. Usability Assessment

The basic steps of assessment are

- It will predict whether usability will meet the target or not.
- It will obtain feedback from user to improve design of product.
- It will assess the targets that have been met.

5.1. Centre of Interest of Usability Assessment

Usability assessment depends on the state of the evaluation and the assessment concentrate on how it works well on different aspects. We will discuss some important scenarios of usability assessment [10].

5.1.1 Application's Information Content. Usability assessment is greatly depending upon the informational content. Usability assessment is performed to evaluate the correctness of information, designing and functionalities of the systems.

5.1.2 User Interface Functionality. Functionality of the user interface is an important property responsible for the application of presenting components of the user-interface relationship. This feature helps user to access different information content by browsing and navigating metrics. User can able to search, select, retrieve and store the information after successful navigation.

5.1.3 Performance of User. User performance is most essential usability assessment and can be distinguished by two aspects. First, one is Effectiveness. (Whether the user fetched the information correctly to provide the correct outputs); and second is efficiency (the duration that user can achieve result or goal).

5.1.4 Workload Distributed to End User. This factor depends on the properties and attributes of task, which performed by the user. The outcome of tasks determines the user performance .Stress is a big factor of cognitive load and it depends on individual capability to learn and to cope with fatigue.

5.1.5 End User Satisfaction. User satisfaction is considered a vital attribute while considering usability issues. Though the system is efficient, or produces outputs effectively but the user, reaction to the system is most important. User perseverance is determined whether the system will be accepted in use or not.

5.1.6 Cost/benefit Analysis. Cost and benefit analysis focuses on functionality of the system so that user can achieve a satisfaction level to carry his work at reasonable cost.

5.2. Assessment Process of Usability

Usability is considered as iterative methods that concentrate on real users and the task performed by them. Variety of techniques is involved with usability engineering and assessment. These techniques are described below:

- Observations of user and task: Here the evaluator goes through observation performed by users while attempting any task in their workplace and analysis of their work processes evaluator finds their mental satisfaction level [10].

- Interviews and questionnaires: A set of questionnaires are prepared before conducting an interview with users, and from feedback of user the report is generated based on user preferences, experiences and their needs.[10], [5], [8].

- Competitive analysis and Benchmarking: Evaluation of usability focuses on the similar products that are available in the market. Thus, competitive analysis is performed between similar product to provide a beneficial usability study [10], [8], [5].

- Paper prototyping: In this process, users are involved to perform the task in the rough and hand sketched prototype model, before beginning of actual coding. Depending on their performance, the actual implementation is done [10], [8], and [5].

- Creation of guidelines: This includes set of rules and standard guidelines, which may be followed by designers to assure consistency in design of the software during the design phase [10], [5].

- Usability testing: In this technique, user tests a product and provides feedback to evaluator. Evaluator analyzes their feedback to find out problem so that corrective measure can be taken [10], [8].

6. Evaluation Methods of Usability

There are several approaches of usability evaluation methods. Some of them are discussed below:

6.1. Approaches of usability evaluation assessment methods: [5], [8], [10]

6.1.1 Heuristic Evaluation. Evaluator and task expert plays important role in heuristic methods[10,5]. It can be considered as a fast process and economically feasible. Evaluators examine the user interface and make a comparison study with established heuristic methods to reduce the problem faced by user.

6.1.2 User Based Evaluation. This method mainly focuses on the feedback of user in design phase. The partial/rapid prototypes are required in the design phase of usability evaluations which will create complete versions of the best quality product.

6.1.3 Evaluation Based on Design Principal. Design phase has a great contribution and impact to establish usability evaluation .Collections of guidelines and standards are essential for design criteria of evaluation of usability.

6.1.4 Evaluation Based on Assessment Model. It is a theoretical model that specifies human-computer interface and human abilities in usability. This model is considered as generic models of industry specific.

6.2. Different types of Usability Evaluation Methods:

Usability Evaluation methods can be categorized in three types: Testing, Inspection and Inquiry.

6.2.1 Testing. Usability testing is a method that associated with user interaction and is used to evaluate a product by testing. In this method a set of user are needed to perform task of the prototype of a product. Feedback from user helps to understand the evaluator about user interface. Testing methods include the following: [10], [13].

