

New Computing Paradigm: Software Testing in Cloud, Issues, Challenges and Need of Cloud Testing in today's World

Swapnil H. Chandane

Computer Science & Engineering, Amravati University
India

Prof. Mahip M. Bartere

Computer Science & Engineering, Amravati University
India

Abstract –

Cloud computing has emerged as a new computing paradigm that impacts several different research fields, including software testing. The cloud computing model continues to gain much attention from software industry practitioners for the development of more effective software testing techniques. Leading companies are investing in the development, packaging and delivery of cloud services over the Internet. There is significantly less research devoted to testing them. Utilizing the cloud for testing started around 2002. Testing services in the cloud today is mainly inclined towards providing a solution that attempts to address a wide range of testing purposes and therefore is not applicable in testing unique applications such as complex distributed systems. Cloud computing not only changes the way of obtaining computing resources but also changes the way of managing and delivering computing services, technologies, and solutions meanwhile, it causes new issues, challenges and needs in software testing. Software testing in the cloud increases the efficacy of testing to improve the quality of the application. Software testing in the cloud can reduce the need for hardware and software resources and offer a flexible and efficient alternative to the traditional software testing process. In this paper we provide an overview regarding trends, opportunities, challenges, issues, needs and latest happening in cloud testing & cloud-based application.

Keywords - cloud testing, cloud-based software testing, testing cloud services.

I. INTRODUCTION

Cloud computing is a business and economic model. This model have been successfully deployed and executed for various material commodities since its inception. But in recent years it has been formalized for IT products and services (Neha Malhotra, 10th annual software testing conference, 2010). Cloud computing has emerged as a new computing paradigm that facilitates the development and utilization of services on-demand, and over broadband network access. Therefore many organizations moving their businesses to a cloud platform. Leading companies such as IBM, Microsoft, Google, and Amazon have a vested interest in cloud computing. Software testing has been one of the best practice areas for migrating to cloud environment. Testing new software requires costly server, storage and network devices only for a limited time. These computing resources are not used after testing, thus incurring extra cost on budget. To ensure a reliable service, providers have to test their services on all platforms. Test automation topic is frequently visited when software testing is considered over the cloud. One of the major drivers of cloud computing adoption is economies of scale. It provides a pay-per-use type of service, thus eliminating the upfront investment in many cases. Cloud services may be allowed to dynamically adapt and update which requires that changes be validated at runtime. However, the high availability requirements of cloud services means that they should employ a sufficiently transparent runtime testing Process i.e., any degradation of the timing, processing, and memory characteristics should be within the limits allowed by the quality of service requirements. Developers and testers of cloud applications that use remote services generally do not have control of this service. We also introduce the notion of test support as-a-service (TSaaS), which provides cloud partners with access to automated test operations for remotely hosted cloud services. Software Testing is an investigation conducted to assess the functionality and correctness of a program or system, usually done by executing or analysing it (Parveen et al, 2010). Testers at the industry are having difficulty in testing the performance of a distributed system under peak load; this is mainly because there are insufficient computing resources to support the testing process. This creates a number of challenges such as inefficiency in the testing process owing to the fact that it could take a long period of time to execute the test (Parveen et al, 2010). Cloud computing offers a solution to the problem described above problem. Cloud computing not only brings new business opportunities, but also causes some major impacts on software testing and maintenance. Questions on cloud testing are listed below.

- What is cloud testing? And what are its special test process and scope, requirements and features?
- What are the major differences between conventional software testing and cloud-based software testing?
- What are the special requirements and distinct features of cloud-based software testing?
- What are the special issues, and challenges, and needs in cloud testing?
- What are the current practice, tools, and major players?

This paper is written to attempt to answer these questions. The paper introduces basic concepts about cloud testing, including its objectives, distinct requirements, features, and benefits. In addition, it covers software testing issues and challenges for clouds and cloud-based applications in different perspectives from end-users, vendors, and application providers. The paper also covers several major players, and provides a comparative view on emergent technologies and

tools in cloud testing. In recent years, cloud computing has taken on significance as a new approach to distributed computing. For instance, when user's upload their applications, the infrastructure within 'the cloud' automatically scale to support the hardware requirements of any given application. Well-known examples of cloud platforms include Google's App Engine, Amazon's EC2, Microsoft's Azure, IBM Smart Cloud. The growing importance of cloud testing has received attention in recent years due to two specialized research workshops in the area of software testing in the cloud.

