

# Cloud Testing: Steps, Tools, Challenges

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## Abstract

Cloud computing has protruded as a modernistic computing model that influences many research areas, such as software testing that has been extended with boundless resources such as scalability and availability of expanded testing environments. Cloud computing minimizes the time needed for testing large software and lead to a decrease in testing cost. Cloud computing also gives the chance for developing many efficacious and wide reach software testing methods. This research will conduct a comparison between traditional software testing and cloud based testing. We also introduced some testing mechanisms in cloud and focus on the challenges of these testing types. Moreover, we discussed the special objectives, lineaments, requirements that are necessary for cloud testing. At the end of the paper we identified several testing tools and determine the key tools for cloud testing.

**Keywords:** Cloud computing, cloud testing, cloud-based software testing, performance testing.

## 1. INTRODUCTION

Back to several years, the industry of technology has developed a new and innovative solution that is called "virtualization". This technology enables multiple computers to share resources through multiple operating systems in order to reduce the costs, increase the flexibility of IT assets, reduce maintenance and management costs, increase scalability and load balancing for IT infrastructure. This evaluation of virtualization develop the concept of cloud computing and recourse sharing.

Cloud computing has evolved over years and is driven by the growing and expanding of the technology which facilitates the requirements of communication and information. In particular, cloud computing provides an online flexible environment that promotes organizations and individuals to work with the huge size of the data that have an impact on the framework execution [1].

Cloud computing means using internet and distributed servers by using software application to access data, manage it and store recourses. Cloud enables the users, enterprises and organizations to use these distributed services and applications without a need to install software and without internet access. In addition, cloud gives users who have different capabilities to store and access their data in third party data centers that are located away from them. Priyadharshini and Malathi [5] defined cloud computing as a model that can provide an indispensable, adequate and on demand access of network to a group of shared resources (ex: server, applications and network) [2]. In other words, cloud computing came as a solution to deliver the IT as a service [5].

It is worth mentioning that cloud computing is an IT hot subject and paradigm that supplies companies with resources

of computing for a cut-price administration [1]. Cloud computing also provides everything as a service by including many layers such as software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS) [2]. In addition, cloud computing provides particularly for SaaS what is called testing as a service (TaaS) with applications that are cloud based. The services and applications that are offered by cloud computing presents many novel challenges, requirements, models which are innovative, standards and new chances [4].

Cloud testing as TaaS has the ability to validate different products for individuals or organizations. Based on that, many of the IT organization are using the licensing model of cloud to test products and services for customers online instead of installing tests. For example, if load testing is needed then it is provided as a service [2].

There are different forms of Cloud testing as it was illustrated in [3]:

1. **Testing inside a cloud:** this type is performed by cloud vendors (HP, Oracle, etc) to check its internal features. Moreover, it depends on the quality of cloud from internal perspective.
2. **Testing the infrastructures and competence:** this type of testing is performed from the security side.
3. **Testing of a cloud:** this type of testing can be done by the customers of the cloud. It will show the validation and the quality of the cloud from the external side.
4. **Testing over clouds:** this type testing is performed by cloud based application providers. It will test the service application based on the system requirements and its specifications, here the testing is done through different types of cloud such as public, private and hybrid clouds.
5. **Testing the whole cloud:** this type showed the cloud as one whole entity.

The main purpose of this paper is to describe the models, types and the steps to perform cloud testing. Moreover, the paper provides a comparison between the cloud based testing and traditional based testing. It also shows a comparison between different cloud testing tools from different overview. This paper is structured as follows: Section 2 provides the necessary background: it briefly describes the categories for the service delivery in Cloud. Related work is reviewed in Section 3. Section 4 describes the steps to perform cloud testing. The answer for the question why cloud testing is given in Section 5. Section 6 provides a comparison between cloud based software testing and traditional software testing. The challenges and problems of cloud testing presented in Section 7.

