Prospectus of Borrowing Software Testing Resources from the Cloud

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ABSTRACT
The exhaustive testing of software is time consuming and expensive process. The aim of software testing is to increase the reliability of software by spotting and fixing the bugs as early as possible. Sometimes it is very difficult to generate the actual test data and appropriate test environment to ensure viability of testing. In the arena of software engineering, now processes are being shifted to the cloud. As it has become imperative for businesses to cut down the cost of entire software development and increase the quality of the software delivered to the client. Software Testing as a Service (STaaS) is going to be the next big thing in this direction. This paper presents a holistic view of the topic and explores the future of software testing in cloud.

General Terms
Software Engineering, Software Testing, Cloud Computing, Service Oriented Architecture.

Keywords
Software Testing as a Service(STaaS), Agile Model, Cost Reduction, Reliability Testing, Performance and Load Testing.

1. INTRODUCTION
Cloud computing has gained significant amount of attention from researchers and practioners in the last few years. It includes virtualized hardware and software resources that are hosted remotely and made available on-demand using a service model (e.g., SOA). Instead of running or storing applications locally, one can host their application in the cloud and access it from anywhere using a thin client application such as a Web browser. Cloud computing promises reduced costs by cutting down the need to buy large amount of resources (hardware and software). It also promises efficiency, flexibility, and scalability for business operations. The cloud computing has the following taxonomy as depicted in figure 1 and it emphasizes on utilizing every thing of need as a service. Through cloud computing, it has now become possible to use software, platform and even infrastructure as a service. In Software as a Service (SaaS) model of cloud computing, applications run exclusively in the cloud. The services are typically hosted and managed in their own data center and make it available over the Web. Platform as a Service (PaaS) model features the services as on-premise applications that are to be built on shared platform in the cloud. This model facilitates development and deployment of applications without the cost and complexity of buying and managing the underlying infrastructure and enhances the on-premises application functionalities by accessing the application specific services provided in the cloud. They can be viewed as the set of attached services useable only by a particular application.

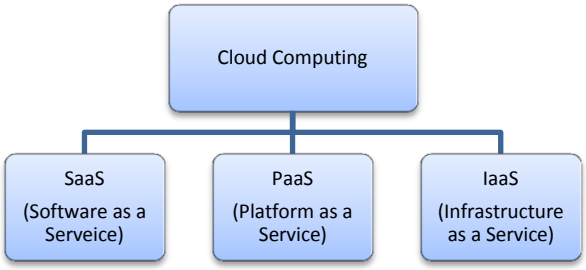

Fig.1: Taxonomy of Cloud Computing Models

Infrastructure as a Service (IaaS) models the delivery of hardware and associated software as a service. A cloud platform provides cloud-based services for creating applications rather than building their own custom foundation, they can be built on a cloud platform. Cloud computing is changing the way we deliver and use software; traditional software licensing is decreasing, whereas companies hiring software services is on the rise. In 2010, Gartner Research predicted that 20 percent of businesses would have zero ownership of IT assets by 2012 and instead seek to acquire assets from the cloud. Kalliosaari et al.[1], explore the current scenario of software testing in practice. They list some of the vendors and clients in engaged in the practice and suggest a practical roadmap for adopting the software testing as a service. The main bottle-neck in the path of performing software testing in the cloud are the concerns related to security and the privacy of the data[2]. Shaikh et al.[2] have thrown the light upon various such security concerns. Kajan et al.[3] propose a framework that relies on some expert tools developed in the context of OptimalSQM initiative. They concentrates on some key challenges for adopting Test as a Service (TaaS) in accordance with the concept of Software as a Service (SaaS). Riungu et al.[4], perform a qualitative study to explore and understand the conditions influencing software testing as an online service. In this study some important research issues were raised after interviewing the mangers from 11 different organizations. The study used qualitative grounded theory as its research method. This study indicates the rise of software testing as a service. The fact is influenced by conditions such as the level of domain knowledge needed to effectively test an application, flexibility and cost effectiveness as benefits, security and pricing as top requirements, cloud computing as the delivery mode and the need for software testers to sharpen their skills. Some other relevant work, on the topic of software testing as a service,