Cloud providers, in general, have their own unique approaches to infrastructure testing, which are typically internal to the company and not necessarily revealed to the public. Software testing in the cloud changes the traditional testing scenario Migrating testing to the cloud can be challenging. Some business applications may not be available in Software-as-a-Service (SaaS) mode, others may have limited configuration options, and the changes need to the testing process may be too onerous. However, when appropriate, testing in the cloud can provide significant benefits.

To support migration of software Testing to the cloud called SMART-T. The name "SMART-T" comes from the SMART method, but specialized for testing ('T'). Testing is nowadays the primary way to improve the reliability of software. Software testing accounts up to 50% of the total cost of software development. The paradigm of cloud computing brings obvious benefits for the software testing process. The deployment of software testing services in the cloud makes them easily available for different companies and projects and allows their on-demand usage. Before testing in the cloud becomes widely accepted and used in industry, various technical, security and privacy protection issues must be resolved. **Cloud computing remains** a hot topic in the IT industry as a model that provides computing resources on demand with reduced administration costs. Its main service layers are infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). Cloud computing supports an everything-as-a-service (XaaS) delivery model, providing Internet services ranging from security and databases to storage and integration (for cloud-based testing .

II. CLOUD COMPUTING, CLOUD TESTING AND TESTING AUTOMATION IN CLOUD

Cloud computing is a relatively recent term, which basically defines a new paradigm for service delivery in every aspect of computing. It is especially based on two key concepts. The first one is *Service-Oriented Architecture (SOA)*, which is the delivery of an integrated and orchestrated suite of functions to an end-user. The second key concept is *virtualization*. Virtualization allows abstraction and isolation of lower level functionalities and hardware, which enables portability of higher level functions and sharing and aggregation of the physical resources.

A. Characteristics

Rapid elasticity allows end users to easily and rapidly provision new services and release them, enabling them to pay for what they utilize and how much they use it. On-demand self-service is an appealing characteristic for consumers because A cloud computing provider pools its computing resources in order to serve multiple consumers by means of a multi-tenant provisioning model.

B. Service delivery

Software as a Service (SaaS) delivery model is described as providing software applications/services over cloud infrastructure for consumers. These applications are accessible from various platforms through an easy-to-use client interface such as a web browser. Platform as a Service (PaaS) delivery model enables consumers to deploy their solutions to the cloud by means of platforms such as application servers and database services provided by the Cloud Platform Provider. Infrastructure as a Service (IaaS) is the lowest level of service model in cloud delivery models. In IaaS consumers acquire computing services and can deploy their own custom configured systems.

C. Deployment

The deployment model of a cloud platform is also important to consider when delivering or procuring on-line services. Public cloud infrastructures are provisioned for use by any consumer.

D. Software Testing and Virtualization

Software testing is an integral part of the software development life cycle challenges in software testing is deploying and maintaining a real-world test platform at the outset of a project. Virtualization technology has been utilized in testing various software since its inception in 1960's. IBM's CP-40 project might be considered as the pioneer of virtualization technology. The concepts that affect software testing as an on-line service are domain knowledge, infrastructure, security, pricing, communication and skills. On-line testing reduces costs related to installing and maintaining testing environment. It also introduces a new market where the providers and consumers can reach skilled test engineers on-demand.

E. What is Cloud Testing?

According to Wikipedia, "cloud testing is a form of software testing in which Web applications that leverage Cloud computing environments ("cloud") seek to simulate real-world user traffic as a means of load testing and stress testing web sites. The ability and costs to simulate Web traffic for software testing purposes has been an inhibitor to overall Web reliability."

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.

F. Why is Cloud Testing Important?

Cloud-based testing has several unique advantages over software testing listed below.

- 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.
- 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.
- Reduce operating and labour costs as much as 30% to 50% by automating development and testing resource provisioning and configuration.
- Shorten its development and testing setup time from weeks to minutes.
- Improve product quality and reduce the detected defects by as much as 15% to 30%.
- Help to accelerate cloud computing initiatives with IBM Cloud Burst™ implemented through QuickStart services.

