CLOUD BASED TESTING OF BUSINESS APPLICATIONS AND WEB SERVICES

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Abstract: *This paper deals with testing of applications based on the principles of cloud computing. It is aimed to describe options of testing business software in clouds (cloud testing). It identifies the needs for cloud testing tools including multi-layer testing; service level agreement (SLA) based testing, large scale simulation, and on-demand test environment. In a cloud-based model, ICT services are distributed and accessed over networks such as intranet or internet, which offer large data centers deliver on demand, resources as a service, eliminating the need for investments in specific hardware, software, or on data center infrastructure. Businesses can apply those new technologies in the contest of intellectual capital management to lower the cost and increase competitiveness and also earnings. Based on comparison of the testing tools and techniques, the paper further investigates future trend of cloud based testing tools research and development. It is also important to say that this comparison and classification of testing tools describes a new area and it has not yet been done.*

Keywords: *Cloud based testing, Cloud testing tools, Business competitiveness.*

JEL Classification: *L86, M15, M21, O32.*

Introduction

Cloud computing changes the way users access the ICT systems, which means resources (computers, infrastructures, data storage, and application services) and the way of managing and delivering computing technologies, services and solutions. It is a new model of delivering computing resources in a pay-per-use approach, which allows businesses to use their applications without any software installation and access their personal files at any computer with internet access. It is a way to significantly lower cost of infrastructure while increasing scale of operations.

Cloud Computing can be classified into 4 types on the basis of location where the cloud is hosted – public cloud (the customer has no visibility over the location of the cloud computing infrastructure, the computing infrastructure is shared between organizations), private cloud (ICT architecture is dedicated to the customer and is not shared with others, is more expensive, considered and secure than public cloud), hybrid cloud (the businesses host some critical, secure applications in private clouds, the not so critical applications are hosted in the public cloud) and community cloud (the cloud infrastructure is shared between the organizations of the same community – e.g. the government agencies). In general, cloud providers fall into three categories [1]:

- Infrastructure as a Service (IaaS): offering web-based access to storage and computing power. The consumer does not need to manage or control the underlying cloud infrastructure but has control over the operating systems, storage, and deployed applications,

- platform as a Service (PaaS): giving developers the tools to build and host web applications,
- software as a Service (SaaS): applications that are accessible from various client devices through a thin client interface such as a web browser.

To deliver highly available and flexible services (i.e., computation as a service), and owing to the maturity of virtualization technology, Virtual Machines (VMs) are used as a standard for object deployment in the cloud. VMs decouple the computing infrastructure from the physical infrastructure and allow the customization of the platform to suit the needs of the end-user. The VM lifecycle has six phases: create, suspend, resume, save, migrate, and destroy. Multiple VMs can run simultaneously in the same physical node. [1]

Cloud based software testing refers to testing and measurement activities on a cloud based environment and infrastructure by leveraging cloud technologies and solutions. It is a form of software testing (improves quality of the product or service) in which web applications and services use cloud computing technologies (a cloud) to simulate testing environment with real world user traffic. Testing requires 40%-70% of software development costs, and even more for mission-critical applications. The one of main parts of quality is usability which making applications and systems easier to use, more closely to user needs and requirements. It is as an important software quality attribute, earning its place among more traditional attributes as performance and robustness. Effectiveness and efficiency together with usability testing in clouds follows current trends in software development, management, business and process improvements. Cloud testing can help to transform development test centers and bring competitive advantages to enterprises. [5], [8], [10]