## 2. BACKGROUND

As described in [1, 2, 3], service delivery can be categorized into four main models:

- A. Software as a Service (*SaaS*): it provides the cloud infrastructure specifications for users. The applications available on this infrastructure can be reached by an interface that can be accessed from different platforms and is available to any user via internet. User can access and use such applications without installing them applications. In fact, the application user interface is web browser (Google doc, Photoshop).
- B. Platform as a Service (*PaaS*): this model gives users the potential for deploying their own solutions by using the platforms of the cloud providers (ex: services of databases and application server) and enable the user to develop, use and manage some web application (Google apps).
- C. Infrastructure as a Service (*IaaS*): where users obtain the services provided by computing plus that they have the ability to deploy systems of their own configurations. They can rent the infrastructures they need as building blocks of the cloud; it mainly deals with physical resources like storage, network devices. All these resources can be used on demand (i.e., the user pay per use (Microsoft azure)).
- D. Hardware as a service: buying IT hardware or maybe hardware virtualization.

Cloud can have four main models. The models as described in [4] are:

1. Public clouds: this type means that the services of the cloud are available to everyone and the cloud owned to the organization that provides the services.
2. Private clouds: usually this type is used by government agencies or some companies that require a huge security and data integrity, so they built their own cloud or use public cloud but protected it by firewall and can be used only to authorized users or users within the companies.
3. Hybrid clouds: this type is a mix between public and private clouds. Some of cloud services is available to any one (public) but some others are only available to authorized users.

4. Community cloud: the cloud services and infrastructure shared by multiple companies.

Cloud testing: means that testing the resources of cloud such as hardware or software that are available on demand. Since cloud computing is often considered to as SaaS and testing appears “as a service”. These various testing method can be performed into cloud application [1]. There are various testing methods that can be performed in cloud applications:

1. Functional testing: is ensuring that the requirement and its specification are met on cloud application. Some examples on functional test are System verification testing and acceptance testing.
2. Non-functional testing: is the focus of web application test to ensure that they met their requirement. Some examples on non-functional testing are availability testing performance testing and security testing.

## 3. LITERATURE REVIEW

### 3.1 Cloud computing definitions and architecture

[1, 5, 6] defined cloud testing, its environment (architecture and infrastructures) and the key objectives of cloud testing as a service. However, [1] concentrated their research on the taxonomy and classification of the cloud computing architecture. In addition, they made a comparison between different types of cloud systems. Then, they used this classification to review some cloud computing services that are developed by Google and Amazon in order to identify the similarity and differences of architecture approaches of cloud computing. Moreover, they provide information to develop and enhance the current and new cloud systems.

In [5], the researchers created a survey on software testing techniques in cloud computing. They define cloud computing in general and its characteristics and the need of cloud computing. Furthermore. In [8], the authors gave a background on cloud computing and software testing in the cloud. Then, they classify the activities performed in cloud-based testing area, define the terminology that they used and identify the gaps. However, both of them did not discussed the tools used in cloud testing.

### 3.2 Testing as a service (TaaS)

Research that have been done in [3, 4, 5, 7, 9] focused on the testing as a service cloud computing structure. [7] defined testing of cloud based services (testing for functional aspects, testing for nonfunctional and operational aspects). In other words, [3] defined cloud testing as that form of testing which can be seen as a means for providing users with the applications of the web formulating the web traffic.

In [4], researchers provided a comprehensive review on cloud-based TaaS for SaaS applications. That offered all concepts on TaaS definitions, scope, motivations, benefits, and

required techniques. They classified testing services and test environments. Moreover, they discussed in details what are TaaS requirements, features, issues, and challenges. They made a comparison between conventional software testing and cloud-based TaaS. However, Gao et. al. [9] summarized and compared some different commercial products and solutions that support the cloud testing approaches such as TaaS.

Several researchers e.g. [3,6,7,9] focused on the challenges of cloud testing. In [7] the authors said that there were some challenges associated with cloud testing (testing as a services) such as (pure cloud-based test beds, testing data integrity and security, choosing a cost-effective model, testing tools and understanding and interpreting test reports). In addition the authors in [9] discussed the basic challenges, issues and needs in testing cloud-based software applications which were: on-demand test environment construction and testing security and measurement in clouds. However, Harikrishna, and Amuthan [3] focused on technical challenges such that testing is a periodic activity so it requires new environments to be set up for each project that needs to be tested. It needs a high cost investment for establishing testing environment). They classified the “cloud testing” into “testing the cloud-resident applications”. Then they presented an evaluation of results and identify gaps and opportunities. Finally, the research provided a classification of basic research studies, the gaps in the literature and set the engagement of software testing with different deployment models of cloud computing.

