Abstract—Cloud computing is emerged as new technology in organization and cooperates. To successfully provide cloud services and sharing of resources, the cloud must be tested before came into service. Cloud testing is a form of testing in which web applications uses cloud computing environment and infrastructure to simulate real world user traffic by using cloud technologies and solutions. The work on this paper is focused on various cloud computing testing techniques and cloud testing challenges faced by cloud service provider. There are three major techniques available for cloud testing which are functional, non-functional and ability cloud testing. These techniques are further subcategorizing as their testing areas. Later, in this paper the seven cloud testing challenge are discussed which are: service, security and layered testing challenge, lack of universal standard, guidance, knowledge and staff expertise, limited infrastructure, procuring cloud service on-demand basis.

Keywords—Ability Testing; Cloud; Cloud Computing; Cloud Computing Challenges; Cloud Testing; Functional Testing; Non-Functional Testing.

Abbreviations—Infrastructure as a Service (IaaS); Platform as a Service (PaaS); Software as a Service (SaaS); Testing as a Service (TaaS)

I. INTRODUCTION

CLOUD testing is a form of testing in which web applications uses cloud computing environment and infrastructure to simulate real world user traffic by using cloud technologies and solutions. Cloud testing basically aligns with concept of cloud and SaaS. Cloud testing provides with the ability to test cloud by using the cloud infrastructure such as hardware and bandwidth that more closely simulate real world conditions and parameters. In simple words, Testing a Cloud refers to the verification and validation of applications, environments and infrastructure that are available on demand by conforming these to the expectations of the cloud computing business model [Prince Jain, 2012; Prince Jain et al., 2013]. Cloud Testing is defined as testing as a Service (TaaS). TaaS is considered as a new business and service model, in which a provider undertakes software testing activities of a given application in a cloud infrastructure for customers. TaaS can be used to validation of various products owned by organizations that deal with testing products and services which are making use of a cloud based licensing model for their clients [Prince Jain et al., 2013].
Effective unlimited storage, quick availability of the infrastructure with scalability, flexibility and availability of distributed testing environment reduce the execution time of testing of large applications. The new area of software testing in the cloud lies at the intersection of these key areas: software testing, cloud computing, and system migration. Cloud test engineer and quality assurance managers encountered many issues and challenges in testing modern clouds and cloud based applications [Prince Jain et al., 2011; Vinaya Kumar Mylavarapu, 2011; Lalit Kumar et al., 2012].

II. TESTING TYPES

Various types of testing required for a cloud setup which mainly categorize into three techniques: Functional, Non-Functional and Ability testing Techniques [Neha Mehrotra, 2011; Sergiy Vilkomir, 2012].

2.1. Functional Testing

Functional cloud computing testing is performed for both remote and local applications. Functional cloud testing is the testing of all the features and functions of a system which includes hardware and software. It is conducted on a complete, integrated software platform to check it’s compliance with the requirements. In functional cloud testing, the process of verification is done against system specifications or requirements are carried out in cloud instead of on-premise software testing. Functional testing is not comprehensive enough to identify all the combinations of a site will be subjected to and its performance under stress conditions [Neha Mehrotra, 2011; Jerry Gao et al., 2011].

2.1.1. System Testing

System testing techniques is used to prove the system’s behavior within its own boundaries. It is critical to prove that the system functions as it has been designed when the system components work together, inputs and outputs are as expected and the overall resulting system is a high quality cloud system [Jerry Gao et al., 2011].

2.1.2. Integration Testing

Integration cloud testing allows the business to verify the cloud solution will work within the current infrastructure and environments which ultimately proving that the implementation of a cloud solution does not detrimentally impact any existing systems. Finally, the business requirements must be verified and validated to prove that the end result of the Cloud solution will meet the documented needs of the business [Vanitha Katherine & Alagarsamy, 2012].

2.1.3. User Acceptance Testing

User Acceptance Testing will be done to prove that delivered cloud solution meets business requirements so that the user accepts the developed cloud solution. User acceptance testing is done on both on-premise and off-premise. However, the onsite testing allows immediate control and monitoring of test progress [Keerti Kulkarni].

Figure 2: Cloud Computing Testing Techniques
2.2. Non-Functional Testing

Non-functional testing is done to ensure that a web application meets the specified performance requirements. Non-functional testing technique is also known a performance testing technique. In cloud, the applications scalability scope is much wider than in conventional performance testing techniques [Keerti Kulkarni].

