Software Testing as an Online Service: Observations from Practice

Leah Muthoni Riungu, Ossi Taipale, Kari Smolander
Department of Information Technology, Software Engineering Laboratory
Lappeenranta University of Technology
Lappeenranta, Finland
leah.riungu@lut.fi, ossi.taipale@lut.fi, kari.smolander@lut.fi

***Abstract*—The objective of this qualitative study was to explore and understand the conditions that influence software testing as an online service and elicit important research issues. Interviews were conducted with managers from eleven organizations. The study used qualitative grounded theory as its research method. The results indicate that the demand for software testing as an online service is on the rise and is influenced by conditions such as the level of domain knowledge needed to effectively test an application, flexibility and cost effectiveness as benefits, security and pricing as top requirements, cloud computing as the delivery mode and the need for software testers to hone their skills. Potential research areas suggested include application areas best suited for online software testing, pricing and handling of test data among others.**

Keywords-software testing; online delivery; service

I. INTRODUCTION

In recent years, innovations towards service-oriented architecture (SOA) and software-as-a-service (SaaS) models have greatly affected the nature of software systems and organizations [1, 2]. This means that software developers from different organizations are continuously surprised to find that their code is more inter-related than they would have initially anticipated [3]. At the same time, the goal of every software organization is to produce high-quality software that is flexible and easy to use – as is the expectation of the modern world's technologically-savvy end user. This evolving nature of technologies implies that the methods, tools and concepts to test them must also change [2].

Software testing as an online service is defined as "a model of software testing used to test an application as a service provided to customers across the internet" [4]. It provides daily operation, maintenance and testing support through web-based browsers, testing frameworks and servers. This model supports a demand-led software testing market by enabling organizations to provide and acquire testing services whenever needed. It envisions an important contribution to the software industry owing to innovations such as Web services and cloud computing that provide new platforms for software testing.

Online delivery of software testing has several benefits: Testing customers do not have to incur major investments in installing and maintaining test environments [4]. This significantly lowers test costs while offering customers a flexible approach to acquiring testing services as the need arises, from anywhere around the globe. Secondly, online delivery of software testing opens up a wider market for both testing providers and customers [5]. The testing provider attracts a larger base of customers while the customer gains access to international testing professionals. Thirdly, it has been claimed that software testing as an online service can be delivered within a period of up to 10 working days [6]. Consequently, this leads to shorter turn-around times, enabling the customers to achieve fast time to market. Furthermore, when dealing with testing infrastructure hosted on the internet, the web service APIs used can hide the complexity of using hosted testing infrastructure, hence encouraging developers and testers to use it more frequently [7].

There are several commercial players and offerings addressing software testing mainly as an online service. Unified TestPro from sdtcorp.com is a complete off-the-shelf key driven test and automation solution that can be used to test various technological areas [8]. UTest provides software testing solutions to its customers through on-demand access to its community of professional testers i.e. crowd sourcing [9]. Sogeti's recently launched testing solution called STaaS - Software Testing as a Service - is tailored to provide the clients with a flexible, easily obtainable cost-effective service [10]. IBM offers its Infrastructure Optimization Services – IBM Smart Business Test Cloud that provides on-demand secure, dynamic and scalable virtual test server resources in a private test environment [11]. Sauce onDemand is a software testing service based on Selenium that enables web applications to be tested across multiple browsers in the cloud [12]. Other online software testing solutions are provided by Skytap, VM Logix, Zephyr and Cybernet-SlashSupport [13, 14], with a projected growth of more providers in the future.

However, academic research in this area is scarce. We are aware that the systems testing excellence program – STEP research team at the University of Memphis, Tennessee is following the information technology (IT) services paradigm that breaks down an IT unit into a set of valuable services such that the quality of an individual service can be quantified [3]. Thus, it is working on a framework for measuring the quality of testing services so that issues such as software usability, user satisfaction, mapping onto business needs, information systems coherence etc., are considered within the software testing

978-0-7695-4050-4/10 $26.00 © 2010 IEEE
DOI 10.1109/ICSTW.2010.62

context [3]. Secondly, cloud9 is a cloud-based testing framework being developed at Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland [7], and it runs as a web service that enables parallel symbolic execution of computer clusters operating on public cloud infrastructures e.g. Amazon EC2 as well as on clusters running cloud software e.g. Eucalyptus. By making use of symbolic execution, cloud9 is said to provide automated testing for large, real software systems [7]. Thirdly, current research under the Test Modelling using Action Words (TEMA) project at Tampere University of Technology, Finland is working on turning its model-based testing methodology into a testing service on the web [15].