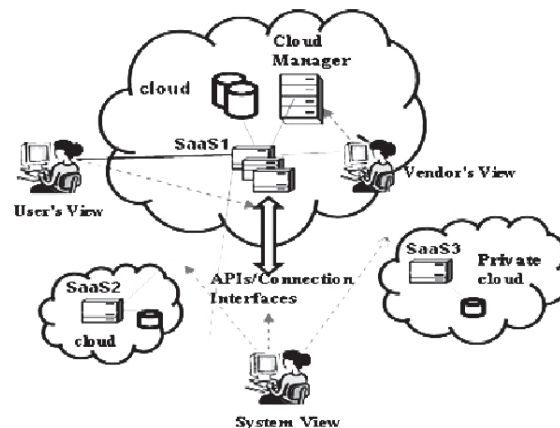


Fig. 1 Cloud testing

G. Tasks in three types of cloud testing given below

1) *Cloud/SaaS-oriented testing*: This type of testing activities usually is performed inside a cloud by engineers of cloud/SaaS vendors. The primary objective is to assure the quality of the provided service functions offered in a cloud (or a SaaS program). These engineers must go through unit testing, integration, system function validation and regression testing, as well as performance and scalability evaluation. In addition, testing cloud-based or SaaS-based security services and functional features must be tested. Performance testing and scalability evaluation in a cloud is very important and critical to cloud/SaaS vendors because this assures the quality of cloud elasticity to support SaaS and cloud services inside a cloud.

2) *Online-based application testing on a cloud*: This type of testing activities usually is performed to check online application systems on a cloud by using with cloud-based large-scale traffic and user accesses. This is a common usage of cloud technology to help current online application vendors to conduct online-based system function testing and performance evaluation on a cloud by taking the advantage of cloud environment.

3) *Cloud-based application testing over clouds*: This type of testing refers to the engineering activities performed to assure the quality of a cloud-based application crossing different clouds. When applications are developed to be deployed and executed over different clouds, new testing tasks are needed to assure its quality.

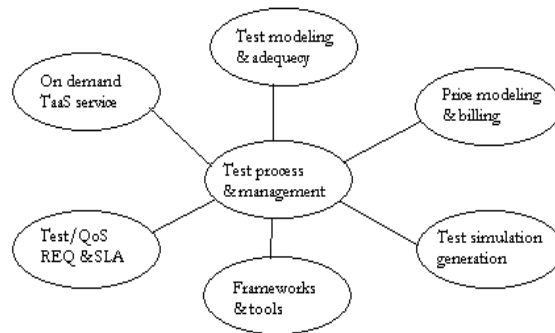


Fig. 2 The scope of cloud based software testing

H. Testing in the Cloud

The term *cloud* became popular after Google’s CEO Eric Schmidt used the word to describe the business model of providing services across the Internet in 2006. In mid-2009, the U.S. National Institute of Standards and Technology (NIST) gave the following definition of the concept (Mell & Grance, 2011): Cloud computing is a model for enabling convenient, on- demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. The essential characteristics of a cloud include on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service. Three service models of cloud computing were defined (Mell & Grance, 2011):

- *Software as a Service (SaaS)* model
- *Platform as a Service (PaaS)*
- *Infrastructure as a Service (IaaS)* model

Software testing as a Service is defined as a model of software testing used to test an application as a service provided to customers across the Internet. It enables daily operation, maintenance and testing support through web-based browsers, testing frameworks and servers.

Migrating to the cloud can be costly, and it is not always the best solution to all testing problems. (Parveen& Tilley, 2010). The characteristics of a program that make it feasible for its testing process to be migrated to the cloud include the following:

Test cases are independent from one another (or their dependencies are easily identifiable),

- A self-contained and easily identifiable operational environment, and
- Programmatically accessible interface that is suitable for automated testing
- A large-scale software testing environment for dependable distributed systems. It uses computing resource provided by the cloud to execute several test cases simultaneously, and thus to accelerate software testing process. D-Cloud takes advantage of virtual machine technology to provide a fault injection facility that allows hardware faults to be emulated according to the user’s request. It also offers an advanced configuration utility that facilitates the system setup and the testing process.

1) *Testing Automation in the Cloud*: Massive simulation or emulation of load for testing purposes can require a huge amount of computing resources. One approach for increasing efficiency in the testing process is to generate such loads rapidly thereby assuring that mass load is achievable by executing the testing program in as short time as possible.

