

Testing as a Service on Cloud: A Review

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Abstract—Software testing is an important part of software engineering life cycle. Software testing is a process used for evaluating an attributes or capability of program and makes sure that it meets the requirements. The application building techniques have changed and has adapted to newly emerging technology of cloud. Cloud computing has changed the way of obtaining computing resources, and also has given a new direction to manage and deliver computing services, technologies, and solutions. Cloud computing not only brings new business opportunities, but also causes some major impacts on software testing and maintenance. Cloud computing creates an opportunity that offers testing as a service (TaaS) for SaaS and Clouds. This lead to a new phase shift in conventional testing thereby identifying new issues, challenges and needs in software testing, particular in testing Clouds and Cloud-based applications. This paper gives a comprehensive view on Testing as a Service. Also a comparative view towards conventional testing and Cloud testing is also considered.

Keywords - Cloud testing, Cloud-based Software Testing, Testing Cloud services, TaaS, SaaS, IaaS, PaaS.

INTRODUCTION

Software testing plays a very significant role in the growth of an enterprise. Over time, the software testing function has become a challenging activity for enterprises due to increasing technological complexities, software sourcing challenges. Typically, software testing is done either internally within the organization. Testing follows its own evolution cycle. This offered customers a dynamically scalable and economic framework which enabled them to outsource their testing requirements.[4]

Cloud computing is a recent evolution of distributed computing paradigm which can support on-demand service sharing with higher level of flexibility and dynamic scalability [2]. Cloud computing received significant role in the way computation and services to customers, For example, it changes the way of providing and managing computing resources, such as CPUs, databases, and storage systems. Today, leading players, such as Amazon, Google, IBM, Microsoft, and Salesforce.com offer their Cloud infrastructure for services. [1] Cloud computing is a business and economical model. This model has been successfully deployed and executed for various commodities since its inception, but in recent years it has been more into IT products & services. IT industry over a period of time offers wide range of services – on demand. We often come across “Games as a service”, “Java as a service”, “Storage as a service” and even more.

A recent study of Market Research Media forecasts that U.S. government spending on Cloud computing is entering an explosive growth phase at about 40% CAGR over the next six years. Expenditure will pass \$7 billion by 2015. Merrill Lynch estimates that within the next five years, the annual global market for Cloud computing will surge to \$95 billion. Cloud computing not only brings new business opportunities, but also causes some major impacts on software testing and maintenance. A major impact is known as Testing as a Service (TaaS) in Clouds. Testing in the Cloud leverages Cloud computing environments and seeks to simulate real-world user traffic as a means of load or stress testing Web sites. [6] Today, Testing-as-a-Service is being increasingly considered a viable testing model by many organizations to achieve reduced costs and improved service for their IT Test requirements. [5]

CLOUD TESTING

Cloud computing affects on all the stages of software life cycle including software testing. Similar to an acceptance of standard terminologies such as SaaS, PaaS, IaaS in Cloud computing, The TaaS is also considered as essential concept today.[1] Cloud testing is an important part of Cloud computing, a new direction in information technology. Cloud testing is a rapidly developing area of research in software engineering.

The first research works on Cloud computing appeared two to three years ago. Two specialized workshops on Software

Testing in Cloud (STITC) were organized in 2009 and 2010. Research on Cloud testing lags in some measure behind practical results in this area. Riungu, Taipale & Smolander provides a comprehensive discussion on Cloud testing issues. This discussion reflects the practical needs and expectation in Cloud testing and is analyzed using 3 categories Application, Management & legal and financial issues. [1]

Cloud Testing offers a suite of services that allow developers, testers and website managers to automate and speed up the testing and archiving of their websites using real browsers from the Cloud. Cloud Testing operate a SaaS (Software as a Service) model, so there is no need to invest in any hardware, software or consultancy; our services provide all you need. [3] Cloud Computing provides a cost-effective and flexible means through which scalable computing power and diverse services (computer hardware and software resources, networks and computing infrastructures), diverse application services, business processes to personal intelligence and collaboration are delivered as services to large-scale global users whenever and wherever they need.