In this study, we wanted to gather views about software testing as an online service from practitioners in the industry. Interviews were conducted with respondents from organizations that were either software testing providers or customers. The underlying research question was: "What conditions influence software testing as an online service?" We were also interested in gathering important issues regarding online delivery of software testing so as to establish a direction for future research.

The paper is organized as follows: Section 2 describes the research process and the grounded theory method used. Results from the analysis are presented in section 3, followed by the discussion and conclusions in section 4.

II. RESEARCH PROCESS

Online delivery of software testing is a recent concept, in which little study or research exists. Hence, an exploratory, qualitative approach using grounded theory was deemed appropriate in order to better understand the issues in online delivery of software testing. Qualitative methods can be used to explore substantive areas about which little is known or about which much is known to gain novel understandings [16]. Grounded theory is also recommended as a valid choice for software engineering [17] because it enables the identification of new theories and concepts. Furthermore, grounded theory, as elaborated by Strauss and Corbin [16] means that the theory emerges from the data that has been gathered and analyzed. By so doing, we allow ourselves the opportunity to gain insight and sound understanding of the real dynamics being studied hence delivering a reliable direction and recommendations for future studies.

Semi-structured (theme-based) questions were used during the interviews. The initial set of questions was developed by one researcher and then reviewed by the rest of the research team. In addition, the questions were also reviewed by a representative from a testing organization. Corrections were made accordingly, and the final set of questions was achieved. A test interview with another organization was conducted so as ensure that the interviews would each be limited to an hour at the most. The themes of the interview are available at http://www2.it.lut.fi/project/MASTO/.

Eleven respondents from different organizations were interviewed between October and November, 2009. Theoretical sampling was used in selecting potential interview participants. Theoretical sampling is particularly important when exploring new or uncharted areas because it enables the researcher to choose those avenues of sampling that bring about the greatest theoretical return [16]. Snowball sampling was also used, whereby an interviewee recommended a representative from another organization as a suitable respondent. However, four organizations that were contacted declined to be interviewed. This was mainly because they did not think that online software testing fitted in with their existing testing practices.

Each organization was involved in software testing either as a software testing provider or as a software testing customer. Six organizations were providers and the remaining five were customers. In general, the providers offered all kinds of testing and quality assurance services. On the other hand, the customers were from organizations in different business areas as shown in Table 1.

TABLE I. BUSINESS AREAS OF CUSTOMER ORGANIZATIONS

Organization	Business Area
1	Develops accounting software for small businesses
2	Information, logistics and mail communication
3	Service development in Banking
4	Develops software for the energy market
5	Develops systems for work time data collection

Development and testing managers as well as other people in leading positions (e.g. a chief executive officer) were selected as interviewees. This is because they are responsible for directing the adoption of appropriate tools, methods, and concepts into the organizations and were therefore deemed to offer constructive views. All interviews took less than an hour each, were tape-recorded and later transcribed for analysis. The transcribed text generated a total of 90 standard A4 pages, with an average of 5000 words each.

To analyze the collected data, the coding procedures found in grounded theory were followed. These are: open coding, where concepts were classified according to their attributes and features; axial coding, where the identified attributes and features were used to establish relationships amongst concepts and selective coding, where the concepts are combined to build the theory [16]. In this paper we report the classification of influencing conditions, which are mainly the results of axial coding.

The software tool ATLAS.ti [18] was used to perform the analysis. The aim of open coding, as implied by the name, is to reveal the underlying meanings, ideas and thoughts within the concepts. The data is critically examined to point out the similarities and differences to uncover abstract concepts which are further grouped into categories based on similar properties and dimensions. As noted by Seaman [17], the initial set of categories is determined by the goals of the study, the research questions and predefined variables of interest. In this case, the categories were deduced from the research question and as well as from areas of interest reflected by the interview questions.