6.2.1.1 Thinking Aloud Protocol: Think aloud method is a technique to accumulate data that can be used in usability scenario. In this method user verbally announce their thought of tasks. Generally an instructor gives instruction to the user to be more verbal at time of working. In "Think-Aloud" protocol, participants have the opportunities to express their feelings which helps usability specialist to analyze the users experience.

6.2.1.2 Rapid Iterative Testing and Evaluation (RITE Method): Another important usability method is Rapid Iterative Testing and Evaluation (RITE) method. RITE is an iterative method of usability study. The tester team focus a set of target population to make testing. In this method particular participant is chosen for a task on a prototype model and usability engineer based on their observation collect the essential data for the participant. The development and testing team decide whether there will need any change for that prototype prior to the next participant.

6.2.1.3 Co-Discovery Methods: Co-discovery method determines that usability test is required for accumulate vital information from pairing of subjects. Discussion can help to find out the problem area of design and documentation which is essential in usability study.

6.2.1.4 Usability Testing Based on Component: Component-based usability testing is used for interaction of component of a system and test the elementary unit of usability. This method involves quantitative measure of usability which is based on user interaction by interview and questionnaires.

6.2.1.5 Benchmarking Methods: Benchmarking method determines the standard of design of the specific product. To establish a benchmark four main characteristics are to be maintained .i)Time for performing the task ,ii) time

needed to fix errors, iii)time required for learning applications, and iv)features and functionality of the system. At first a benchmark has to be established and then to determine the usability of other system by comparative study.

6.2.1.6 Coaching Method: In this technique an expert coach will answer the question of participants best of his capability. Tester observes the interaction between expert coach and user. The main purpose of this technique is to modify the design of the product and make it more users friendly.

6.2.1.7 Remote Testing: Research on remote usability evaluation is performed with the user and the evaluators located in separated space and time. Remote testing can be divided in to two categories synchronous and asynchronous. Synchronous usability testing is related to video conferencing or employs remote application that shares the tools such as WebEx. And other one related to real time communication between the evaluator and participant user one to one.

6.2.1.8 Retrospective Testing: Sometimes videotape has been used for usability test session, and evaluator can able to gather information by reviewing the videotape and make query to participants regarding their attitude during the test. The main requirement for this technique is the user's interaction with the service has to be recorded and replayed when necessary.

6.2.1.9 Shadowing Method: In this method an expert user helps the tester during usability test .User performs in task domain and expert user explains the attitude and behaviour of normal user to the tester. This technique is needed when tester are not able to communicate with user directly.

6.2.2 Inspection. Usability inspection technique is mainly carried by usability specialists and software developers before usability test and this method helps the evaluator to resolve an issue related to usability. Some popular Inspection methods are: [10], [5].

6.2.2.1 Feature Inspection: Feature inspection technique concentrates on the features of a product. In this method analysis of each feature is needed for availability, understandability and functionality aspects of service.

6.2.2.2 Perspective-based Inspection: Perspective-based inspections are used to broaden the problem-finding ability based on user perspectives. User can face different situations of interacting a new service or product [15].

6.2.2.3 Pluralistic walkthrough: In this method Experts and specialists together discuss different usability scenarios and try to find optimizations to evaluate a service or product [14].

6.2.2.4 Cognitive walkthrough: Cognitive walkthrough technique is used to detect any usability problems and make the service easy for novice user. This method is under usability inspection methods. Experts emulate the user's thoughts and concern when solving problems.

6.2.3 Inquiry. The main objective of usability evaluators is to concern about user feedback. Users' facility, discomfort, necessity, and understand ability of a new system are very

important for evaluators. Observing the user attitude and discussing with them evaluator perform the task of evaluation. Inquiry methods comprise the following methods [10], [8], [16].

6.2.3.1 Field Observation: Evaluator will physically present at the workplace and observe the task of representative user. Evaluators try to understand how the user deals with the system.

6.2.3.2 Focus Groups: In this method, a group of representative user are selected by evaluators to collect data and find out the issues of the service. Evaluator plays the role of moderator, who prepares the list of issues from the discussion with user. This method able to capture the spontaneous user reactions that evolves in the process of dynamic group.

6.2.3.2 Interviews and Questionnaires [13]: In this method, evaluator prepares a set of questions about the product and they interview to the users from these questions in order to gather information. In an evaluation interview technique, user answers the question verbally, and the interviewer records those responses. There are two types of interview: unstructured interview and structured interview.

- Unstructured interviewing: In this method interviewer is not concerned with the specification of systems. They ask the question to user to collect information based on their experience.