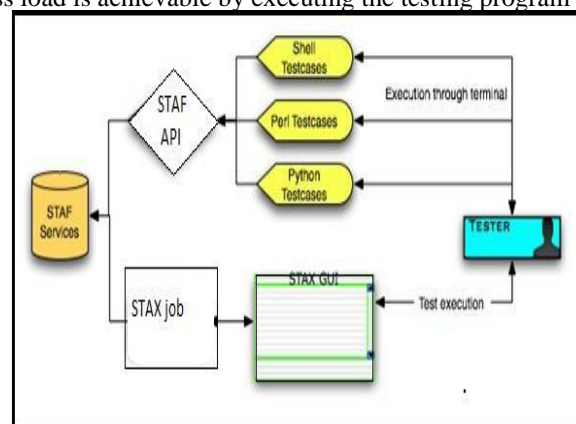


Fig.3. the STAF framework

Automation of tests helps gather and disseminate information about tests quickly, to give developers a fast feedback. The two main objectives of automating tests are; quick detection of destabilizing changes in the new builds and quick exposure of regression defects (Cervantes, 2009). Cervantes, 2009, explains that test automation gives a tester the

possibility of achieving unattended testing capabilities and with end-to-end test automation a tester can schedule tests to run autonomously. Cervantes, 2009, Cervantes, 2009, presented the idea that one prospect for enabling and improving the practice of automating tests is the use of software test automation framework (STAF).

I. Testing and the cloud

There are several factors to be considered for testing in the cloud:

- Testing is a periodic activity and requires new environments to be set up for each project. Test labs in companies typically sit idle for longer periods, consuming capital, power and space. Approximately 50% to 70% of the technology infrastructure earmarked for testing is underutilized, according to both anecdotal and published reports.
- Testing is considered an important but non-business-critical activity. Moving testing to the cloud is seen as a safe bet because it doesn't include sensitive corporate data and has minimal impact on the organization's business-as-usual activities.
- Applications are increasingly becoming dynamic, complex, distributed and component-based, creating a multiplicity of new challenges for testing teams.

For instance, mobile and Web applications must be tested for multiple operating systems and updates, multiple browser platforms and versions, different types of hardware and a large number of concurrent users to understand their performance in real-time. The conventional approach of manually creating in-house testing environments that fully mirror these complexities and multiplicities consumes huge capital and resources.

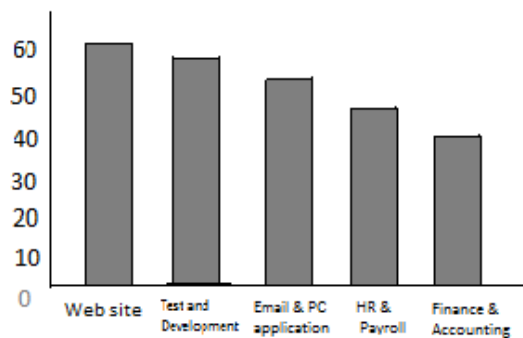


Fig. 4 Top application in cloud

Source: Cognizant report

J. Current technologies and Solutions

Since 2008, testing as a service (TaaS) and cloud testing become hot topics in industry. IBM and Hewlett-Packard have jumped into the market for cloud testing in clouds. Meanwhile, there is a handful of start-ups already offer their solutions on-premises testing on clouds.

- *SOASTA* – It has its unique cloud testing product family (known as *SOASTA CloudTest™*) to support common web application tests in performance and load testing, function testing, and UI testing either inside a firewall or inside "The Cloud". Their on-demand testing service offers users with a scalable cloud testing environment at affordable costs for testing service. In addition, *SOASTA's* Cloud Test-Appliance, allows customers perform affordable load testing and end-to-end performance evaluation using scalable system appliances inside a firewall. In addition, *SOASTA* supports test engineers to validate large-scale web applications and services with many web pages, messages and events. These web applications may support tens or hundreds of thousands of users, and have a variety of connectivity protocol. Such as HTML, SOAP, REST, HTTP, Ajax and so on.
- *iTKO* – It provides its customers with a *LISA* product suite. It focuses on development and testing service for cloud applications. *iTKO's* LISATM Test is an integrated and collaborative automated testing solution designed for Cloud.

III. NEEDS, CHALLENGES AND LATEST IN CLOUD TESTING

A. Opportunities, Issues, Challenges and Need of cloud testing

To effectively perform cloud testing, it is very important to understand the issues, challenges and needs.

1) *Issues and Challenges in Cloud Testing*: Jerry Gao, Xiaoying Bai and Wei- Tek Tsai in a white paper titled "Cloud Testing – Issues, Challenges, Needs and Practice" published in *Software Engineering: An International Journal* highlights the major issues and challenges in cloud testing.

- *On-Demand Test Environment Construction*- The question that often arises is how to build a testing environment for on- demand cloud testing services which is either systematic or automatic. According to Gao et al, the current cloud

technology does not have any supporting solutions that will help cloud engineers build a cost effective cloud test environment.

