

Practices of Software Testing Techniques and Tools in Bangladesh Software Industry

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Abstract—For high-quality software development, Software Quality Assurance (SQA) is an important factor where testing is at the base of this factor. Software industry used to maintain software quality using manual testing process, which is being replaced by automated testing tools. Using the automation testing tools, testing has become easier and user-friendly to the software testers. Bangladesh software industry started its journey around three decades ago, and over the 2 decades, it has been flourished. Currently, there are approximately 500 software firms enlisted with the Bangladesh Association of Software and Information Services (BASIS). BASIS officially conducted a research on export income that comes from software and service products, and it turned out that Bangladesh exported software worth of \$800 million (6,720 corer) last year. With the rapid growth of the economy, there has been an increased internal demand for quality software. Moreover, the government of Bangladesh is patronizing this sector so that Bangladesh can earn foreign exchange from the software export. As a result, growth of the software industry has become essential through utilizing the youth force and applying modern tools and techniques for developing high-quality software. However, in Bangladesh, use of modern and automated testing tools and techniques are far from satisfactory. In this paper, we surveyed 10 leading software firms to assess the current practices of software testing techniques and tools in the industry. We also wanted understand the present barriers and challenges that impeding the industry from producing better products. The responses from each firm have been presented in the beginning, and an overall comparative analysis on the usage of testing tools are given later in this paper. This analysis will assist the professionals in this industry to deeply understand the present situation in Bangladesh.

Index Terms—Software Industry, Software Quality Assurance, Software Testing, Software Testing Tools

I. INTRODUCTION

Software applications play an important role in the information technology enabled system. For a reliable and effective information system, the quality of software is very crucial. As the development of software components are changing drastically day-by-day, SQA and SQC have become important for producing quality software. Testing is an important part in the SQA area and is the basic activity which is aimed at detecting and solving technical issues in the software source code. It assesses the overall product usability, performance, security, and compatibility. It isn't only the main part of quality assurance; it is also an integral part of the software development process. Software testing is considered as a collection of techniques, procedures and tools which are related to software, are called on an umbrella activity which can be defined as a systematic approach. SQA is a process which assures that all software engineering processes, methods, activities and

work items are monitored and comply against the defined standard and the standards could be one or a combination of any like ISO 9000, CMMI model, ISO15504, etc. A software firm should maintain the following things for SQA: creating an SQA management plan regarding how the SQA will be carried out in the project, setting checkpoints according to which it evaluates the quality of the project activities at each checkpoint/project stage, applying software engineering techniques that aids a software designer in achieving high quality specifications, executing formal technical reviews, having multi-testing strategy which means that one should not rely on any single testing approach, instead, multiple types of testing should be performed so that the software product can be tested well from all angles to ensure better quality, enforcing process adherence during the software development process. According to a [18] by the American National Institute of Standards and Technology (NIST), the United States faces the negative effect of \$62 billion USD per year due to the lack of SQAT infrastructure. Undoubtedly, the challenges are also facing the other countries. For the developing countries like Bangladesh in the Information Technology (IT) sector, it is very crucial to identify these challenges first, in order to overcome. Although, several surveys have been conducted to identify the practices and challenges of software testing in several countries like Australia [11], Canada, USA, India, Sweden, Finland [6] over the years, however, there is no such survey on software testing tools & methods in Bangladesh has ever been conducted to the best of the authors knowledge. Now-a-days Bangladeshi IT firms are developing software systems that are used not only in Bangladesh but also in many countries across the world. It is expected that IT sector would add 7.28 percent to the GDP growth of Bangladesh by the end of 2021 [1].

There are hundreds of software firms in Bangladesh and as of September 2019, 1232 software firms are enlisted members of BASIS [7]. In this survey we have contacted 10 leading software firms in Dhaka. And the analysis of those firms helped our paper to reach the goal. The result of our survey revealed five important findings which are very important for developing a software industry. Those findings are: low usage rate of automated testing tools & methods, difficulties due to a lack of STMTs, use of testing tools in a limited manner, lack of QA expertise, lack of sufficient knowledge & interest about software testing in existing QA tester. This paper actually represents an overview of the present situation of Software industry in Bangladesh & also represents the challenges what

are they facing & also presents that they are not able to cope with the other developed Software firms in the world because of these challenges.

This paper can help not only the students who are studying in software testing & techniques but also both the start-up & existing software firms in Bangladesh and other countries to look out the situation & what types of lacking are there. In the next section we have discussed about the related research works in which the overview of many countries software industry were discussed.