Gowri Amutha, [6] discussed the challenges associated with cloud testing (testing as a services) such as (pure cloud-based test beds, data integrity test, choosing cost-effective model, choosing the best tools for testing and explaining the reports generated to assess the test process). In addition [6] discussed the basic challenges and needs in testing cloud-based software applications which were: on-demand test environment construction, testing security and measurement in clouds.

Patidar et. al. [12] related the privacy and security issues of using cloud computing on two basic concepts: the first one is the required transformation of data in and out of cloud. The second one would be the unauthorized access of data that is not assured by the owner of that data but the provider of cloud since it is externally stored by him.

On another hand the authors of [10] presented a cloud computing approach that was represented as graph. The researchers tried to answer a basic question which is “What is a cloud application?” they considered a computing cloud as a kind of graph (a graph-theoretic model to describe applications of computing cloud in a small, and interaction way), and the use of the resource as a predicate on an edge of the graph.

### 3.3 Cloud computing adoption

The study of [11] focused on the adoption and using of cloud-based testing in collaborate organizations. They

produced thirty-five interviews from 20 organizations. The results showed that cloud computing has the possibility to outfit organizations with sufficient resources to support various testing needs. They described the reasons motivates utilizing cloud-based testing. Including the resources used in cloud testing such as: performance, multiplatform, and testing data applications. Moreover, they showed the impact of cloud-based testing on the system under test, and the strategies that can be used in the organizations that decided to choose cloud-based testing. In addition, they study the contribution of the growing interest of using cloud-based services, such as cloud-based testing.

## 4. STEPS TO PERFORM CLOUD TESTING

There are 7 steps to perform cloud testing, the steps are:

**Step1:** Deriving scenarios form users: User scenarios are established in this step and these scenarios usually have functional objectives that users need and the expected outcome from user perspective.

**Step 2:** Developing test cases: Here the test cases are defined for testing; these test cases depend on user requirement and are developed from the tester.

**Step 3:** Choosing a suitable cloud service vendors: here the service provider is selected for doing and performing the testing needed. Choosing the provider is not an easy step and it depends on user and the infrastructure of the application to be validated. There are many providers that can be chosen such as SOASTA that provide tools to test the cloud. From 2008 until now, cloud testing and testing as a service (TaaS) had become important issue in the IT field. IBM and HP had integrated and become the major providers to cloud and cloud testing but there are several and other tools to deal with cloud testing. Through that, they start to offer test solutions for cloud computing. There are several surveys focused on cloud testing technologies and vendor solutions based on services and products. Table 1 provides a comparison between different cloud testing tools based on different criteria. We used some of the criteria that have been used in [9]. However, in this paper we choose different tools. The tools are: Blazemeter, LoadStorm, SOASTA, and NeoLoad.

**Step 4:** Establishing the needed infrastructure and Setting up cloud server: The purpose of this step is to establish testing traffic of the web by the assistance of the service providers such as IBM, Amazon, Microsoft and Oracle.

**Step 5:** starting the testing process: cloud testing is begun and test cases are used. Many types of testing can be performed during the testing process but this depends on the contract between users and providers [7,6,3,2,5]. Usually, cloud testing is used. The infrastructure, capabilities and services of the cloud are used to perform or execute the testing for software. Cloud computing sometimes is defined to

computing utilities or to as SaaS. testing types can be defined as follows:

- Functional testing: Since software is generated to meet specific requirement. Such requirements can be business requirement or process and user requirements. So functional testing is used to ensure that the services offered to users is what he paid for, and ensure that single function are running smoothly . This kind of testing can be done by human tester (manually) or by program tools and software (automatically). There are some functional techniques used in the literature such as:
  - Unit Testing – this test is performed into single component or group of related component together.

It can show the testing as a function, strain or component separately from remnant of the system.

- Integration Testing – this test takes multiple unit or group of unites and put them together into single unit. So test cases are taken as inputs from the several unit test –that represent several units- and are grouped into single outright and perform the test for this aggregation .
- System Testing – this test takes the system as one whole program and exercises its compliance and how it meets its requirement specifications.