2.2.1. Business Requirement Testing

Before migrating their business to a cloud computing solution, the organizations and cooperates must carefully analyze and document their business requirements clearly, precise and unambiguously. Business requirements are foundations for building a cloud computing solution. These business requirements can be achieved through reviews, periodical customer meets and workshops. Later, this in turn provides a perfect system is constructed which is capable of delivering the business requirements [Prakash & Gopalakrishanan, 2012].

2.2.2. Cloud Security Testing

Security testing which is an indispensable part of testing applications due to increase in security breaches in business. This can provide assurance that business critical data is stored and transported safely. To identify methods of gaining access to a system by using common tools and techniques used by hackers can very well guarantee the security of Cloud solutions [Prakash & Gopalakrishanan, 2012; http://www.toolsjournal.com/testing-lists/item/404-10-cloud-based-testing-tools].

2.2.3. Cloud Scalability and Performance Testing

Cloud Scalability is another major area of concern where adequate amount of testing is needed. Cloud Computing solutions always claim to be scalable on demand. Load or Stress testing can be used to prove that the developed cloud solution can be scale as required with the help of software tools. Hence Cloud solution can be accurately measured and its capacity is verified. Cloud Performance testing techniques allow us to measure the cloud systems performance accurately. Performance testing with the load testing techniques allows getting an accurate image of the solution’s ability on the cloud [Prakash & Gopalakrishanan, 2012; http://www.toolsjournal.com/testing-lists/item/404-10-cloud-based-testing-tools]. Performance is generally tied to an application’s capabilities within the cloud infrastructure. Finding out thresholds, bottlenecks & limitations is a part of performance testing. For this, testing performance under a particular workload and vary the nature of traffic on-demand is necessary [http://www.toolsjournal.com/testing-lists/item/404-10-cloud-based-testing-tools].

A. Cloud Load and Stress Testing

Application stability is a major factor as the user count is expected to be increases. Load testing of an application involves creation of heavy user traffic and measuring its response. There is also a need to tune the performance of any application to meet certain standards. Measure response times and isolate issues related to specific actions while system is subjected to increasing load from different locations and multi user operations. It is imperative to identify issues as system is tested to breaking points maximum expected capacity or often beyond the expected usage. Stress Testing is used to determine ability of application to maintain a certain level of effectiveness beyond breaking point or maximum expected capacity or beyond the expected usage [http://www.toolsjournal.com/testing-lists/item/404-10-cloud-based-testing-tools; Eljona Proko & Ilia Ninka, 2012]. It is essential for any application to work even under excessive stress and maintain stability. Stress testing assures this by creating peak loads using simulators. But the cost of creating such scenarios is enormous.

B. Latency Testing

Cloud testing is utilized to measure the latency between the action and the corresponding response for any application after deploying it on cloud [Prakash & Gopalakrishanan, 2012; http://www.toolsjournal.com/testing-lists/item/404-10-cloud-based-testing-tools].

2.3. Ability Testing Techniques

Ability testing is done to ensure that the cloud environment is able to gives its service on-demand to users. In this category, the compatibility, interoperability and multi-tenancy ability of cloud computing environment is tested [Spirent Communications, 2010; Eljona Proko & Ilia Ninka, 2012].

2.3.1. Compatibility and Interoperability Testing

In cloud environment, different software’s and operating systems is used and created on demand which makes the compatibility testing must. A cloud application must capable to work and executed across multiple environments and various cloud platforms. Hence, it is very easy to migration of a cloud applications and platforms from one infrastructure to another infrastructure [Spirent Communications, 2010; http://www.toolsjournal.com/testing-lists/item/404-10-cloud-based-testing-tools].

2.3.2. Disaster Recovery Testing

The cloud service provider has always prefers that his cloud services must be available all the time to end-users but actually it is not achievable. There may be some chance of failure so the disaster recovery time must be low. Cloud verification must be done to ensure the service is back online with minimum adverse effect on business [Spirent Communications, 2010; IXIA, 2011].
### 2.3.3. Multi-Tenancy Testing

Multi-tenancy testing ensures that the multiple clients and organizations using on-demand services activated at a given time. Cloud service should be customizable for each client and provide data and security level to avoid any access related issues [IXIA, 2011].