In the third section, we have discussed about the design and execution of the survey where we have discussed that how we have designed our survey questionnaire and which questions were included in the survey, which were participated in the survey, when this survey was conducted *etc*. In the fourth section, we have analyzed the survey responses. We have divided this section into 2 parts. In the first part, the individual firm's analysis was done and in the second part, a comparative analysis was done to show a crystal clear comparison between each firm. In the fifth section we have discussed about survey findings. Here we have showed the ratio of various testing techniques, tools, QA engineers, overview of each firm and also showed the major challenges facing by the Bangladesh software industry. At last, we gave a summary that what we have done in this paper and what is our future work. Basically the aim of this survey was to investigate the usage of software testing tools and techniques in perspective of Bangladesh software industry. In this survey we also tried to find out the challenges that are faced by the Bangladesh software industry.

II. BACKGROUND

As Software testing is a crucial word for a software firm in any country, many researches have been conducted throughout the world to identify the practices & challenges. The first research has been directed back to 1983 in the USA which was focused on test procedures [4][2]. Then all the researches have been conducted on the basis of country specific. Like, a survey was conducted on software testing practices in Australia where 65 organizations participated [5][2] & the goal of this survey was to focus the current testing practices in Australia as well as their recommendations and observations. Similar researches also have been done in Canada, Finland, Sweden, UK [8][2]. For software quality assurance in software development area, the testing of software is very important. And for these testing methods & tools are very essential. In 2012, a research was conducted in Korea which was based on software testing methods, tools & opportunities for improvement [1].

In 2003, a survey was conducted in India where the authors goal was to find out the test standards and procedures, hardware platform, test practice, matrices and test certification in practices of India [17].

In 2013, a large nationwide survey of software testing practices was conducted in Canada which with a revisited list of questions which were reported the results of a regional survey among practitioners in the Canadian province of Alberta in 2009 [16]. From this survey the authors reveal out some

findings that testing related training importance is increasing, functional and unit testing are two most important testing type, Test-Last-Development style and mutation testing was getting more priority in Canadian firms, JUnit and IBM rational tools are getting more popularity, combination of decision coverage and condition coverage are used mostly, passing acceptance testing and tracking defects in software are two most important factors, testers are out-numbered by developers in terms of ratio, spend less budget and time in testing purpose.

In 2007, a survey was conducted in UK where the authors represented that there is a disconnection between software testing research and practices where the research is making better testing in technical terms and the practice is how to design tests that are most effective in satisfying organizational needs and also minimize the effort and time required to demonstrate that software is 'good enough' [7].

In 2010, a survey was conducted in Sweden where the goal of the research was finding regression testing practices in industry [15]. Here the authors want to represent that regression testing needs and practices vary within the organization significantly and also vary at different stages of a project. They also reveal out that the importance of automation testing is crystal clear.

With the development of ICT sector, software engineering related researches has been gained attention in Bangladesh now. In these years, several types of research have been performed on the different aspects of software engineering in Bangladesh [9] [10] [14] [11] [12] [13][2].

In 2017, a research was conducted in Bangladesh based on software engineering practices and challenges where the authors designed their survey based on five objectives like characterizing the organizations, identifying software development life cycles preferences and challenges, performance measurement, requirement prioritization, and communication. Finally they reveal out that Scrum is the more popular SDLC model than Waterfall. They also investigated that due to lack of proper communication that means preference of skype/email rather than face to face/ITS and complexity of the prioritization techniques, the practitioners are facing challenges in this phase mostly. They also provide some recommendations for academia as well as the industry. Those are: Govt. and organization should focus on promising products like data science/ cloud computing, training institutions should update the curriculum, devise new prioritization techniques, increase development team for decision making and increase collaboration between academia and industry [3].

Almost similar types of research have been also conducted in 2018 where the authors focused on capturing the essence of testing team along with testing tools and understanding the SQAT challenges, training, education as well as career prospect [2]. They also provide some recommendations based on the findings from their survey. There recommendations are: raise awareness of the practitioners about the importance of software quality assurance and testing, number of developer and testier should be reasonable, process maturity and quality model should be practiced, educational and training

institutions should be updated and should include a course on requirements engineering, reduce competitions between testers and developers, automation testing should get much priority.

However, no research has been executed on software testing methods, tools, challenges & practices in Bangladesh. Actually this paper contains the crystal clear face of Bangladesh software industry because this paper is based on the survey findings of leading 10 software firms of Bangladesh. Due to the expanding growth and importance of Bangladeshi ICT sector, the authors believe that it is essential to carry out a survey on software testing methods & tools as well as software testing practices and challenges in Bangladesh.