Table 1: Compare Between Different Cloud Testing Tools From Different Persepective

Testing Tools	Blazemeter ( <a href="http://blazemeter.com/">http://blazemeter.com/</a> )	LoadStorm ( <a href="http://loadstorm.com/">http://loadstorm.com/</a> )	SOASTA ( <a href="http://www.soasta.com/products/cloudtest/">http://www.soasta.com/products/cloudtest/</a> )	NeoLoad ( <a href="http://www.neotys.com/">http://www.neotys.com/</a> )
<b>Testing product</b>	-Performance testing for developers -API tests	- LoadStorm PRO -cloud load testing tool .	- SOASTA Cloud Test.	NeoLoad load and performance testing tool.
<b>Test services provided</b>	-Test on demand -Mobile Performance Testing. -Continuous Integration Testing.	- Cloud based platform -In-depth analysis for load testing in the cloud -Can simulate user load for Web applications	- Cloud Test On-Demand -Cloud Test devices -Supply different platforms and can simulate the user traffic for performance and load testing -Cloud Test expand overall load testing from development process to production the application. -Test speedily and constantly, at any part, with matchless real-time to end-to-end performance.	-Fast, realistic, powerful load and performance testing that simulates user process and observe infrastructure behavior so can eliminate bottlenecks and downs in web applications.
<b>Function Testing</b>	-Web-Based testing. -Performance Testing as Code.	-Testing supported for testers, developers and managers for websites . -LoadStorm PRO provides matchless facility of use for huge scale and originations load testing scheme.	-Web and mobile performance testing.	-Automatic GUI testing - Codeless testing
<b>Test methodology and solutions</b>	-Blazemeter enable a huge load tests to be executed in the cloud and can simulate user cases for Web apps, sites, and mobile apps or Web services.	-It is on-demand and performance and load testing that employ cloud infrastructure increase the power of Web applications to expand the power as needed to test the applications. It automatically adds machines from system server to perform the processing .	-Cloud test enable user to perform some actions like( build, execute, and analyze)performance and load tests on a One strong platform to execute the tests of SOASTA’s Test at any traffic scale.	- continued validation for events and actions of user behavior - entire and collaborative load test
<b>Test Execution support and control</b>	Blazemeter compatible with open-source Apache JMeter, so performance-testing is done by the Apache Software platform .	-LoadStorm PRO enable to execute totally on cloud platform. This implies there is no need to buy hardware, software or installation them, and provide you complicated control to all tests inclusive distribution of traffic.	- Scheduled test - CloudTest test any scale of predictable use in one interface that’s enable the user to control the decline and level of user usage and traffic from any place around the world and calculate the impact in real time.	-NeoLoad run on oracle forms application and fresh user can update characteristic decreased the scenario time by 90% (from 60 hours down to 6 hours). -NeoLoad said that they are “faster than the other performance testing tools on the market.”
<b>Service costs</b>	-free for 10 test and 10 user -99\$ monthly for 200 test/year and 1000user -499\$ monthly for 250test/year and3000 user	-Pay as you test -from (299\$ to 9.999\$ for enterprises ) - have a custom pricing plan with private contracts	-Pay per test From free lite and 2500\$ and up for each use .	-Pay per test from free to 100.000 \$ for custom and enterprise uses

- Nonfunctional testing: Concentrates on web application tests to affirm the quality of these applications and make sure that they meet the requirements that prevail in cloud. There are some nonfunctional testing [7,6,3,2,5]:
  - Performance Testing: is performed to identify how the system will act (e.g., is it responsive and stable) when some specific workload occur. It is performed to identify the threshold, restriction of cloud application. In addition the performance testing avoid the limitations of conventional testing such as: availability of the hardware, the installation of software, generating test cases, and the cost of leasing and training work teams. It may also render to examine, gauge, verify and validate some quality attributes of the system such as: simplicity, scalability, and availability.
  - Load Testing: This include generating traffic from users then calculate the system response under this traffic., This need to identify the acceptance performance of the system and the capacity capability. The acceptance testing is performed to identify the specifications of the requirement and what the user needs. Moreover, the reason of doing load testing dominates the web application attitude for normal and expects top load and traffic conditions.
  - Stress Testing: this includes testing the cloud application ability to perform in an efficient and effective way when some breaking point occurs. The reason of stress testing to determine the application problem that may appear when some critical condition occurs. This includes (heavy load, altitude concurrency) and the acceptable load include not altering or losing in services or data that may not be acceptable in critical applications. Stress testing and load testing both used in performance testing because they which concerned on cloud application availability , robustness, and completeness when extreme conditions occurs.
  - Compatibility testing: this includes testing the capability of the system or application to act on various operating systems or how well the application performs efficiently on various devices. Furthermore, how the application can easily emigrate from one vendor to another, and is used to fix compatibility problems that are important for the system.
  - Compatibility test cover: different hardware arranging, various operating systems compatibility and network, computer and application environment.
  - Security Testing: this tries to discover the weakness of the software. That could contain testing