Cloud computing is the next stage of the Internet evolution. A typical Cloud must have several distinct properties: elasticity and scalability, multi-tenancy, self-managed function capabilities, service billing and metering functions, connectivity interfaces and technologies. In addition, a Cloud supports large scale user accesses at distributed locations over the Internet, offers on-demand application services at anytime, and provides both virtual and/or physical appliances for customers. There are three types of Clouds:

- a) Private Clouds, which are internal Clouds based on a private network behind a firewall;
- b) Public Clouds, which are the Clouds with public accessible services over the Internet; and
- c) Hybrid Clouds, which are made of different types of Clouds, including public and private Clouds.

TESTING ON CLOUD

Cloud Testing is defined as Testing as a service. It industries that deals with testing products and services are making use of Cloud based licensing model for their end clients. The offering includes Functional as well as non-functional testing of various applications. The Cloud testing provides services in two modes:

On-Premise: Testing as a service can be used for validation and verification of various products owned by organizations or individuals. Load testing is available in both types.

On-Demand: Testing on demand is used to test On-Demand software. It is becoming increasingly popular to use testing as a service to simulate production such as Cloud environments instead of traditional On-Premise testing products. [11]

In short, Cloud-based software testing refers to testing and measurement activities on a Cloud-based environment and infrastructure by leveraging Cloud technologies and solutions. It has four major objectives. To assure the quality of Cloud-based applications deployed in a Cloud, including their functional services, business processes, and system performance as well as scalability based on a set of application-based system requirements in a Cloud.

- To validate software as a service (SaaS) in a Cloud environment, including software performance, scalability, security and measurement based on certain economic scales and pre-defined SLAs.
- To check the provided automatic Cloud-based functional services, for example auto-provisioned functions.
- To test Cloud compatibility and inter-operation capability between SaaS and applications in a Cloud infrastructure, for example, checking the APIs of SaaS and their Cloud connectivity to others.

IMPORTANTANCE

Comparing with current software testing, Cloud-based testing has several unique advantages listed below.

1. Reduce costs by leveraging with computing resources in Clouds – This refers to effectively using virtualized resources and shared Cloud infrastructure to eliminate required computer resources and licensed software costs in a test laboratory.
2. Take the advantage of on-demand test services (by a third-party) to conduct large-scale and effective real-time online validation for internet-based software in Clouds.
3. Easily leverage scalable Cloud system infrastructure to test and evaluate system (SaaS/Cloud/Application) performance and scalability.
4. Reduce its capital and licensing expenses as much as 50% to 75% using virtualized resources. [6]
5. Reduce operating and labor costs as much as 30% to 50% by automating development and testing resource provisioning and configuration. [6]
6. Shorten its development and testing setup time from weeks to minutes.

7. Improve product quality and reduce the detected defects by as much as 15% to 30%.[6]

FORMS OF CLOUD-BASED SOFTWARE TESTING

There are four different forms of Cloud-based software testing. Each of them has different focuses and objectives.

- **Testing a SaaS in a Cloud** – It assures the quality of a SaaS in a Cloud based on its functional and non-functional service requirements.
- **Testing of a Cloud** – It validates the quality of a Cloud from an external view based on the provided Cloud specified capabilities and service features. Cloud and SaaS vendors as well as end users are interested in carrying on this type of testing.
- **Testing inside a Cloud** - It checks the quality of a Cloud from an internal view based on the internal infrastructures of a Cloud and specified Cloud capabilities. Only Cloud vendors can perform this type of testing since they have accesses to internal infrastructures and connections between its internal SaaS and automatic capabilities, security, management and monitor.
- **Testing over Clouds** – It tests Cloud-based service applications over Clouds, including private, public, and hybrid Clouds based on system-level application service requirements and specifications. This usually is performed by the Cloud-based application system providers [6]

TESTING AS A SERVICE (TAAS)

Testing as a service (TaaS) concept was initially introduced by “Tieto” in Denmark in 2009, and the solution of TaaS was nominated by IBM. Now the TaaS has a wide attention due to its advantage in its scalable testing environment, cost reduction, utility-based service model, and On-demand testing services.[8]

Testing as a Service (TaaS), a new Cloud based global delivery model can help you address these issues more effectively. In the areas of performance testing, security testing, reliability testing, experience in virtualization technologies and investments in hardware infrastructure, the third party independent testing service providers are well suited to do this work [3]