1 Cloud computing as a new economic model increases business competitiveness

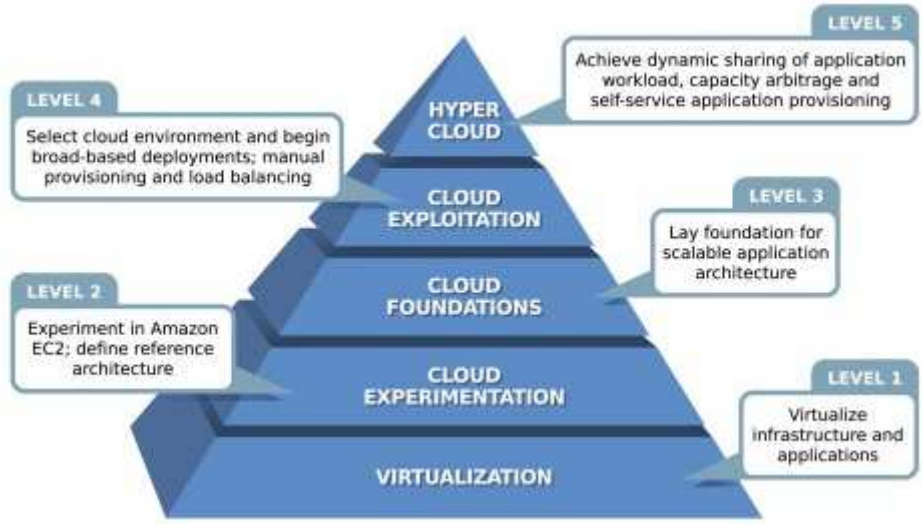
A recent study of Market Research Media forecasts that U.S. government spending on cloud computing is entering an explosive growth phase at about 40% compound annual growth rate over the next six years. Expenditure will pass $7 billion by 2015. Merrill Lynch estimates that within the next five years, the annual global market for cloud computing will surge to $95 billion. [5]

Early cloud computing success has been centered on the success in areas such as customer relationship management (CRM), personal and talent management (human capital management applications). As number of applications has begun to grow, vendors try to generalize their infrastructure for additional applications they are beginning to refer to cloud computing capabilities as platforms for application development and deployment. A number of large dynamically scalable computing service providers such as Amazon.com and Google have begun to offer application deployment environments based on the adoption of virtualization and VMs, service-oriented architecture and delivery computing model for PaaS focused on testing. [1]

Commercial offerings are required to meet SLA, but specific terms are less often negotiated by smaller companies, which usually define the quality of service (QoS) properties. By packaging applications as virtual applications, organizations ensure that the application will remain manageable and controllable throughout its lifecycle. The cloud computing adoption model, as illustrated in Fig. 1, is a logical set of steps designed to ease

the transition from today's traditional application delivery model to tomorrow's use of cloud computing: a graduated approach for adoption of cloud technologies that allows benefits to be realized incrementally. Top 10 cloud computing providers of 2011 includes Amazon, Verizon/Terremark, IBM, Salesforce.com, CSC, Rackspace, Google, Bluelock, Microsoft and Joyent. [9]

Fig. 1: The cloud computing adoption model.



Source: [9].

However, cloud-based hosting introduces risks to the dependability of systems. Applications are remotely deployed in a virtualized runtime environment using shared hardware/software resources, and of course hosted in a third-party infrastructure. The performance of application in the cloud is affected by many factors such as the number of VMs instances, VMs management policies, the effectiveness of hypervisor scheduling, the strategy of application migration and recovery in case of failures. Some of these factors change at runtime and thus cannot be fully predicted and controlled. Applications hosted on remote clouds may have lower controllability and observability, compared with conventional in-house hosted applications. [2]

2 Business applications and web services in cloud environment

Any application needs a model of computation, a model of storage, and a model of communication. The statistical multiplexing necessary to achieve elasticity and the illusion of infinite capacity requires each of these resources to be virtualized to hide the implementation of how they are multiplexed and shared. The applications of cloud computing are practically limitless – thanks to the way cloud computing is set up. It does give more application providers the choice of deploying their product as SaaS without provisioning a datacenter. Web services enable each user to provide access to their internal functionality and data to other users in a cloud environment. All of these applications and services could work on a cloud computing system. [2]

Business applications and services basically help businesses increase productivity, measure it, perform the analysis, collect data for benchmarking etc. There are a lot of business application categories, which depend on basically on the size of the business environment, number of employees, financial capital, business processes etc. The main meaning of cloud computing technologies is in the applications lifecycle management, especially in development and testing phases.

Development, migrating or testing applications in/from the cloud has its own set of challenges and risks such as data integrity, security, privacy, reliability, scalability, business acceptability and manageability, which can be mitigated through adoption of additional procedures. Businesses need to have a better understanding of the way different types of cloud work, how they impact businesses processes and which testing approaches should be used for them. It is necessary to adopt an end-to-end testing approach, starting from requirements to deployment, because each stage has different testing requirements. Cloud computing environment is best for [2], [8]:

- Applications that do not have much interaction with back-end systems,
- applications where demand increases dramatically over a cycle (peaks),
- applications for business intelligence and data mining procedures,
- development and testing with short-term use (advertisement, campaigns).