unauthorized access from unauthenticated user to specific component [2].

**Step 6:** Define testing objectives: Objectives of testing are reviewed to see if they are met and pleased after testing is finished. Usually the main objectives that are asked include some of the following or all of them. The main objectives of performing cloud testing:

1. To ensure about the quality of cloud applications that prevail in a cloud (functional services, performance).
2. To ensure if the application can be accessed by authorized users.
3. To advocate software as a service (SaaS) in a cloud environment (software performance, scalability, security).

**Step 7:** Submitting the outcomes: Outcomes are delivered to the user or organization that asked for testing. After the outcomes are delivered back to the requesting side, analyses are made on these outcomes and critical decisions are made.

## 5. WHY CLOUD TESTING

Numerous of IT companies and software dealer want to discover why cloud testing is so important and why we need to perform testing as a service (TaaS) here are some reasons that illustrate the importance [4,5] :

1. Reducing the costs and the process of sharing the resources when testing process is performed. Because TaaS allow IT and software dealer to initialize virtual experimental tests for cloud without the need to have licenses to use cloud resources or testing and install them including (testing tools). This minimize the costs of testing and increase sharing for resources and the use of services.
2. Widespread environment of testing and the use of virtualization. Because of the flexible nature of cloud, TaaS can supply Widespread environment of testing and SaaS app that support automatic items for both virtual and real (physical) computing recourses. These advantages are useful for measuring the scalability of SaaS and load or performance testing by providing simulation for testing specially for large-scale tests.
3. Supporting on demand automated services testing. TaaS Supporting on demand automated services testing 24/7/365 that is ready to perform online testing all the time and from anywhere.
4. Pay per use or pay per test: contrary to traditional software testing, in TaaS, Consumer and end user are responsible for their draw services depended on a pre-defined service pattern and cost measurement. They performed a pay-as –test model. This model supports

many flexible services for TaaS end users to face active business and service needs.

- Support multi\_renter based testing services. This provides distinctive characteristic of SaaS applications, TaaS have to provide multi-renter based testing services.

## 6. CLOUD BASED SOFTWARE TESTING VS. TRADITIONAL SOFTWARE TESTING

Companies require to be conscious about danger related to their cloud deployments then find out the testing planning to alleviate the danger when overall testing types is performed . The main focus to be looked for testing is cloud determined and applied for functional and the nonfunctional testing scope. Both functional and nonfunctional testing are usable for traditional deployments. So, it is important to test assured

parts that are appointed to cloud deployments. But testing started with conventional testing that have many differentness from cloud based, So companies tried to do some planes for applying cloud testing by planning for [4,2,7]:

- Ownership new hardware to apply testing. This covers the budget needed to get the hardware in order to test cloud servers (testing performance , stress, load for the server).
- Purchasing new software. This includes budget and buying new software, or getting the license for using the software.
- Installing software and configuring them and configuring test cases .

Table 2 compares between cloud based software testing and traditional software testing from different perspectives.