- Structured interviewing: In this method there are a predetermined and specific agenda and a set of specific questions are prepared, a guidelines are maintained when interrogation going on. There are two types of Questionnaire methods.

- Pre-test Questionnaire: Pre-test questionnaire requires various attribute to perform the test, such as first impressions of user about a product, user information.

- Post-test Questionnaire. This process is done after the completion of the task successfully. User provides their opinions and feelings of that service after completing their works

7. Cloud Usability Metrics

There are some metrics which are based on statistical and countable information. Countable metrics can be constructed from raw data that are collected from various log, video recording, interview and questionnaires. We will discuss 10 metrics which are used for usability evaluation [5], [8], [6], [17].

- Unstructured interviewing: In this method interviewer is not concerned with the specification of systems. They ask the question to user to collect information based on their experience.

- Completion Rates: Completion rate can be considered as a basic usability metric. It can be determined as gateway metric also. It can be represented as a binary metric (1 can be considered as Success of task and 0 is treated as failure of task.)

- Usability Problems: It is considered as a key metric for measuring usability activity. This focuses the problem

which is done by user while using the cloud service or web service. It also describes severity ratings of those problems.

- Task Time: It is one of the important key metric that can be used to measure the efficiency and productivity of cloud and web service. Total task time defines how long a user takes to complete a task. Task time is the duration between a Start task times and end task time.

- Task Level Satisfaction: When user completes a task his or her feedback is essential to determine the satisfaction and difficulty level of tasks.

- Test Level Satisfaction: An interview is to be conducted with users at the end of usability test and from the feedback of the user, tester determine the ease of usability. System Usability Scale (SUS) is required for testing of software, hardware and devices .The SUS is technology independent and is very simple which provides global view of subjective assessments of usability.

- Errors: Error may be encountered by user by doing wrong action, omission and mistakes while performing a job. Description of error along with each instance is recorded which is helpful in Usability Inspection problems.

- User Expectation: It is based on the expectation of user about the difficulty level of a task .A comparison is done between the expectation of user about difficulty of task and actual difficulty of task. (Experiment conducted on set of user).

- Page Views/Clicks: This metric is specially needed for web-applications and cloud application. Only this fundamental metrics user can able to access. Clicks or page view determines success rate or failure of a task .This metrics is used for better measurement of efficiency of web or cloud service.

- Conversion: Conversion metric is used for the measurement of the effectiveness of a product. It is essential metric used in e-Commerce. Usability of conversion rates is used in all phases of the sales process by focusing on the usability problems, errors and reduces time.

- Single Usability Metric (SUM): This metric is the combination of four usability metrics respectively task completion rate, average number of errors, average time on task and post-task satisfaction . This metrics is summation of efficiency, effectiveness and satisfaction.
Standard Units of Measure (SUoM) is metric is particularly used for cloud evaluation. Service provider and vendors provide cloud metric that relevant to business needs. To manage the cloud services following metrics are to be considered [13], [6], and [18].

- Costing of Cloud percentage of Revenue: It describes the costing price of cloud that is related to revenue of business.

- Cloud Cost based on Application/Business perspectives: The main aim of this metric to maximize business profit at low cost. Cloud Cost related to per Transaction of business infrastructure.

- DiskRead time: This metric is required to identify the rate at which the application reads a disk.
- DiskWrite time: This metric is required to identify the rate at which the application writes to a disk.
- Average Load Time: It considered the load time to upload video and image
- File CRUD Times: The time required to Create, Read, and Update or Delete a file of fixed size.
- Database CRUD Times: Average time required to execute the commands to create, read, update or delete file from desired cloud database.
- Average & Peak CPU Utilization: It is a crucial matrices which depends on how much percentage CPU is computed in cloud environment and how many instance is currently running.
- CPU Performance Variance: It defines the consistency level of CPU performance and also defines how cloud virtualization is responsible for CPU cycles.
- Network-In: This metrics identifies number of bytes received in all network interfaces by the instance.
- Network-Out: This metrics identifies number of bytes sent in all network interfaces by the instance.

8. Conclusion

Today the World Wide Web gain huge popularity because of various services provided to the user in the field of cloud computing and human computer interface. Thus, usability becomes a vital attribute for measuring user satisfaction level, which may further improve the performance and effectiveness of software product as well as web cloud. Usability can be considered as an attribute to measure the intelligence of Cloud while performing the task in order to achieve the user's goal and needs. In this paper we summarize usability evaluation techniques, assessment and issue related to cloud computing services. The users' performance in the cloud environment can improve the quality of cloud service .The user performance in the cloud environment can improve the quality of the cloud service which leads to increase in ROI and user satisfaction level.