There are various features in Cloud testing. One of them is Testing as a service (TaaS).It provides the static and dynamic On-Demand testing services in/on/over Clouds for the client at any time. The main goal is to reduce the IT budget of business to focus their core business by outsource software testing tasks to a third party using TaaS service model.[8]

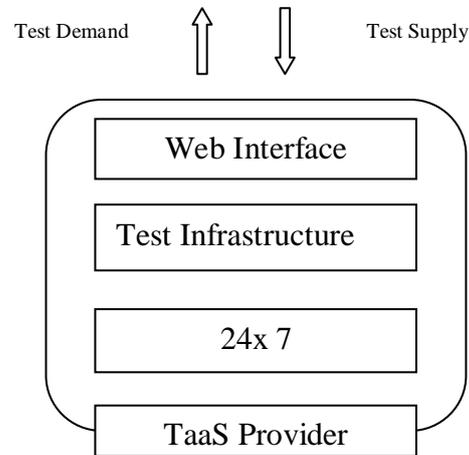


Figure 1:TaaS Model

TaaS alleviates the customer's burden of installing and maintaining test environments, sourcing and (test) support. Using TaaS can also reduce the costs of testing, through less costly, on-demand pricing.[7] One of the primary objectives is to reduce the IT budget of businesses to focus their core businesses by outsource software testing tasks to a third party using TaaS service model. TaaS involves the on-demand test execution of well-defined suites of test material, generally on an outsourced basis. The execution can be performed either on client site or remotely from the outsourced providers test lab facilities.

TaaS has received wide attention due to its advantage in its scalable testing environment, cost reduction, utility-based service models, and on-demand testing services.

WORKFLOW OF TaaS

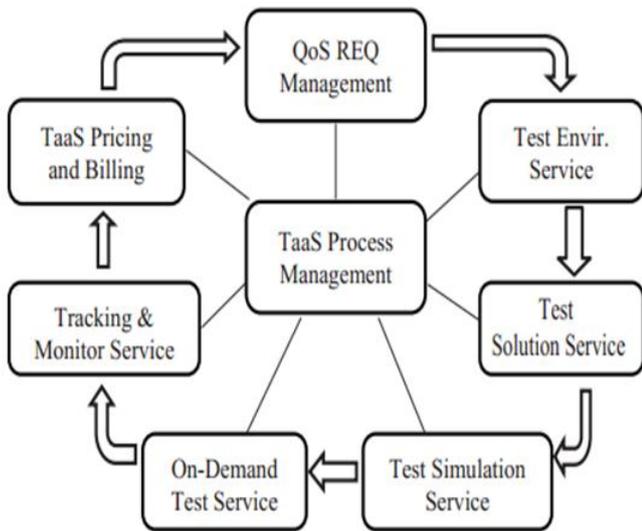


Figure 2: Workflow of TaaS

The work-flow of TaaS includes the following major TaaS service capabilities.

- **TaaS process management**, which offers test project management and process control.
- **QoS requirements management**, which supports book keeping and modeling of software testing and

QoS requirements, including quality assurance modeling.

- **Test environment service**, which provides on-demand test environment services to establish the required virtual (or physical) Cloud-based computing resources and infrastructures, as well as the necessary tools.
- **Test solution service**, which offers diverse systematic testing solutions (such as, test modeling and test methods), and test-ware generation and management services.
- **Test simulation service**, which establishes on-demand test simulation environments with selected facilitates (such as tools), and supports the necessary test data/message generation.
- **On-demand test service**, which provides on-demand test execution services based on selected schedules and test wares.
- **Tracking and monitor service**, which allows test engineers to track and monitor diverse program behaviors at different levels in/on/over Clouds for the testing purpose.

TaaS pricing and billing, which enables TaaS vendors to offer customers with selectable testing service contracts, based pre-defined pricing models, and billing service

Cloud Testing VS. Conventional Software Testing

Table 1 show below comparison between Cloud Testing and conventional software testing.