III. SURVEY DESIGN & EXECUTION

For the survey purpose we developed a Questionnaire to reach our goal. Our survey was fully based on Bangladesh perspective and leading 10 software firms of Bangladesh were participated here. This questionnaire includes 33 questions and which is broken down into three sections: general information & testing environment of the participated company, types of techniques and tools followed by those company, current practices & challenges facing by those firms in the IT industry. The first section of the questionnaire asks general information about the company or the experts that participate in the survey. Like, in this section we asked which categories of software the firms are building & for which platform, number of total employees & software developers & in which process (formally / informally, in-source / outsource, development for client / product development) are they following. The second section asks about the software testing methods & tools what they are following. Like, in which way are they testing (manually / automated), which of the following basic testing methods (white-box / black-box / grey-box / static testing) they are follow, which of the following functional testing (unit testing / integration testing / smoke testing / sanity testing etc) & non-functional testing (compliance testing / performance testing / usability testing / localization testing etc) & security testing (vulnerability scanning /penetration testing / fault injection based testing etc) they are following. Not only these questions were asked but also asked the two most important testing like Regression testing , Load testing & Acceptance testing are they following or not. In this section we have also covered which types of tools were used in these firms for completing these testing methods for computer software, mobile apps (Appium/ Robotium/ Selendroidetc), web apps (Selenium/ Smartbear/ Parasoftetc), load testing (SmartBear/ Jmeter/ Apicaetc) & for tracking bugs / defects (Jira/ Github/ BugZilla/ FogBugz/ SpreadSheets). In the third section, the questions are based on difficulties in software testing, level of test automation, challenges facing by software firms in the software testing market. In this section, we have also tried to contain information about their level of standard that means which standard level they are following like CMMI, ISO etc. This questionnaire also includes a five level rating scale which ranges from “strongly agree” to “strongly disagree” and these questions represents the overview of the participated firms.

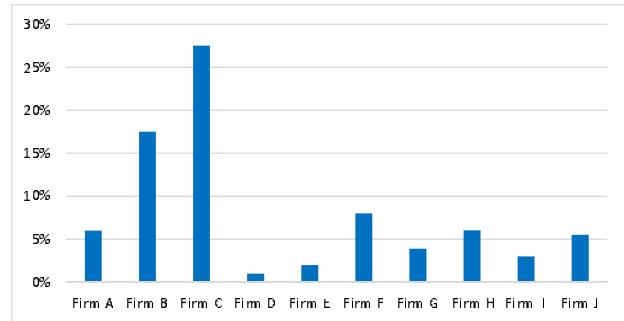


Fig. 1. Percentage of QA engineer in the surveyed firms.

The questions were multiple choice questions. There were also options for customize answers. This survey was conducted between July 2019 to September 2019 where leading 10 Software firms in Bangladesh were surveyed. The estimated time for the giving response was one hour. The respondents were mainly heads of that company's QA team. In some occasion the respondents were assistant by their deputies. In this paper the firms name were mentioned as A, B, C, D, E, F, G, H, I, J.

IV. ANALYSIS OF SURVEY RESPONSES

This section summarizes the responses to the survey questions which is divided into two parts. In the first part, the analysis of each firm's responses is given and in the second part, a comparative analysis of all firms is given.

Analysis of company “A”: This firm mainly develops mobile apps, face recognition, fingerprint recognition based applications. They use .Net, Java, Android, MacOS/iOS platforms in their development. They develop applications for clients and they also develop software products. During the survey , the respondents were asked about the percentage of permanently assigned QA engineers. They answered that 6% of their employees work as QA engineer. When the respondents were asked about their software testing process they replied that they follow both the formal and informal processes and they perform in-house testing. The respondents also mentioned that they follow both the manual and automation testing, they also perform static testing. However, they mostly follow manual testing in their organization. When the respondents were asked to describe about the details of their testing techniques and tools, the respondents answered that they perform b lack box testing, white box testing as correctness testing. They also perform unit testing, integration testing, system testing, GUI testing, smoke testing and sanity testing – as functional testing. They mentioned that they use Selenium tool for functional testing of web application when they frequently perform automation testing. They always perform manual testing for functional testing of mobile apps. As non-functional testing, they perform compliance testing, usability testing, performance testing, load testing, localization testing, install testing and for load testing they use Jmeter tool. As security testing, they perform vulnerability scanning, penetration testing, fault

injection based testing, property based testing, risk assessment. They use Asana tool for tracking bugs/defects. Most important testing like “regression testing” and “acceptance testing” are also done by this company. When the respondents were asked about the types of challenges they are facing in the software industry then they answered that hiring testers is difficult for them because the quality of available testers are far from satisfactory. The respondents also mentioned that they don’t provide any formal training period for SQA team, even their company doesn’t put any emphasis on ISTQB training. This company doesn’t follow any standard like CMMI/ ISO. As per their opinion, they think unit testing should get much priority to improve the software industry of Bangladesh.