References

[1] J. Miller, "Usability Testing: A Journey, Not a Destination," Internet Computing IEEE, 10(6), pp. 80-83, 2006.

[2] F. Liu, "Usability evaluation on websites" In 9th International Conference on Computer-Aided Industrial Design and Conceptual Design, CAID/CD, pp. 141-144, China, 2008.

[3] A. Lodhi, "Usability Heuristics as an assessment parameter: For performing Usability Testing", In 2nd International Conference on Software Technology and Engineering (ICSTE), pp. 256-259. USA, 2010.

[4] L. Hasan, "Evaluating the usability of nine Jordanian university websites", In 2nd International Conference Communications and Information Technology (ICCIT), pp. 91-96, Tunisia, 2012.

[5] S. Roy, P.K. Pattnaik, "Some Popular Usability Evaluation Techniques for Websites", Advances in Intelligent Systems and Computing 247, FICTA, pp. 535-543, 2013.

[6] Measuring Usability [Online]. Available: http://www.measuringusability.com.

[7] J. Nielsen, "The Usability Engineering Lifecycle. IEEE Computer, 25(3), pp. 12-22, 1992.

[8] J. Nielsen, "Usability Engineering", Academic Press, Cambridge, MA, 1993.

[9] L. Schubert, K. Jeffery, "Research in Future Cloud Computing", Expert Group Report Public version 1.0

[10] J. Nielsen, "Usability and Its Assessment & Evaluation", an Article, pp 1-7, 2000.

[11] A. Xu, S. Gao, "Discussion on Usability and Optimization Issues in Overseas University Websites: A British University as an Example," 11th International Symposium on Distributed Computing and Applications to Business, Engineering & Science, pp-482-485, 2012.

[12] Evidence-Based User Experience Research, Training, and Consulting [Online]. Available: http://www.useit.com

[13] Usability Evaluation, [Online]. Available: http://www.usabilityhome.com.

[14] R. Bias, "The Pluralistic Usability Walkthrough: Coordinated Empathies" In: Nielsen, J. and Mack, R. Usability Inspection Methods, Chapter 3, pp. 63-67. John Wiley, 1994.

[15] Z. Zhang, V. Basili, B. Shneider-man, "An empirical study of perspective- based usability inspection", In Proceedings of the Human Factors and Ergonomics Society 42nd annual meeting, pp. 1346-1350. Chicago, 1998.

[16] J. Nielsen, "Heuristic evaluation", In: Nielsen, J, Mack, R. L. (Eds.), Usability Inspection Methods, John Wiley & Sons, pp. 25-64, New York, 1994.

[17] S. Ahmed, D. Mohammad, B. Rex Kline, K.P. Hrkirat, "Usability Measurement and Metrics: A consolidated model", Software Quality Journal, pp. 159-178, 2006.

[18] Measuring the User Experience, Second Edition: Collecting, Analyzing, and Presenting Usability Metrics, [Online], Available: http://www.amazon.com

Author Profile

1. Bratati Chakraborti received the BSc. (Computer Science), MCA degrees from Calcutta University and West Bengal University of Technology in 2005 and 2008 respectively. Now she is pursuing her M.Tech in Database Engineering from KIIT University. Her research area includes: Cloud computing, Data

mining, Software Usability. She has also industry experience and teaching experience.

2. Sharmistha Roy received the B.Tech and M.Tech degrees in Computer Science and Engineering from National Institute of Technology Agartala, in 2010 and 2012, respectively and pursuing her PhD in the field of Cloud Computing and Usability Measurement from KIIT University. Currently, she is working as a Assistant Professor, in School of Computer Engineering, KIIT University, Bhubaneswar. Moreover, she has received Gold medal during her M.Tech. Her research area includes: Cloud Usability, Security, and Software Engineering.

3. Dr. Prasant Kumar Pattnaik is currently working as a Associate Professor, in School of Computer Engineering, KIIT University, Bhubaneswar. He is a senior member of IACSIT. His research area includes: Cloud Computing, Usability Engineering, Green Computing, MANET, Wireless Sensor Network. Email: patnaikprasant@gmail.com.