3 Effectiveness, usability and testing of software

Effectiveness is the capability of producing a desired result, whereas efficiency means doing the thing right, effectiveness means doing the right thing. With cloud computing it refers to cost effectiveness.

Usability testing is a technique used to evaluate a product by testing it on users. This can be seen as an irreplaceable usability practice, since it gives direct input on how real users use the system. This is in contrast with usability inspection methods where experts use different methods to evaluate a user interface without involving users. Usability testing focuses on measuring a human-made product's capacity to meet its intended purpose. Examples of products that commonly benefit from usability testing are foods, consumer products, web sites or web applications, computer interfaces, documents, and devices. Usability testing measures the usability, or ease of use, of a specific object or set of objects, whereas general human-computer interaction studies attempt to formulate universal principles. [6]

There are generally three types of usability evaluation methods – testing, inspection, and inquiry. In usability testing approach, representative users work on typical tasks using the system (or the prototype) and the evaluators use the results to see how the user interface supports the users to do their tasks. In usability inspection approach, usability specialists and sometimes software developers, users and other professionals examine usability related aspects of a user interface. Usability evaluators obtain information about users likes, dislikes, needs, and understanding of the system by talking to them, observing them using the system in real work (not for the purpose of usability testing), or letting them answer questions verbally or in written form. [6]

Usability testing generally involves measuring how well test subjects respond in 4 areas: efficiency, accuracy, recall, and emotional response. Usability testing in/from the cloud offers a lot of opportunities – low cost, dynamic deployment and online reconfiguration, built-in distributed parallel computing, high fault-tolerance, online massive scalability with unlimited resource pool, dynamic scale up/down in response to usage and the changes in the environment such as infrastructure configurations. [3]

4 Cloud based testing

Cloud based software testing (cloud testing) basically uses the concept of cloud and SaaS or PaaS. It provides the ability to test by leveraging the cloud. These systems are designed based on cloud platform and service oriented concepts for continuous testing without procuring licenses for programs and testing tools and installing them. Service providers give testers environment with tools, which offer access to scalable and virtual labs with a library of operating systems, test management and execution tools, middleware and storage necessary for creating a test environment that closely mirrors the real environment. Cloud testing has six major objectives [3], [5], [8]:

- To assure the quality of cloud-based applications and services 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 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, which validates the quality of a cloud from an external view based on the provided cloud specified capabilities and service features,
- To test cloud compatibility and interoperation capability between SaaS and applications in a cloud infrastructure, checking the application programming interface (API) of SaaS and their cloud connectivity to others,
- Testing in (on or over) clouds (application based testing) tests cloud based service applications over clouds, including private, public, and hybrid clouds based on system level application service requirements and specifications, this is usually performed by the cloud based application system providers.
- Testing from the cloud (web based software testing) is the process of using cloud-based resources and services typically to test a web facing system, low cost cloud computing resources enables the creation of test conditions that replicate real world systems for both functional and non-functional testing.

4.1 Types of cloud-based testing

Cloud testing has the following features [3]:

- Multi-layer testing: faults may exist in various cloud components. For thorough analysis, testing needs to be performed on each component at all of these layers. Each layer requires different testing focuses and techniques.
- SLA-based testing: SLA is negotiated between software and infrastructure providers, including functionalities for test design, execution, and evaluation.
- Large scale simulation: testing needs to simulate various inputs and scenarios. The load is high and unexpected and large fluctuations can occur.
- On-demand test environment: helpful for test assets sharing, automatic test generation/ selection/execution, results collection and analysis,

- Embedded continuous testing for SaaS.
- Scalability metrics: clouds needs new metrics as it needs to consider both the performance gain versus the resource needed.