### III. Testing Challenges

#### Table 1: Challenges in Cloud Computing Testing Environment

<table>
<thead>
<tr>
<th>Challenge Category</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Challenge</td>
<td>1. Service Availability</td>
</tr>
<tr>
<td></td>
<td>2. Service Assurance</td>
</tr>
<tr>
<td></td>
<td>3. Service Efficiency</td>
</tr>
<tr>
<td>Security Challenge</td>
<td>1. Confidential Data Security</td>
</tr>
<tr>
<td></td>
<td>2. Depending on customer data</td>
</tr>
<tr>
<td></td>
<td>3. Meeting Security Requirements</td>
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<tr>
<td>Layered Testing Challenge</td>
<td>1. Three layers testing Protocol</td>
</tr>
<tr>
<td></td>
<td>2. Communication between Layers</td>
</tr>
<tr>
<td>Lack of Universal Standard and Infrastructure</td>
<td>1. Limited Technology configuration</td>
</tr>
<tr>
<td></td>
<td>2. Limited Servers and Storage Infrastructure</td>
</tr>
<tr>
<td></td>
<td>3. Networks interconnectivity</td>
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<tr>
<td></td>
<td>4. Virtualization level</td>
</tr>
<tr>
<td>Guidance, Knowledge and Staff Expertise</td>
<td>1. Obtaining Guidance</td>
</tr>
<tr>
<td></td>
<td>2. Expertise Teaching Staff</td>
</tr>
<tr>
<td></td>
<td>3. Acquiring Direct Knowledge</td>
</tr>
<tr>
<td>Procuriing Cloud Service on-Demand Basis</td>
<td>1. Define Specific Quantity and Costs</td>
</tr>
<tr>
<td></td>
<td>2. Dependency on Remote Installed Applications</td>
</tr>
<tr>
<td></td>
<td>3. Increasing Expenditure on Encrypted Data</td>
</tr>
<tr>
<td>Other’s Challenges</td>
<td>1. Planning of Test Environment</td>
</tr>
<tr>
<td></td>
<td>2. Accrediting Vendors which meets Standards</td>
</tr>
<tr>
<td></td>
<td>3. Ensuring Data Portability and Interoperability</td>
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<tr>
<td></td>
<td>4. Proper Utilization of Cloud Resources</td>
</tr>
</tbody>
</table>

#### 3.1. Cloud Service Challenges

The fundamental challenge in cloud computing testing environment is the cloud service challenges. The first challenge in this category is service availability without experiencing undue delays because user organization is looking to adopt cloud services rather than maintain local installations. Cloud service must look and feel as local services rather than remote services. The second challenge is the cloud service assurance. The cloud services provider must assure timely delivery of cloud service and controls data communication connection between cloud service and corporate users. The final challenge is service efficiency. It encompasses efficiency in all aspects from cost savings, space and power efficiency to efficient and scalable cloud service delivery using virtualization, high end servers and high speed interfaces [IXIA, 2011; Ravichandran, 2012].

#### 3.2. Security Challenges

Since information travels through the Internet, testers have to perform security testing to make sure there is no data leakage when data is sent over the Internet. Security in the public cloud is still a major issue. The first challenge in this category is the security of the confidential data. There may come up the situation about the leakage of private information, internet suspending, and suddenly disruption of service due to a maintenance window, slow internet speed, virus attack. The second challenge is some test methods are depends upon the customer data. In order for effective testing to take place, some testing tasks depend highly on the actual customer or production data. In some cases, the customers are prohibited from supplying confidential or production data to third parties. So the test data should be doubly scrutinized for testing in cloud. The third challenge is meeting security requirements. Cloud vendors may not be familiar with security requirements that are unique to government agencies such as continuous monitoring and maintaining an inventory of systems [Ravichandran, 2012; Swapnil H. Chandane & Prof. Mahip M. Bartere, 2013].

#### 3.3. Layered Testing Challenges

The third major challenge category is the testing at multiple layers of the cloud environment. The first challenge in this is the layers testing Protocol. In this, the testing network connection, server performance, database and software application adds multiple layers to cloud testing. Testers have to test beyond what they can physically control in their environment [Priyanka et al., 2012; Swapnil H. Chandane & Prof. Mahip M. Bartere, 2013].