Analysis of company “B”: This firm develops Web MIS, ERP solutions, mobile Apps and enterprise solution based software and use .Net, Java, Android, iOS, Angular, Node-JS, AWS platform in their development. They develop software for clients and also develop software product but the last one gets the less priority. This firm have 17.5% QA engineer of their employees who are divided based on project specific. They follow formal process and perform both manual and automation testing, but mostly follow the manual testing. They perform in-house testing and static testing in their organization. As correctness testing, black box testing and white box testing are performed. As functional testing, they perform regression testing, unit testing, integration testing, system testing, GUI testing, smoke testing, monkey testing, adhoc testing, acceptance testing and sanity testing and use Selenium automation tool for functional testing of web application and use Appium, Protractor, Robotium, Selendroid for functional testing of mobile apps. As Non-Functional testing, they perform compliance testing, usability testing, performance testing, load testing, localization testing, install testing and for load testing Loadrunner and Jmeter automation tools are used. As security testing, they perform vulnerability scanning, risk assessment. Redmine, Cimbug, BugZilla tools for tracking bugs/defects are used. They mentioned that qualified test automation engineer and certified test engineers are not sufficient as per demand and they are not getting satisfactory tester for SQA. They provide on job training period for SQA team, even they also put large emphasis on ISTQB training. This company follows standard CMMI level 3. They give their suggestion that static testing should get much priority for developed software industry.

Analysis of company “C”: This firm develops Web MIS and Mobile Apps-categories of software and use Java, Android, MacOS/iOS platform and language for development. They develop only software product development and they have only 27.5% QA engineers among their all employees. They follow only the formal process which is in-house testing. They also follow both manual (mostly) and automation testing. They follow static testing. They perform black-box testing and grey-box testing as correctness testing. They perform regression testing, unit testing, integration testing, system testing, GUI testing, smoke testing, sanity testing and acceptance testing-as functional testing and use Selenium automation tool for functional testing of web application but mobile apps testing

are performed manually. As Non-Functional testing, they perform compliance testing, usability testing, performance testing, load testing, localization testing, install testing and for load testing they use Gatling and Jmeter automation tools. As security testing, vulnerability scanning, fault injection based testing and risk assessment- categories of testing techniques are performed. They use Jira tool for tracking bugs/defects. The respondents mentioned some challenges which include tester’s mindset missing in fresher course in BSc and MSc related to software testing and practical knowledge related to QA. And they also mentioned that they are getting satisfactory tester for SQA but not sufficiently. They provide training period for SQA team, they puts no emphasis on ISTQB training and they have one ISTQB certified tester in their organization. As per their opinion both manual and automation testing should get much priority which depends on type of software.

Analysis of company “D”: This firm focuses on Financial Transaction System-categories of software and their development is for Java, Android, iOS platform based. They develop only software product development. This company has 1% permanently assigned QA engineers among their all employees. They follow only the formal process which is in-house testing and also follow static testing. They perform both the manual and automation testing and also perform black box testing, white box testing and grey box testing as correctness testing. They perform regression testing, unit testing, integration testing, system testing, GUI testing, acceptance testing, smoke testing and sanity testing – as functional testing and use Selenium, Sauce Labs-automation tools for functional testing of web application and Appium, Calabash, Sauce Labs, UI Automator- automation tools for functional testing of mobile apps. As Non-Functional testing, they perform compliance testing, performance testing, load testing and for load testing they use Locust, custom made, load test script and Jmeter automation tools. As security testing, they perform vulnerability scanning, fault injection based testing and penetration testing. They use Jira and Github tools for tracking bugs/defects. They mentioned that there are crisis of QA tester in the market. They provide in-house training period for SQA team and puts no emphasis on ISTQB training.