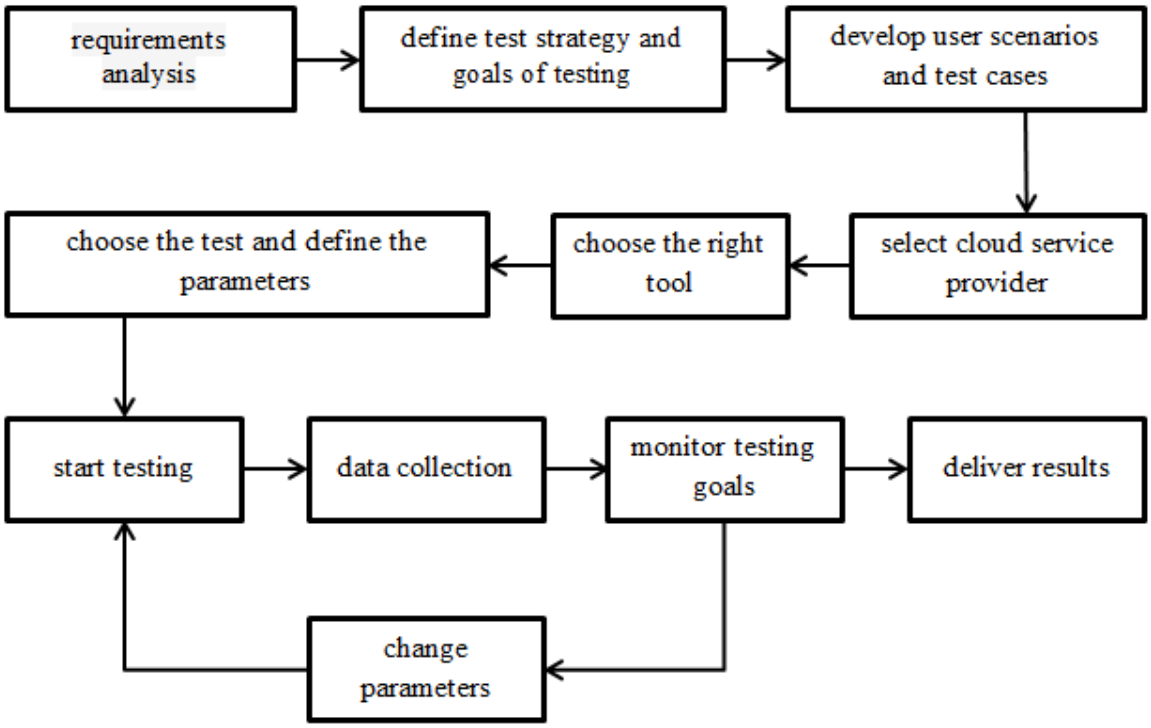
There are also three types of cloud test environments – a cloud-based enterprise test environment, in which application vendors deploy web-based applications in a cloud to validate their quality; a private/public cloud test environment, in which vendors deploy SaaS applications SaaS in a private (or public) cloud to validate their quality; a hybrid cloud test environment, in which vendors deploy cloud-based applications on a hybrid cloud infrastructure to check their quality. [5]

There are two options of usability cloud testing techniques – testing for functional requirements and non-functional requirement (e.g. cloudonomics, security – data, processes, vulnerabilities, availability – under various loads peaks and SLA, policies). Also in cloud testing is used cross browser testing, because every project has default web browser and every functional test run in it context. Some types of cloud-based testing [5], [8]:

- Functional testing is concerned with the functional requirements and covers how well the system executes its functions, these include user commands, data manipulation, searches and business processes, user screens, and integrations, the process of verification against specifications or system requirements is carried out in the cloud instead of on-site software testing:
    - System integration testing – SaaS interactions and cloud connections,
    - and user acceptance testing – both to ensure the developed cloud solution meets the functional requirements.
- non-functional testing –how a system must behave, it is a constraint upon the systems behavior - system's quality characteristics and quality attributes, 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:
    - Security testing – SaaS/application data security requirement,
    - service oriented architecture (SOA) testing,
    - performance tests – testing by simulating a large number of users:
        - load testing – to test application´s cloud scalability,
        - stress testing – to test max performance in the cloud,
        - browser performance testing,
    - compatibility and interoperability testing – to ensure meeting the business requirements specific to cloud computing,
    - disaster recovery testing – to ensure data recovery from crashes and hardware failures in the cloud environment.

Most cloud testing today is being performed via automated services, but there are software packages that offer a variety of options in pricing, performance, and feature set. The Fig. 2 shows the steps for cloud based testing. [7]

Fig. 2: Steps for cloud testing.