can be found in [5] and [6]. Cloud-based testing is on demand and billed as per use. Many organizations provide cloud-based testing services (see Table 1). Performance testing, load testing, and Web-based application testing, as well as the testing of environments hosted in the cloud can be done in cloud. The primary benefit of cloud-based testing is reduced costs to put up, maintain, and license internal testing environments. Other benefits of testing in cloud include the flexibility to acquire a testing environment as per need and the global market access for both customers and vendors. On the other hand, testing in the cloud may require special technical skills to generate test cases and scripts, and providing and monitoring security might also incur additional costs [1]. Software testing in the cloud positions itself at the intersection of software testing, cloud computing, and system migration. It has the potential to change the way software testing is performed, and is greatly drawing the attention of researchers, practitioners, and managers. It seems to be a total replacement of something called as a test lab. That would take up hundreds of square feet of space and contained many high end testing computers (servers). Each such computer had different combinations of system software. We would have to install, test, and then possibly re-configure machine for the next test run. Today, for example, VMWare Fusion (plus a big hard drive) can be used to get all those configurations running on one computer. In cloud-based testing, cloud computing environments can be used to simulate real-world user traffic and uses cloud infrastructure for software testing. Testing in general and load, performance testing and production service monitoring in particular are challenged by several problems like limited test budget, meeting deadlines etc.

2. SOFTWARE TESTING IN CLOUD

Traditional approaches for software testing incur higher cost to simulate user activity from different geographic locations. Also, testing firewalls and load balancers involves expenditure on hardware, software and its maintenance. Moreover, in case where the number of users is unpredictable or there is variation in deployment environment depending on client requirements, cloud testing is more effective. Software testing in cloud is more useful for web applications. The real world web users can be simulated by using cloud testing services that are provided by cloud service vendors. In general, as a first step, the user scenarios are developed and then tests are designed. For instance, the service providers

Fig. 2: Process of Testing in the Cloud

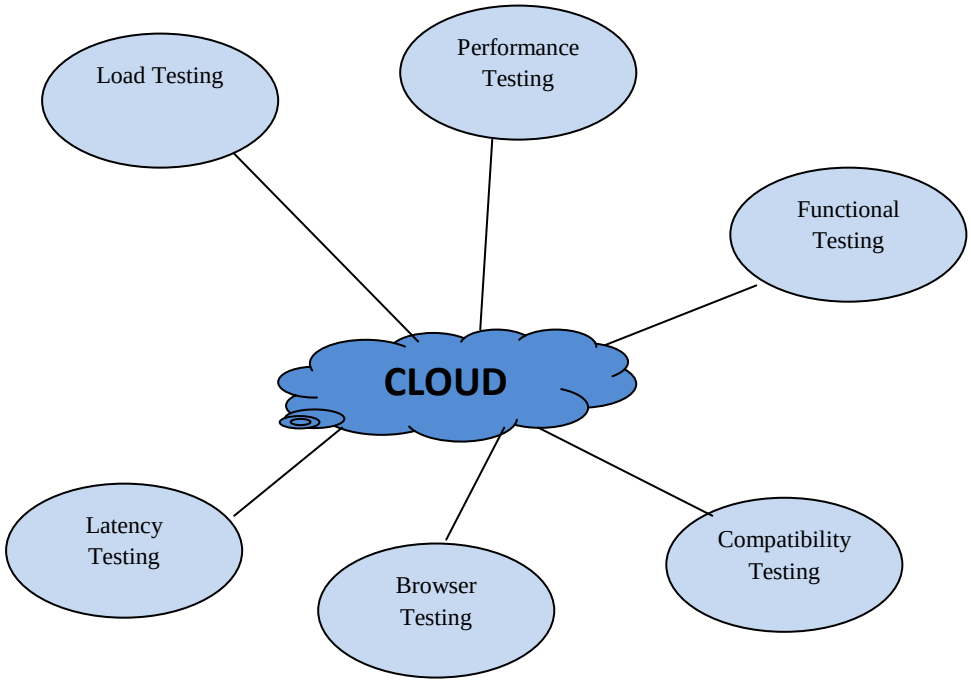

Fig. 3: Various Types of Software Testing in the Cloud.

can leverage cloud servers to generate Web traffic. Real-time dash boards are used by the service providers to deliver results and analytics back to clients for a complete analysis of how their applications will perform during peak volumes. Figure 2 depicts the process of software testing in the cloud.

(a) Load Testing in Cloud

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. Load testing is used to determine ability of

application to maintain a certain level of effectiveness beyond breaking point. It is needed for any application to work even under excessive load and maintain stability. Peak loads are simulated to test the viability of the application. As the cost of creating such scenarios is huge, so instead of investing capital in building on-premise testing environments, cloud testing offers affordable and scalable alternative.

(b) Performance Testing in Cloud

Finding out thresholds, bottlenecks & limitations is a part of performance testing. For this, testing performance under a particular workload is necessary. By using cloud testing, it is easy to create such environment and vary the nature of traffic on-demand. This effectively reduces cost and time by simulating thousands of geographically targeted users.

(c) Functional Testing in Cloud

Functional testing of both internet and non-internet applications can be performed using cloud testing. The process of verification against specifications or system requirements is carried out in the cloud instead of on-site software testing.