#### Table 2: Layered Approach for Cloud Testing

<table>
<thead>
<tr>
<th>Layer Number</th>
<th>Layer Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 3</td>
<td>Database and software applications</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Server Performance</td>
</tr>
<tr>
<td>Layer 1</td>
<td>Network Connection</td>
</tr>
</tbody>
</table>

Second challenge in this is the maintaining communication between layers. In this, Testers have to test the communication between the layers, test connection between the elements and also plan for the risks such as connection breaks midway, server down and software crashes [Laurin H. Mills, 2009; Priyanka et al., 2012].

#### 3.4. Lack of Universal Standards and Limited Infrastructure

The fourth challenge category is the lack of standards and limited infrastructure in public cloud environment. The first challenge in this is the lack of universal standards. Presently, there are no proper universal standard solutions to integrate public cloud resources with user company’s internal data center resources. Public cloud providers have their own architecture, operating models, pricing mechanisms and offer very little interoperability. This leads to a big challenge for companies when they need to switch vendors. The second challenge in this is the limited infrastructure. Some cloud...
providers offer only limited types of configurations, technology, servers, storage, networking and bandwidth which making it difficult to create real-time test environments [Laurin H. Mills, 2009; Pat Hyek, 2011].

3.5. Obtaining Guidance, Knowledge and Staff Expertise

The fifth challenge category is the obtaining guidance, knowledge and staff expertise. The first challenge in this is the obtaining guidance for testing cloud service. Existing federal guidance for using cloud services is insufficient or incomplete. Agencies cited a number of areas where additional guidance is needed such as purchasing IT commodity and assessing information security management with security levels. The second challenge is the taking expertise teaching staff. Service provider may not have the necessary tools or resources such as expertise staff to implement cloud solutions. Teaching their staff an entirely new set of processes and tools such as monitoring performance in a cloud environment has been a challenge. A third challenge is the acquiring direct knowledge. Delivering cloud services without direct knowledge of the technologies and tools has been a challenge [Pat Hyek, 2011; Swapnil H. Chandane & Prof. Mahip M. Baterre, 2013].

3.6. Procuring Cloud Services on On-Demand Basis

The sixth testing challenge category is the procuring cloud service on the on-demand basis. The first challenge in this is the delivering on-demand services with specific quantity and costs. The on-demand and scalable nature of cloud services can be difficult to define specific quantities and costs. These uncertainties make contracting and budgeting challenge because of the fluctuating costs associated with scalable and incremental cloud service procurements. The second challenge is the dependency on remote installed applications. Since applications are not installed locally in controlled environments. This makes it harder for testers to replicate the user environment. The third challenge is the increasing expenditure on encrypted data. Improper usage of cloud based test environments can increase costs [Laurin H. Mills, 2009; Pat Hyek, 2011; Priyanka et al., 2012].

3.7. Other’s Challenges

The seventh testing challenge category contains some other’s challenges related to testing a cloud computing environment. The first challenge in this is the planning of test environment and overcome cultural barrier. Testing teams should rigorously plan their test environments from utilization periods through disassembly with the awareness of the associated expenses such as cost of encrypting data, before putting testing in a cloud environment, since these requirements will consume additional CPU and memory. Organization culture may also act as an obstacle to implementing cloud computing solutions. The second challenge is the accrediting vendors which meets standards. Organization may not have a mechanism for certifying that vendors meet standards for security because the risk and authorization management program had not yet reached initial operational capabilities. Third challenge is the ensuring data portability and interoperability. To preserve their ability to change vendors in the future, agencies may attempt to avoid platforms or technologies that lock customers into a particular product. Forth challenge is the proper utilization of cloud resources. It is important to monitor utilization of cloud resources to avoid over-usage and over-payment.

IV. Conclusion and Future Work

The growth of cloud computing created a demand for benchmarks that can measure the performance characteristics of cloud applications. Testing teams should equipment themselves with viable strategies to mitigate the risks and issues associated with cloud computing by covering additional capabilities available in the cloud computing environment. Only a few advantages and a few testing challenges of the cloud computing solutions have been identified in this paper. In future, as it is getting more matured architecture for cloud computing and more and more testing on the cloud applications there is every possibility of more testing challenges which can be explored by researchers.

References


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