- Scalability and Performance Testing- A survey by Gao and others found that many of the published papers have discussed about performance testing and solutions; however, they only “focus on scalability evaluation metrics and frameworks for parallel and distributed systems.” The current metrics, frameworks and solutions, does not support the features such as dynamic scalability.
- On demand Testing Issues and Challenges- Software testing services in TaaS should be controlled and managed by keeping in mind the on demand testing requests and this raises many issues and challenges such as identifying the test process for TaaS which will support on-demand automated testing, or to identify the various approaches to help engineers cope with the breakdown of test cases or test scripts.
- Regression Testing Issues and Challenges- Software challenges and bug fixing brings in regression testing issues and challenges. The on – demand cloud testing services should address the various issues and challenges.
- Testing security and measurement in clouds- Security testing has becoming a important research subject with many open questions in 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. Here are some related issues and challenges:

-How can we assure the security of cloud based application processes and business data inside a third-party cloud infrastructure?

-What are the QoS standards for security oriented quality assurance for end-to-end application process and related business data in/on/over clouds?

-What are the test models, test adequacy, test techniques and tools for security testing for end-end applications in/on/over clouds?

-How can we assure and assess user privacy in a cloud infrastructure?

B. Major Needs in Cloud Testing

Needs in cloud testing as mentioned by Jerry Gao, Xiaoying Bai and Wei- Tek Tsai in a white paper titled “Cloud Testing – Issues, Challenges, Needs and Practice” published in Software Engineering: An International Journal. Some needs are given below.

- Adequate test models and criteria- Test engineers should be provided with adequate test models and criteria that effectively support cloud testing. The test models and criteria should be in the following areas:

1) *Scalability models for SaaS and Cloud - based Applications:* To validate and measure system’s scalability and performance, test engineers should be provided with well-defined adaptive test models and evaluation metrics which address scalable computing resources and others.

2) *Adequate integration models and criteria:* Adequate test models and criteria which addresses Cloud-based connectivity protocols and APIs crossing clouds, SaaS (or application) APIs and interactions to legacy systems outside clouds and End-to-end application integration crossing clouds are needed.

- Innovative test methods and solutions- The ever changing requirements and features of cloud applications bring in demands for newer test methods and solutions. Here are some of the demands.

- *Continuous validation and regression testing solutions:* Whenever software has been changed due to bug fixing or for feature update, test engineers should be provided with automatic re- testing techniques which address the multi – tenancy feature of cloud.

- *New automatic test solutions for cloud interoperability:* Test engineers should assure the interoperability quality of the cloud applications as both cloud and SaaS offers connectivity protocols and APIs.

3) *Innovative test technologies for cloud compatibility testing:* To access services using diverse client platforms, technologies and browsers, the cloud applications and SaaS should support the global online users. Therefore, in order to find out the applications’ compatibility across various platforms, browsers and technologies, vendors have to come up with new and effective technologies.

4) *New automatic test solutions for cloud:* Interoperability – Because both clouds and SaaS provides their connectivity protocols and APIs, this requires engineers to assure the quality of interoperability of cloud-based applications crossing different clouds in connectivity protocols, firewalls, interactions between SaaS and legacy systems.

C. Innovative test technologies for cloud

Compatibility testing – Cloud-based applications and SaaS must support global online users to access the provided services using diverse client platforms, browsers, and technologies, this suggests that vendors need new effective test technologies to support the validation of application compatibility on different platforms, client technologies, and browsers. Cloud testing requires large scale real-time test loads in a scalable web-based distributed environment. This suggests the need of several test tools and solutions. **One of them** is a powerful test simulator, which provides large-scale web based test simulation and data generation in a cloud using virtual and physical computing resources. To effectively use the existing performance solutions, it is clear that certain flexible interfaces and gateways are needed in the simulator

to connect to existing performance test tools. The *second* is an innovative integration test solution that supports easy and seamless integration between SaaS and applications crossing clouds. This implies that certain standard API-based and connectivity-enabled test frameworks are needed to support the integration over clouds. *The third* is the cloud-based performance and scalability solutions that support engineers validate non-function requirements for SaaS and cloud-based applications at different levels to assure their performance and scalability based on the given SLAs and certain economic scales (or cost models). *Furthermore*, an innovative end-to-end program tracking solution is needed to support software testing, bug-fixing, and maintenance of cloud-based programs at different levels. This solution enables engineers to understand, test, and monitor end-to end application processes, transactions, service functions, and interactions between SaaS and clouds.