In axial coding, the categories were further developed mainly by merging related codes together. Most of the

categories were independent of each other, with very little causal relationships existing between them.

Selective coding is the last step of the analysis process in which the final theory is integrated and refined [16]. The final theory is characterized by a central category that is related to all other categories. Sometimes, as is in our case, each category was found to tell a part of the story without standing out as a central category. When this happens, Strauss and Corbin [16] recommend that a conceptual idea that covers all the categories should be developed.

III. RESULTS

In the following, we describe the results of the analysis. The conditions that influence online delivery of software testing were identified from the research data. They were classified as domain knowledge, requirements, benefits, challenges and enabling conditions associated with online software testing. In addition, a list of potential research issues was outlined based on the respondents' views.

A. Domain Knowledge

Early in the research, it became evident that online delivery of software testing was not applicable for some application areas. Representatives from four organizations declined to participate in the interviews citing reasons such as:

"Most of our software is PLC [Programmable Logic Controller] software where the hardware is an essential part of the system just as the software. On the other hand our software/systems are so customer domain specific and a tester needs to be very familiar with the customer process, functional requirements and operational environment. From the viewpoint of UI [user interface] some parts of testing could be done as a service, but in our case UI is so tightly related to PLC software and it is also used for simulation testing (and in practice it is tested at the same time), so I don't see testing as a service as possible for UI either." (Manager, customized automation provider)

The other three respondents came from organizations dealing with employee insurance business, emissions trading software and services, and building and construction software products. They shared similar views, all emphasizing the need for testers to possess sufficient knowledge about the customer's business in order to efficiently test the applications. As a result, testing was an integral part of the whole software development cycle and it could not be outsourced to external parties.

B. Requirements

1) Infrastructure: Different interviewees pointed out that cloud computing was going to be a huge driver for online delivery of software testing. The interviewees seemed to agree that cloud computing presented a new approach to testing, both as an environment for testing and as a hosting platform for testing environments. Furthermore, a couple of the interviewees also perceived cloud computing as an appealing solution for systems requiring huge amounts of computing power and virtual data storage.

"Cloud computing will make software testing as a service more appealing and it will make software testing as a service easier to produce and, I see that as an enabler for software testing as a service."(CEO, quality assurance provider)

2) Security: An online software testing provider would be expected to assure customers that the information exchanged during a test process is safe. High levels of confidentiality were emphasized as being imperative so as to facilitate successful online delivery of software testing. While recognized as a vital requirement, security was also seen as a risk that would need to be addressed by all parties involved.

"If for example there is tight integration with the software testing provider and the customer, then a security breach occurs at the software testing provider and that some hacker gains access to the software testing customer's systems. I see a big risk there, and it has to be addressed."(Software manager, accounting software producer)

3) Pricing: Online software testing service providers would be expected to provide transparent pricing models and service level agreements in order to attract customers. Invoicing, e-invoicing, online bank transactions, paypal and credit cards were mentioned as ways to handle the payment process. However, the interviewees felt that the payment metrics were more important – what is a customer actually paying for? Is it effort, results, test goal specifications e.t.c.

"I would say that the biggest obstacle right now is, pricing models, service descriptions and metrics that would cover the quality of service." (Vice President, Quality and Testing Consultancy)

"… if the pricing models are transparent then it's very easy to see what the cost is so it's predictable."(Quality and processes manager, Information, logistics and mail communication)

4) Communication: The interviewees maintained the view that effective, regular communication between the online software testing provider and the customer would be of high importance if at all software testing was to be successfully provided as an online service. Live meetings, video conferences, emails and telephones and instant reporting should be used for communication. At the same time, face-to-face meetings should not be underestimated especially at the beginning of a project. A formal software testing management system was also suggested as a way of harmonizing the communication.

5) Skills: It was reported that software testers were going to have to develop a vast set of skills in order to keep up with the demands of software testing as an online service. From both the provider and customer point of view, the successful execution of an online testing process would depend on possession of technical as well as soft skills as outlined in Table II.