Source: Author

4.2 Cloud based testing vs. traditional testing

In traditional software lifecycle, testing is usually a stage in the process, and is often performed offline by test engineers before product delivery. As cloud based software has unique lifecycle models and quality issues, new testing capabilities are necessary to meet the needs of cloud testing such as continuous online testing and massive scalability testing. The in-house environment is usually fully controlled by software vendors with dedicated resources, while the cloud environment provides infrastructure as leased services from a theoretically unlimited resource pool. [3]

Traditional approaches to setting up a test environment for testing involves high cost to setup multiple servers with various operating systems, hardware configuration, browser versions etc. In complex cases, where organizations are integrating cloud and their business systems, testing needs to encompass integration testing of the overall system to ensure business requirements are met. Before adopting testing in/from the cloud (in contrast with traditional testing), important issues have to be solved – e.g. data security, local network bandwidth limitations and latency during testing etc. [4]

Regardless of types of testing, the process and methodology for testing and quality management should remain consistent. So it's good to connect the different methods of these two approaches – e.g. remote usability testing is particularly well suited to testing web sites and web applications. It can complement traditional usability testing in which the tester and user are side by side in the same location, and is more practical when users are widely dispersed geographically (this part of process can be solved by cloud testing techniques). There are several ways to do this, including attended, real-time evaluations similar to traditional laboratory testing but conducted in real time over the internet. [4]

4.3 Testing as a a service

Testing as a Service (TaaS) is service model, in which a provider undertakes software testing activities of a given application system in a cloud infrastructure for customers as a service based on their demands. TaaS was proposed to establish a unified service-based framework for promoting reuse of all test artifacts including test data, tools and process and also to decompose (outsource) the value of an ICT services rendered to both internal and external customers. It provides static/dynamic on-demand testing services in/from/on/over clouds for the third-parties. [3], [5]

TaaS provides organizations an option to set up a virtual test lab without any upfront investment in lab infrastructure, automation tools licenses, and skilled resources. Cloud TaaS architecture consists of five layers [10]:

- Test tenant and test service contributor layer – the tenants of TaaS can use a portal, or an integrated development environment to access testing services via the web, even employ a programmatic approach for interaction,
- test task management layer – supporting service registry and repository, scheduling and dispatching test tasks from each VM,
- test resource management layer – it plays the role of the cloud infrastructure, and provides an interface to cloud services including resource management, accounting, monitoring and provisioning,
- test layer is the kernel part of the platform: specifies a workflow and related services to complete the testing tasks, hosts test services for different types of testing and aggregates results, which belong to a tenant from different VMs,
- test database layer – stores test tasks of tenants, targets-under-test, service images, and bug tracking results.

5 Comparison of cloud testing tools

This part is focused on comparison of selected cloud testing tools which offered testing services from cloud. Selected tools are shown in Tab 1. The comparison is focused on trial or free versions of these tools – availability of free registration (email address is needed), if it's cloud testing through the web browser (no installation needed) and number of virtual users (VUs). The entire configuration can be usually carried out at runtime systems through a web browser and continuously monitor and modify the set parameters. Most of tools will automatically stop a testing if it can determine that server has been overloaded or the application is unstable.

Tab. 1: Comparison of some of the most relevant commercial and open-source cloud testing tools 1/2

Tool	Description of tool´s services.	Trial or free version			Pricing (full version)
		Regis-tration	Browser based	Num. of VUs	
Apica LoadTest	SaaS load tests are performed from the outside cloud. Complex of tools – WebOverload or WebPerformance.	No			Not available.
		-	-	-	
CLAP	Persistent CLAP is a load testing framework to load test the applications, websites, web-services and cloud applications.	No			Not available.
		-	-	-	
Cloud Assault	The service can also be used for basic HTML-only website performance testing, but it's really meant for APIs.	Yes			3.5 cent per VU.
		Yes	Yes	5	
CloudTest Lite	For rapid test creation and real-time analytics for functional testing and lower-scale performance testing.	Yes			Not available.
		Yes	No	100	
Cloud Testing	Automated website testing from the cloud in multiple real browsers.	No			Not available.
		-	-	-	
HP LoadRunner	Complex of tools – HP LoadRunner, HP Performance Center and HP Diagnostics, help test application performance under realistic load conditions.	Yes			Not available.
		Yes	No	25	
LISA	The essential platform for truly elastic, effective pre-production cloud environments for automated regression, functional and performance testing.	No			Not available.
		-	-	-	
LoadImpact	Online load testing service for stress test of websites.	Yes			$60 monthly per 500 VUs.
		Yes	Yes	1-350	
LoadStorm	Cloud load testing tool – real time graphs with performance metrics (e.g average response time, error rates).	Yes			$19.99 monthly per 100 VUs.
		Yes	Yes	25	
NeoLoad Cloud Testing	The load testing tool for all web and mobile applications.	Yes			License for $2797 per 50 VUs.
		Yes	No	10	
		Yes	Yes	-	