D. Latest in Cloud testing

- Skytap Automation Pack Brings Testing to the Cloud- Today, Seattle-based Skytap Inc. released the Skytap Automation Pack, designed to securely connect enterprises' on-premises app dev tools with the Skytap Cloud.
- Build.com Taps Cloud-Based Vera code- To Improve Code Security Across SDLC Build.com is looking to more quickly and easily detect and plug application bugs and vulnerabilities by automating key elements of its application testing. The company bringing Veracode's cloud-based application security testing solution into its software development lifecycle.

IV. CONCLUSION

Cloud computing and software testing are likely to be popular research fields in the near future. Traditional software testing techniques are being adapted for the cloud. On the other hand, cloud computing itself is under constant evolution, continuously bringing in new opportunities and challenges for software testing research. In this paper, we have presented a software testing with different deployment models of cloud computing. We have observed that test task management is also among the potential areas for further research. Finally, our future research will be focusing on filling these gaps for achieving a verification and validation model in cloud computing. We proposed the migration of autonomic self-testing to the cloud, and introduced the notion of test support as-a-service.

REFERENCE

- [1] Koray Incikci*, Ismail Arı*, Hasan Sözer*: A Survey of Software Testing in the Cloud, 2012.
- [2] Tariq M. King, Annaji Sharma Ganti: Migrating Autonomic Self-Testing to the Cloud, 2007.
- [3] Johnson Onajite Igugu Pooja Biltoria: STAF-on-Eucalyptus: A Cloud Based Software Testing Environment for Distributed Systems , 2011.
- [4] Jerry Gao, Xiaoying Ba, and Wei-Tek Tsai: Cloud Testing- Issues, Challenges, Needs and Practice, 2011
- [5] Neha malhotra: Cloud testing vs. testing a cloud (10th annual software testing conference, 2010
- [6] William Jenkins, Sergiy Vilkomir, Puneet Sharma, George Pirocanac: Framework for Testing Cloud Platforms and Infrastructures, 2011.
- [7] Leah Riungu-Kalliosaari, Ossi Taipale, and Kari Smolander: Testing in the Cloud: Exploring the Practice, 2012.
- [8] Nikolai Kosmatov: Concolic Test Generation and the Cloud: Deployment and Verification Perspectives
- [9] Cognizant report: Taking Testing to the Cloud, 2011.
- [10] Skytap Automation Pack Brings Testing to the Cloud: <http://visualstudiomagazine.com/articles/2013/01/29/skytap-automation-pack.aspx>
Access on 01/02/2013 at 3:43 pm
- [11] Major needs in cloud testing: <http://qa.siliconindia.com/news/major-needs-in-cloud-testing-nid-8059.html>
Access on 02/02/2013 at 3:46 pm
- [12] The undeniable role of cloud in software testing: [http:// qa.siliconindia.com/news/ The- undeniable-role-of-cloud-in-software-testing-nid-138670.html](http://qa.siliconindia.com/news/The-undeniable-role-of-cloud-in-software-testing-nid-138670.html)
Access on 03/02/2013 at 3:51 pm

[13] Cloud testing: Issues and challenges: [http:// qa.siliconindia.com/news/cloud-testing-issues-and-challenges-nid-137698.html](http://qa.siliconindia.com/news/cloud-testing-issues-and-challenges-nid-137698.html)

Access on 03/02/2013 at 4:51 pm

[14] Build.com Taps Cloud-Based Vera code To Improve Code Security across SDLC: [http://www.idevnews.com/stories/5621/Buildcom-Taps-Cloud-Based-Veracode-To-Improve-Code-Security-Across-](http://www.idevnews.com/stories/5621/Buildcom-Taps-Cloud-Based-Veracode-To-Improve-Code-Security-Across-SDLC0)

SDLC0 Access on 4/02/2013 at 3:54 pm

[15] O-demand software testing moves to the cloud by cloudtweaks on jan 15, 2013 in business, cloud computing, computing, IT, security, technology, tools <http://www.cloudtweaks.com/2013/01/on-demand-software-testing-moves-to-the-cloud/>

Access on 04/02/2013 at 04:02 pm

[16] Parveen, T., & Tilley, S.: Migrating Software Testing to the Cloud”, 26th IEEE International Conference on Software Maintenance in Timisoara, Romania, 2010.

[17] Mell, P., & Grance, T.: The NIST definition of cloud computing (NIST Special Publication No. 800-145). Gaithersburg, MD, USA: The National Institute of Standards and Technology (NIST), 2011, September.

[18] Cervantes, A.: “Exploring the Use of a Test Automation Framework”, 2009 IEEE Aerospace conference, March 7-14, 2009.