(d) Compatibility Testing in Cloud

Using cloud environment, instances of different Operating Systems can be created on demand, making compatibility testing effortless.

(e) Browser Performance Testing in Cloud

To verify application's support for various browser types and performance in each type can be accomplished with ease. Various tools enable automated website testing from the cloud.

(f) Latency Testing in Cloud

Cloud testing is utilized to measure the latency between the action and the corresponding response for any application after deploying it on cloud.

3. BENEFITS OF SOFTWARE TSTING IN THE CLOUD

The ability and cost to simulate web traffic for software testing purposes has been an inhibitor to overall web reliability. The low cost and accessibility of the cloud's extremely large computing resources provides the ability to replicate real world usage of these systems by geographically distributed users, executing wide varieties of user scenarios, at scales previously unattainable in traditional testing environments. Minimal start-up time along with quality assurance can be achieved by cloud testing. There are the following benefits of testing in the cloud:

(i) Improved and Efficient Performance Testing

Cloud computing can carry out performance, scalability, and stress testing in a timely and economical manner. With the cloud, it's easy to provision servers at a speed and cost that would be impossible with traditional methods. Traditionally, a testing lab would be a large room with many servers running different variations of an operating system. This is usually a large investment that requires maintenance even when the servers aren't in use. With cloud computing, we can acquire the necessary amount of servers as well as different variations of the operating system and testing environments; in other words, we can test faster. Then, we can decommission the servers when we're not using them. Two interviewees discussed performance testing in the cloud.

(ii) Overall Reduced Testing Time

Overall, testing times have become shorter: which promotes faster development. After developing a new feature, whatever it is, you can test-run it in, say,10 different environments. And you have the results available immediately and you can use them in further development and so on.

(iii) Realistic Test Results

A cloud-based system can easily work across different operating environments, letting developers understand their services' usability from the users' perspective. The owner of Organization 1 found this beneficial. I have these customers that I have given this service for use at a discounted price, and in return they give me feedback about the service, about possible bugs, or other deficiencies that they find.

(iv)Availability of Wide Range of Tools

Cloud computing lets organizations carry out technical feasibility studies while trying to identify the best test tools and environments. One can just get the environment, test it and verify it according to specific needs. It ensures to cut a lot of speculation. Instead of purchasing licenses for testing tools, the clients can provision them from the cloud whenever needed. It increases the flexibility in various aspects. Readily available cloud-based tools and environments enhance agility in testing and in overall software development. Moreover, use of agile development methods results in a continuous, fast evolving IT services market. It addresses business needs faster and can tailor the end products in a better way.

(v) Developer-Tester Communication

When both development and testing tasks are taking place in the cloud, development and testing teams have equal access to the system resources. If access rights are given to all teams, developers might not have the quickest access anymore to try a little bit of this and that to see if it works. This can enhance interaction between teams. Development teams must promptly communicate changes in requirements so the testing teams have the correct parameters for tests.

(vi) Enhanced Service Delivery for Vendors

Cloud-based development and testing follow an agile approach, which lets organizations address customer needs in a quicker way. As the set-up of the larges Because we do not need to set up huge environments and so on, we are able to kind of go and say, OK, these are the requirements, let's build it, and after one or two weeks, let's look at it. What do you like about it? What don't you like? Make changes, and agree, OK, the product fits . . . the need. Cloud computing also lets vendors interact with each other. If a customer demands testing capacity beyond one vendor's capabilities, the vendor can hire resources from other vendors.

4. CONSIDERATIONS FOR SUCCESSFUL SOFTWARE TESTING

Before actually migrating task of software testing to the cloud, the business needs to consider a tradeoff between internal and external test environments. When considering whether to test in the cloud, companies with existing internal test

environments must make their decision based on what they find important. The tradeoff between an internal test environment, that's probably smaller than the production environment, and a cloud-based test environment, that would be similar to the actual production environment, needs to be evaluated meticulously. An internal test environment can be safer but may compromise with the quality of test results. On the other hand, a cloud-based testing environment generates more realistic test results but can raise data security concerns. Organizations must decide which is appropriate for them keeping in view the nature of application under test.

Following are some considerations which can lead to successful software testing in the cloud:

1. It is better to understand a platform provider's elasticity model/dynamic configuration method before choosing a one from the available options.
2. It may be fruitful to stay informed about the provider's evolving monitoring services and Service Level Agreements.
3. While producing Commercial off-the-Shelf (COTS) software, it is good to engage the service provider as an on-going operations partner.
4. Being willing to be used as a case study by the cloud service provider can lead to cost reductions, as it paves the path to more rigorous analysis of practices.