Source: Author

Tab. 1: Comparison of some of the most relevant commercial and open-source cloud testing tools 2/2

Parasoft SOAtest	Parasoft's full-lifecycle quality platform, which includes Parasoft SOAtest and Parasoft Load Test, ensures secure, reliable, compliant business processes.	No			Not available.
		-	-	-	
PractiTest	The SaaS platform for managing the entire quality life cycle – monitors requirements, tests, issues and reporting.	Yes			Starting at $35 / VU / month.
		Yes	Yes	-	
Proxy Sniffer	Proxy Sniffer is a load testing product on a "Pay As You Go" basis. Offers both free and professional edition.	Yes			$673 per year with 200 VUs.
		No	No	20	
ReQtest	Software testing in the cloud with bug reporting and issue tracking.	Yes			Starting at €30 = user per month.
		Yes	No	-	
SandStorm	Cloud based load testing and performance testing tool – tracking, reporting and metrics in real time.	Yes			Not available.
		Yes	No	Up to 1000	
Silk-Performer CloudBurst	Cloud-based extension to SilkPerformer using for the performance testing.	Yes			Pay-as-you-go.
		Yes	No	-	
TestMaker Community / Enterprise	A test tool that installs on the desktop, runs tests in cloud environments, pinpoints root causes and offers mitigation.	Yes			Not available.
		No	No	50	
Test Perspective	Is a hosted, self-service website load testing tool.	Yes			Not available.
		Yes	Yes	3000	
The JMeter Cloud	The cloud testing tool with a sole focus on load testing, designed to simplify performance and load testing for developers and testers.	Yes (free and trial versions)			$199 monthly per 1000 VUs.
		No/Yes	Yes	10/50	

Source: Author

Based on the results in Tab. 1, the cloud testing tools can be distinguished in three categories:

- Browser based tools (accessible through a web browser), which are free available without registration and offers a number of virtual users used to test the performance from the cloud, it is possible to buy more virtual users – e.g. The JMeter Cloud, Cloud Assault or Load Impact,
- browser based tools available after registration, which usually allows the user to try out all the essential functions of this testing tool for one week to one month, then it is necessary to buy a version with the desired functionality – e.g. Test Perspective 3.0, PractiTest or LoadStorm,

- tools that have to be installed on the client side, registration is required, after which it is possible for some time to use the selected functions, then it is necessary to buy a version with the desired functionality – e.g. SilkPerformer CloudBurst, Proxy Sniffer, HP LoadRunner, SandStorm, NeoLoad Cloud Testing or TestMaker Community / Enterprise.

According to comparison of cloud testing tools above and their possible using for improving business competitiveness, the best solutions are The JMeter Cloud (good price and VUs for small and medium enterprises), Test Perspective 3.0 (offers more free VUs than others, advantageous for large projects) and TestMaker Community, which is free to use for everyone.

Systematically comparing the performance of cloud providers can be found in [7]. One key element of any test strategy is also to collect metrics. Some metrics using for comparison of cloud testing tools are [2]: large scale performance testing, scalability testing, fault tolerance testing, recovery testing, cost-related testing; external service mocking, geographical simulation, parallel execution, test resource management and results aggregation. Measuring is process of environment setup, inputs generation, test configuration, test executable deployment, execution, results collection and analysis.

The last important question is cost effectiveness. In the one year horizon (or time of duration of the project) is usually necessary to calculate the all cost of the project or projects within the horizon with the cost of traditional in house testing and cloud based testing related with these projects.

C = cost of cloud based testing environment / cost of in house testing environment

In the selected time period (e.g. testing during project), the C value have to be less than 1 for project, where the cloud based testing is advantageous. Cloud based testing is basically advantageous for the single events or short-term projects realized by small and medium enterprises.