Table 2: A comparison between Cloud based software Testing and traditional Software Testing

Service type	Traditional software testing	Cloud based software testing	Service type	Traditional software testing	Cloud based software testing
Major testing objective	-Affirm the quality of component and its performance according to requirement specifications -Review component usability, compatibility.	-Affirm the quality of component and the performance of cloud applications and assess the cloud SaaS based on environment. - Check the quality of cloud flexibility and scalability	Put multiple tool (machine) together	N/P	-Restricted by storage space
Testing and fulfillment time (execution time)	-offline testing execution -test the output before it being delivered	-Online and on demand execution time for public cloud by third parties -For private cloud offline execution time	Configuration for parameter to lab test	Manual susceptible to faults	-Mostly automatable and customizable
Testing environment	-Testing labs with configured software and bought hardware	-The environment opened to any one (public) -Closed in test labs (private )	Testing costs	-Need to purchase hardware and cost for software licensing	-Pay as you test -Cost of engineering the application /cloud.
Configuration environment for testing	-Takes many days	-Takes a few minutes	Integration testing and validation function	-Validate system and component functionality -Function /component/architecture /interface based integration	-Cloud based services function -SaaS integration based in cloud -SaaS integration between clouds
Testing as a Service	-Testing inside the company (internal testing)	-Third-party testing service(real-time on-demand and online )	Security testing	Purpose of security testing : -User privacy -Secure access for client /server -Function security -Process access security -Data integrity	Purpose of security testing : -User privacy -SaaS security -application security across cloud -Secure testing in vendors cloud
Testing simulation	-Emulated user access and traffic data (online)	Simulation virtual user access and traffic data			

## 7. CLOUD TESTING (TAAS): CHALLENGES AND PROBLEMS

Even there were many advantages of cloud testing, there were some problems or challenges related to TaaS. The challenges described in [4,2,7,5] are:

- Need a Pure test beds designed to cloud: Vendors of TaaS apply online automated test. When choosing TaaS provider we should make sure that given cloud-based test match the whole specification of the requirement and the configuration elaboration to application to testing and test environments. So to defeat this problem, some TaaS providers collaborate to gather with IaaS vendors to establish on-demand and big test

beds. IaaS could be exercised on minimum costs and less time needed to design new test beds and minimize complexity.

- Testing the integrity of data and the security: Data integrity and security is the most important concern of public clouds. Important data must be prevented and stored in remote places. Vendors of TaaS have to make sure that data security specification is being met and must make a track to support the confidentiality requirements had being met, and test the secured application.

- Select most effective paradigm and criteria. since there are a lot of available license paradigm, it is significant to select the right paradigm, that is suitable to company's requirements and to make sure about the security concerns of the company, tester, managers and developers who must plan to no extra costs that are required to save and encrypt data to be sent to TaaS vendors.

- Testing tools and analyzing eventual testing reports. Tester need to be knowledgeable to performing several TaaS tools and need to determine the suitable tool to their software and their requirements. Several tools may have various reporting techniques for generating test reports. Tester must have the ability to understand and explain different test reports . It may need new anatomy (analysis) to understand the problems generated from reports ( such as performance threshold).

- Since testing is a cyclic process and need novel environments to be initialized for every new project that is difficult to be implemented in-house testing in the company and require big budget to setup testing environment.

- Integration testing in cloud - because many current software and applications are engineered without authorization to the technology to facilitate and backing software integration. But in cloud infrastructure, developer have to work in integration of several applications and services across cloud but as black-box just according to their APIs . This affect the need for additional integration costs.

- Shortage of standards: currently, there are no unified standard resolution to integrate organizations with public cloud companies. Because vendors for public cloud already create their own architecture, infrastructure, operating types and value technique and support a few interoperability. This produces a huge problems for organizations when they decide to migrate to cloud.

## 8. CONCLUSION

After reviewing several studies, we found that cloud computing is an area that can be utilized very for several applications and has the ability to save time, effort and money. But at the same it has its own challenges, opportunities, security and privacy issues. As a good organization to succeed in the usage of cloud computing, the

researchers in this area have to be aware of these issues and build a strong architecture with the models and layers of the cloud computing. Cloud computing SaaS has been expanded widely and the TaaS also took a big place in today's market to ensure the quality of products in the cloud.

There are many service providers such as SOAST. Such providers have tools to test the cloud . Choosing the provider is not easy step that's depend on user and the infrastructure of the application he/she want to validate it .

Both types of testing (Functional testing and nonfunctional testing) require more investment to use all hardware and software to simulate user actions. Moreover, only few benefits and small testing challenges of cloud computing can be addressed by performing testing to the cloud. Also, because of testing is cyclic process there is continuous need to add and initialize requirement for every system.

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