5. SERVICE PROVIDERS

Many vendors are providing the services to facilitate software testing in the cloud. Generally, cloud testing is often seen as only performance or load testing for applications, however, as discussed earlier it covers many other types of testing too. In regard with test execution, the software offered as a service may be a transaction generator and the cloud provider's infrastructure software. Distributed systems and parallel systems mainly use this approach for testing, because of their inherent complex nature. For testing non-internet applications, virtual instances of testing environment can be quickly setup to do automated testing of the application. The cloud testing service providers provide essential testing environment as per the requirement of the application under test. The actual testing of applications is performed by the testing team of the organization which owns the application or third party testing vendors. Zephyr [7] is a scalable platform that manages all aspects of the testing life cycle, integrates various test tools and systems, and provides global access, collaboration, management visibility, and real-time updates. Sauce Labs [8] uses Selenium-based testing service that tests Web applications across multiple browsers, supports the automation of browser tasks, and lets many tests run at the same time. Skytap [9] is another scalable cloud-based solution that provides visibility and control over cloud-based applications and can be used to develop, test, migrate, and evaluate applications, as well as create hybrid clouds. uTest [10] provides functional, security, load, localization, and usability testing from a crowd-sourced pool of professional testers for "Web, desktop, and mobile applications. IBM [11] provisions for the on-demand, secure, dynamic, and scalable virtual test server resources in a private test environment with an easy-to-use platform, service request management, automation, and configuration management. PushToTest [12] is a service with continuous integration platform that combines grid technology and cloud computing to run tests across single or multiple cloud-based test environments. CloudTestGo [13] is a cloud-based performance testing solution with quick, cost-efficient, real-world environments that perform load testing on Web-based, e-business, and vertical business applications.

Certain communities are evolving on testing in the cloud. One such popular cloud testing community is Software Testing & Quality Assurance group hosted by LinkedIn. Testing professionals openly share their experiences and exchange ideas related to cloud testing in order to enhance each-others' proficiencies.

6. CHALLENGES AND ISSUES FOR SOFTWARE TESTING IN CLOUD

High costs per test, large number of test cases, and little or no reuse of tests and geographical distribution of users add to the challenges for testing in cloud. Ensuring high quality service delivery and avoiding outages requires rigorous testing in one's own datacenter, outside the data-center, or both. Cloud testing seems to be the potential solution of many problems. Since 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 and lead to cost-effective solutions. Cloud-based testing requires testing of additional aspects and parameters. These might not necessarily be new, but testing in the cloud might exacerbate them. For example, different cloud systems need a certain level of integration and interoperability to work together. One interviewee said that future cloud-based enterprise resource planning systems will call for integrations between different clouds with different technologies. Two other interviewees emphasized load balancing, network latency, and multi-tenancy. Security-related issues are a major concern, especially in test data management. Storing and handling test data should never compromise confidentiality. One way to test cloud security is to selectively expose data to public clouds, as one interviewee suggested. Use the cloud to host some typically less-secure stuff. So, not really any customer contracts, for example, but some test plan might take place in a Google group. Test data management is critical due to variations in regulations across different geographical regions. In our previous empirical study, we observed that organizations that develop safety-critical applications tend to value the possession of domain knowledge. For this reason, these organizations are usually reluctant to consider cloud-based testing. Additionally, companies might be resistant due to budgets. Cloud-based testing providers should provide transparent pricing models so that customers are equipped with sufficient information for budgeting and cost estimation. Taking testing to the cloud can introduce significant changes to an organization. Thus, they need effective change-management strategies and procedures. The initial setup cost for migrating testing to cloud is very high as it involves modifying some of the test cases to suit cloud environment. This makes the decision of migration crucial. Therefore, cloud testing is not necessarily the best solution to all testing problems. Legacy systems & services need to be modified in order to be tested on cloud. Usage of robust interfaces with these legacy systems may solve this problem. Also like any other cloud services, cloud testing is vulnerable to security issues. The test results may not be accurate due to varying performance of service providers' network and internet. In certain cases, service virtualization can be applied to simulate the specific performance and behaviors required for accurate and thorough testing.

7. CONCLUSIONS

An increasing number of organizations are accepting cloud computing as a model to deliver, test, and use software due to its growing number of services. The spectrum of services is expected to have more cloud-based applications. With improved interaction between developer and tester teams, the quality of applications is also expected to improve. The present review could act as a starting point for organizations considering adoption of cloud-based testing. Since the topic being into its infancy state and a robust framework suggesting the roadmap for organizations to adopt cloud-based testing does not exist. Our future aim is to devise such a framework for adoption of the cloud-based testing in practice.

8. ACKNOWLEDGMENTS

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