TABLE II. SKILLS SET FOR TESTERS

Skills
Adjusting to different working methods especially for global projects
Increased understanding of customer's business needs and requirements
Communication, project management and other soft skills
Better technical skills (web technologes, testing environment setup and javascript among others)
Service mindset
Flexibility to learn and adapt to evolving technologies

C. Benefits

1) Reduced costs: The interviewees were of the opinion that a well-planned online software testing service would help to cut down on costs. An online software testing service would be accessible on an on-demand basis. This would help to reduce the licensing and testing hardware costs as well as save on man-hours spent on setting up test environments.

"Yes, I think costs can be reduced, for example license fees, you can have on-demand licensing, with that you can save quite a lot of money. You also don't have to invest in servers at your site, because somebody else is doing that for you us. And, of course there's management. When you have less administration to do, of course that can also save time and money."(Program manager, banking service development)

2) Flexibility: Flexibility was viewed as a tremendous benefit, offering customers the chance to start and/or stop testing online whenever they wanted and only paying for the results. One interviewee mentioned that it would be possible to forecast on one's expenses more accurately.

"In general software as a service compared to traditional ways of delivering software is much more flexible of course, you can start now and stop after a month and you can, from a financial point of view, forecast your expenses more accurately."(Software manager, accounting software producer)

3) Access to global markets: Software testing as an online service would internationalize software testing, presenting versatile opportunities both for the providers and customers. This would facilitate access to wider, global markets, hence a chance for the provider to serve a larger base of customers as well as for a customer to compare different providers.

"Software testing as a service will just create more versatile opportunities, more options for serving the customers better, finding the best way to serve the customer in different situations and find the most economical and most feasible way of doing the testing."(CEO, quality assurance provider)

Furthermore, software testing as an online service would support agile development methods by providing availability of continuous testing services. Therefore, shorter development cycles would be achieved leading to faster time to market of the software products.

D. Challenges

The quality of the system under test partly depends on the test data. Sometimes, the original production data is necessary for testing. In such a case, the issue of the test data would have to be resolved. This was an issue particularly reported by testing service providers.

"…I would say that the biggest challenge and at the same time the biggest requirement is, connectivity to customers' development and testing environments and that's really, really hard."(Vice President, quality and testing consultancy)

"…most of the time in a customer's agreement, for them to give some information out of their own office, they require first of all, non-disclosure agreements (NDAs) and then sometimes security assessments … the typical customer requirement is that they can give some information, some test data, but they cannot give, any sensitive test data out of their own premises… Sometimes, it's by law that they cannot give sensitive information. So, there's a risk that testers are actually missing some information…So that's the risk that results in there."(Testing and methodologies director, testing provider)

"I don't know how easily the customer would give a copy of their production database, for example, to a third party. I don't know if that would be very easy or not."(CTO, energy markets software provider)

Software testing providers are faced with the challenge of having to invest in appropriate resources to facilitate availability of the software testing services at all times.

"... a big risk, for the service providers, is in order to set up that [online software testing] service, [they need to] develop this kind of investment."(Testing service manager, testing provider)

Other mentioned challenges were change management during the transition to adapting software testing as an online service in an organization, lack of proper coordination especially for big projects, software testing provider falling short of promised service levels and legal issues in different countries. In addition, a customer may question the testing skills of the testers on the service provider's end. On the other hand, a provider may risk serving customers without having sufficient information about them.

E. Enabling conditions

The effect of standards on online software testing was investigated. The general view was that standards e.g. Simple Object Access Protocol (SOAP) for e-business and 3GPP for the third generation mobile services (3G) were not an absolute necessity for the success of software testing as an online service. Standards-based applications would only make online testing more predictable, easier and faster.

Telecommunications and any web-based applications were also seen to be favorable for online testing. The adoption of software-as-a-service (SaaS) applications into business operations may drive the need for these applications to be tested in their host environment – the internet.

"… at least with our customer from functional testing point of view, there are plans for the customers to take most of their applications online, which means that they want testing done on their software as an [online] service… and of course then that very much becomes not location specific." (Unit leader, functional testing)

F. Research Issues

It was also in our interest to elicit research issues in online software testing. The interviewees were asked to suggest issues they felt were important for research. Table III contains the suggested issues that have the potential to be researched in future.