Parameter for testing	Internet-Based Software Testing (i.e. Distributed/Web-Based System Infrastructure)	Cloud-Based Software Testing
Primary Testing Objectives	Assure the quality of system functions and performance based on the given specifications Check usability, compatibility, interoperability.	Assure the quality of functions and performance of SaaS, Clouds, and applications by leveraging a Cloud environment. Assure the quality of Cloud elasticity & scalability based a SLA.
Testing as a service	In-house internal software testing as engineering tasks.	Real-time on-demand testing service offered by a third-party. Online testing service based on a pre-defined SLA.
Testing Environment	A pre-fixed and configured test environment in a test lab.	An open public test environment with diverse computing resources. A scalable private test environment in a test lab.
Testing Costs.	Required hardware costs and software (license) costs Engineering costs in a test process.	- Based on pre-defined SLA's - pay as you test (Cloud testing cost) - Engineering cost in SaaS/Cloud/application vendors.

Test simulation	<ul style="list-style-type: none"> - Simulated online user access - Simulated online traffic data 	<ul style="list-style-type: none"> - Virtual /Online user access simulation - Virtual /Online traffic data simulation
Functional Testing	<ul style="list-style-type: none"> - Validating functions (unit and system) as well as its features 	<ul style="list-style-type: none"> - SaaS/Cloud service functions - End-to-end application functions
Integration Testing	<ul style="list-style-type: none"> - Function based - Component based - Architecture based 	<ul style="list-style-type: none"> - SaaS based integration in Cloud - SaaS integration between Clouds - End to end integration over Clouds
Security testing	<ul style="list-style-type: none"> - Function based security features <ul style="list-style-type: none"> - User privacy - Client / server based security - Process based security. 	<ul style="list-style-type: none"> - SaaS/Cloud security features, - User privacy in diverse web clients - SaaS/Cloud API and connectivity security - Security testing with virtual /real-time tests in vendor’s Cloud
Scalability & performance testing	<ul style="list-style-type: none"> - Performed a fixed test environment - Simulated user access and test data. - Online monitor and evaluation. 	<ul style="list-style-type: none"> - Performed in a scalable test environment based on SLA - Apply both virtual and real time online test data <ul style="list-style-type: none"> - Online monitor, validate and measurement.

Table 1: Comparison between Cloud testing and Conventional software testing

MAJOR ISSUES IN CLOUD TESTING

There are a number of major issues; some of them are discussed below:

- **On-demand test environment construction** – How to set up a testing environment systematically (or automatically) for on-demand testing services in a Cloud? Although the current Cloud technologies support automatic provision of required computing resources for each SaaS (or application) in a Cloud, there are no supporting solutions to assist engineers to set up a required test environment in a Cloud using a cost-effective way.[4]
- **Scalability and performance testing** - Although many published papers discuss system performance testing and scalability evaluation in the past two decades, most of them address issues and solutions in conventional distributed software or web-based software systems. Since these systems are set up with pre-configured system resources and infrastructures, performance testing and scalability evaluation are usually conducted in a static and pre-fixed system environment (such as a test lab.), so the existing evaluation metrics, frameworks, and solutions did not consider the special features in Cloud testing, such as dynamic scalability, scalable testing environments, SLA-based requirements, and cost-models.
- **Testing security and measurement in Clouds** – Security testing has becoming a hot research subject with many open questions in current software testing community. Since security becomes a major concern inside Clouds and security services become a necessary part in modern SaaS and Cloud technology, engineers must deal the issues and challenges in security validation and quality assurance for SaaS and Clouds.[4]
- **Integration testing in Clouds**- One of the major reasons is the existing software and components are developed without Enabling technology and solution to support and facilitate systematic software integration. In a Cloud infrastructure, engineers must deal with integration of different SaaS and applications in/over Clouds in a black-box view based on their provided APIs and connectivity protocols.

- **On-demand testing issues and challenges** - In TaaS, software testing services must be controlled and managed based on on-demand testing requests. This kind of new testing service model raised several issues and challenges.
- **Regression testing issues and challenges** - Supporting on-demand software validation in Clouds must address the regression testing issues and challenges caused by software changes and bug-fixing. However, most existing research in software regression testing pays most attention to re-test a specific software version in a pre-configured test environment.

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CONCLUSION AND FUTURE WORK

TaaS is still an emerging research area with many open problems. This paper highlights the Cloud testing and research issues, , and features as well as the comparison with conventional testing. At this time it is safe to say that quantitative and qualitative intensification of research activities in Cloud testing can be expected in future.

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