6 Discussion

Cloud computing offers for businesses a lot of opportunities, as well as cloud based testing. Aim of this paper was the meaning of cloud computing in the life cycle of business applications and web services. Therefore organizations need to support and develop new ICT approaches to increase their competitiveness and thus prepare them for current and future challenges. At present, there are many cloud testing tools, which can help to save costs of ICT services. This can be a competitive advantage therefore derives both from unique knowledge as well as the abilities to use this knowledge. There is no need to aware of cloud computing technologies when security rules and SLAs are observed. The future research can be focused on implementation of these rules and a trend towards standardization of cloud based testing approaches. The other possibilities – case studies with selected cloud based testing tools and their comparison with business plans or a model guide for businesses of different sizes and orientation.

Conclusion

Today's management cost increases as the number of business applications and web sites increases. The low cost and accessibility of the cloud's environment provides the ability to replicate real world usage by geographically distributed users, executing wide varieties

of user scenarios, at scales previously unattainable in traditional testing environments. These new architectures are proposed to provide continuous testing services and large scale system testing capabilities. However, cloud testing is not necessarily the best solution to all testing problems. Legacy systems and services need to be modified in order to be tested in/from cloud. Also like any other cloud services, cloud testing is vulnerable to security issues. The test results can be also influenced by the varying performance of network service providers and internet.

With all these facts, it can be said that implementation of cloud based testing into the business processes leads to reduce cost, improvement of effectiveness and also increasing of business productivity. The testing tools which are in this paper compared and distinguished in three categories can be used for the support of these activities.

References

[1] ANTONOPOULOS, N.; GILLAM, L. *Cloud Computing: Principles, Systems and Applications.* London: Springer, 2010. 379 p. ISBN 978-1-84996-240-7.

[2] ARMBRUST, M. et al. *Above the clouds: A Berkeley view of cloud computing.* University of California, Berkeley, Feb 2009. [cit. 2012-04-04]. Available from WWW: <http://www.eecs.berkeley.edu/Pubs/TechRpts/2011/EECS-2011-71.pdf>.

[3] BAI, X.; MUYANG, L.; BIN, C.; TSAI, W.T.; GAO, J. Cloud testing tools, *Service Oriented System Engineering (SOSE)*, p.1-12, Dec. 2011. [cit. 2012-04-04]. Available from WWW: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6139087&isnumber=6139076>.

[4] BIAS, R. G; MAYHEW, D. J. *Cost-Justifying Usability: An update for an Internet age.* 2. ed. San Francisco: Elsevier, 2005. 660 p. ISBN 0-12-095811-2.

[5] GAO, J.; BAI, X.; TSAI, W.T. Cloud Testing - Issues, Challenges, Needs and Practice, *Software Engineering: An International Journal (SEIJ),* Vol. 1, No. 1, p. 9-23, Sept. 2011. [cit. 2012-04-04]. Available from WWW: <http://seij.dce.edu/Paper%201.pdf>.

[6] JACKO, J.; STEPHANIDIS, C. Human-Computer Interaction: Theory and Practice (Part I). New Jersey: Lawrence Erlbaum, 2003, 1325 p. ISBN 08-058-4930-0.

[7] LI, A.; YANG, X.; KANDULA, S.; ZHANG, M. CloudCmp: Comparing public cloud providers. *Proceedings of the Internet Modeling Conference.* 2010. [cit. 2012-04-04]. Available from WWW: <http://www.cs.duke.edu/~angl/papers/imc10-cloudcmp.pdf>.

[8] NARAYANAN, C. Testing, the 'Cloud' Testing, the Way*, Siliconindia* [serial online]. vol. 13(7), pp.36-38, July 2010. [cit. 2012-03-20]. Available from WWW: <http://www.siliconindia.com/magazine_articles/Testing_the_%E2%80%98Cloud%E2%80%99_Way-NLJO444799615.html>.

[9] SOROFMAN, J. *How to Achieve the Strategic Value of Cloud While Delivering Real ROI.* [online]. [cit. 2012-03-20]. Available from WWW: <http://www.eweek.com/c/a/Cloud-Computing/How-to-Achieve-the-Strategic-Value-of-Cloud-while-Delivering-Real-ROI/>.

[10] YU, L.; TSAI, W.T.; CHEN, X.; LIU, L.; ZHAO, Y.; TANG, L.; ZHAO, W. Testing as a Service over Cloud. *Service Oriented System Engineering (SOSE),* p. 181-188, June. 2010. [cit. 2012-04-04]. Available from WWW: <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=05569908>.

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