TABLE III. RESEARCH ISSUES

Suggested research issues
1. Business areas suitable for online software testing
2. How to create a big enough available pool of testers
3. Providing a ready online performance testing package for any customer
4. Effects of software testing as an online service on the customer's business
5. How to handle test data. Where does it come from? Who owns it? How is a system under test made accessible to the tester? What if signing of Non-Disclosure Agreements (NDAs) is required?
6. Pricing models and service descriptions for online software testing services
7. Quality checks for applications that have been tested on the internet
8. Methods, tools and facilities for managing online software testing processes. Harmonizing test processes across multiple players
9. Online testing solutions for e-business applications
10. Change management issues during the processes of adopting software testing as an online service.

IV. DISCUSSION AND CONCLUSIONS

The objective of this study was to explore the conditions that influence software testing as an online service and to find the direction for future research. The findings suggest that software testing as an online service is experiencing a progressive trend. The industry seems to be ahead of academic research and there is a need for collaboration between the two in order to develop relevant findings.

As more and more software products shift from the traditional desktop form to becoming online services, we can expect that software testing will follow the same trend. Cloud computing is increasingly becoming the means through which online services are made available. In view of software testing, cloud computing presents two avenues whereby (1) the system under test is accessible online or (2) testing infrastructure is hosted in the cloud for example the testing service mentioned in [7]. Therefore, research regarding online software testing may benefit from advances in cloud computing.

We found that the requirement to possess the domain knowledge of some systems highly influenced the decision to consider online software testing. Hence, software testing providers may have to focus on delivering testing services for other software applications, such as SaaS and web-based applications that can be tested online. While outsourcing of testing may be ruled out for organizations dealing with software requiring high level of domain knowledge, all hope is not lost. Such organizations as well as those dealing with mission critical systems and real-time data can leverage the benefits of testing infrastructure hosted as virtualization environments on the internet.

Security was perceived to be an important requirement for an online software testing service. Just as with any other online services, an online software testing service needs to be safe, bearing in mind the security of the test data and test results. Pricing of an online software testing service should also be taken seriously. For example, the pricing model used for the testing service described in [7] charges the users according to their test goal specifications. Software testing providers have a challenge of developing pricing models that truly reflect the worth of their work so as to sufficiently meet the customer expectations. A transparent pricing model would enable the customer to predict costs.

While software testing as an online service may offer cost cutting prospects for its customers, it may also pose the threat of customers losing control of the testing processes and resources. This would be risky for the customer in the event that the software testing provider failed to deliver the service. In addition, the customers may also lose internal software testing skills. On the other hand, due to the ability of web service APIs to conceal the complexity of the process they are running [7], this may result in shorter learning curves for software testing professionals. On the overall, testing professionals will be expected to hone their skills so as to meet the demands of online software testing.

The issue of test data needs to be resolved. It was reported that the success of some testing tasks depended on the actual customer or production data. Some rules and regulations prohibit the customers from supplying sensitive or production data to third parties. A solution to this problem may be the development of new models that would generate almost "identical" test data to facilitate productive testing results. Perhaps customers need to evaluate if their systems and platforms would by any reasonable amount be duplicated. If not, then it may mean that they would have little to worry about.

The topic of this study is based on a rather new field of research. As a result, a major limitation to the study is the shortage of scientific and academic literature related to the topic. At this stage, this makes it difficult to make comparisons with other related studies. Practitioners seem to be aware of the changing information technology trends and some of them are gearing up for a future of online services. We believe that research in online software testing is related to SaaS research as recommended by [19]. While only eleven organizations were interviewed, we still are convinced that the results obtained offer a reasonable picture of the overall software market.

In conclusion, we recommend a reflection on the suggested research issues. Each of them introduces a problem that should be addressed. At the same time, the delivery of online software testing will have to leverage the resources availed by cloud computing. Therefore we see cloud computing as a possible inclusion during future studies.

REFERENCES

[1] G. Goth, ""Googling" test practices? Web giant's culture encourages process improvement", IEEE Software, 25, 2, pp. 92-94, 2008.

[2] R. Collard, "Performance innovations, testing implications," Software Test & Performance Magazine, vol. 6, No. 8, pp. 19-20, August 2009.

[3] Y. Yang, C. Onita, J. Dhaliwal, X. Zhang, "TESTQUAL: conceptualizing software testing as a service," Proc. 15th Americas conf. on information systems, 6-9.08, San Francisco, California, USA, paper 608, 2009.

[4] L.V.D. Aalst. "Software testing as a service (STaaS)." Internet: http://www.tmap.net/Images/Paper%20STaaS_tcm8-47910.pdf, [May 06, 2009].

[5] M. Turner, D. Budgen, P. Brereton, "Turning software into a service". IEEE Computer Society, vol. 36, issue 10, pp. 38 – 44, 2003.

[6] "STaaS - Software Testing as a Service." Internet: http://www.sogeti.com/upload/Looking%20for%20Solutions/Documents/STaaS_leaflet%20v%20Feb%2009.pdf, [May 10, 2009].

[7] L. Ciortea, C. Zamfir, S. Bucur, V. Chipounov, G. Candea, "Cloud9: A software testing service," Proc. 3rd SOSP workshop on Large Distributed Systems and Middleware (LADIS), Big Sky, MT, October 2009.

[8] "Unified TestPro – Keyword Driven Automation and Manual Testing Tool." Internet: http://www.sdtcorp.com/utp_solution.html, [January 25, 2010].

[9] "Case Study: Community Testing for Agile-Development Web Applications."Internet:www.utest.com/download/uTestCaseStudyCommunityTestingForAgileDev.pdf, [May 12, 2009].

[10] "STaaS - Software Testing as a Service." Internet: http://www.sogeti.com/looking-for-solutions/Services/Software-Control-Testing/STaaS-/, February, 2009, [January 25, 2010].

[11] "Infrastructure Optimization Services – IBM Smart Business Test Cloud." Internet: http://www-935.ibm.com/services/us/index.wss/offering/midware/a1030965, [January 19, 2010].

[12] "Sauce OnDemand: cloud testing service." Internet: http://saucelabs.com/products/sauce-ondemand, [January 27, 2010].

[13] J. Foley, "The cloud's next big thing: software testing", http://www.informationweek.com/cloud-computing/blog/archives/2009/06/the_clouds_next.html, June 23, 2009, [September 14, 2009].

[14] "Cloud Based Performance Testing." Internet: http://www.csscorp.com/product-lifecycle-services/cloud-based-performance-testing.php, [February 5, 2010].

[15] A. Jääskeläinen, M. Katara, A. Kervinen, H. Heiskanen, M. Maunumaa, T. Pääkkönen, "Model-Based Testing Service on the Web," Proc. 20th IFIP TC 6/WG 6.1 International Conference on Testing of Software and Communicating Systems: 8th international Workshop, Lecture Notes in Computer Science, vol. 5047, pp. 38-53, 2008.

[16] A. Strauss, J. Corbin, Basics of Qualitative Research: Grounded Theory Procedures and Techniques, Newbusy Park CA: SAGE Publications, 1990.

[17] C. B. Seaman, "Qualitative Methods in Empirical Studies of Software Engineering," IEEE Transactions on Software Engineering, vol. 25, pp. 557-572, 1999.

[18] ATLAS.ti – The Knowledge Workbench, Scientific Software Development, 2005.

[19] M. von Hertzen, J. Laine, S. Kangasharju, J. Timonen, and M. Santala, "Drive for Future Software Leverage: The Role, Importance and Future Challenges of Software Competences in Finland," Tekes Review, 262/2009.

[20] K. M. Eisenhardt, "Building Theories from Case Study Research," Academy of Management Review, 14(4), pp. 532-550, 1989.

[21] A. Dubey, D. Wagle, "Delivering Software as a Service," The McKinsey Quarterly, 2007.

[22] N. Gold, A. Mohan, C. Knight, M. Munro, "Understanding Service-Oriented Software," IEEE Software, vol. 1, issue 2, pp. 71-77, 2004.