Analysis of company “E”: This firm mainly develops Web MIS, ERP solutions, E-Governance solutions and Mobile Apps based software and their development is based on .Net, Java, PHP, Android, python, C, C++ and MacOS/ iOS. They develop software for client and also develop software product development. This company has 2% permanently assigned QA engineers among all their employees. They follow both the formal and informal process which is in-house testing. They frequently do static testing. They perform both manual and automation testing and also perform black-box testing, white-box testing and grey-box testing as correctness testing. They perform unit testing, integration testing, system testing, GUI testing, regression testing and acceptance testing for functional testing and use Selenium automation tool for functional testing of web application but functional testing of mobile apps are

performed manually. As Non-Functional testing, they perform compliance testing, usability testing, performance testing, load testing, localization testing, install testing and for load testing Jmeter automation tool is used. As security testing, they perform vulnerability scanning; fault injection based testing, penetration testing and risk assessment. Github and mantis tools are used for tracking bugs/defects. The respondents mentioned that lack of resources and lack of proper time is hampering our software industry which are challenges for them and also mentioned that they are not getting satisfactory tester for SQA. They provide training period for SQA team and they puts no emphasis on ISTQB training. This firm follows CMMI level 3 and ISO 27000 standard. As per their opinion test plan and strategy should get much priority depending on type of project which can improve our software industry.

Analysis of company “F”: This firm develops Web MIS, Banking, Microfinance and Mobile Apps types of software and their development is based on .Net, Java, PHP, Android and Flutter. They follow only software product development. This company has 8% permanently assigned QA engineers among all employees. They follow the formal process which is in-house testing. They don’t perform static testing. This is only the firm which perform only automation testing and perform grey box testing as correctness testing. Unit testing, integration testing, system testing, regression testing and acceptance testing are performed for functional testing and use Selenium automation tool for functional testing of web application and Robotium, UI Automator, Selendroid for functional testing of mobile apps. As Non-Functional testing, they perform performance testing, security testing, load testing and install testing and for load testing Jmeter automation tool is used. As security testing only penetration testing is performed. They use Github and BugZilla for tracking bugs/defects. They mentioned that load testing & integration testing are not followed properly. they also mentioned that they are getting satisfactory tester for SQA as per their opinion. They provide training period for SQA team where they encourage clarity in bug reporting and don’t treat QA as the final development phase, even they also mentioned that their company puts emphasis on ISTQB training and they have 9 ISTQB certified testers in their organization. This firm follows CMMI level 5 standards. As per their opinion, encourage clarity in bug reporting, write test case properly, treat testing like a team effort, use tools to make testing easy and find “good enough” threshold- can help to improve our software industry a lot.

Analysis of Firm “G”: This firm focuses on telecommunication solutions including soft-switch and mobile apps which are mainly based on Java, Android, iOS and Go platform. They only follow in-house software product development . They have 3.9% QA engineer among their technical employees. They don’t perform static testing. They only follow informal process in testing purpose but they perform both manual and automation testing in their firm. As correctness testing, only black box testing is used, and for functional testing, unit testing, regression testing, acceptance testing are used. For non-functional testing, they use compliance testing, usability

testing, security testing, load testing are performed. Jmeter automation tool is used for load testing purpose and their own developed portal is used for tracking bugs/defects. As security testing, vulnerability scanning and fault injection based testing are performed. They mentioned that full cycle testing takes longer time which seems challenge for them and they are getting sufficient satisfactory QA tester. They provide three years training period for SQA team, but they puts no emphasis on ISTQB training. They follow CMMI level 3 standard. As per their opinion, continuous integration and continuous delivery are not practiced in our local software firms which could help software firm to deliver their product quickly.

Analysis of Firm “H”: This firm develops Web MIS, ERP solution and mobile apps which are based on .Net, Java, PHP, Android, MacOS/ iOS platform. They develop applications for clients and they also develop software products.. They perform both in-house and out-source testing. They have 6.02% QA engineer among their employees. They perform static testing and follow only formal process in testing purpose but they perform both manual and automation testing in their firm. As correctness testing, only black box testing and for functional testing, unit testing, GUI testing, acceptance testing, are performed. They perform regression testing. For non-functional testing, compliance testing, usability testing, performance testing, security testing, localization testing, install testing, load testing are performed. Jmeter automation tool is used for load testing purpose and Jira, Mantis are used for tracking bugs/defects. As security testing, vulnerability scanning, penetration testing, fault injection based testing and risk assessment are performed. They mentioned that less knowledge about testing tool, most priority given on manual testing are challenges for them and they are not getting sufficient satisfactory QA tester. They provide training period for SQA team even they desire to put emphasis on ISTQB training in future. They follow CMMI level 3 Standard. As per their opinion, agile in testing could help Bangladesh software firm to reach its goal.

Analysis of Firm “I”: This firm basically develops mobile apps which are Android, MacOS/ iOS platform based. They develop application products.. They perform in-house testing. They have 3% QA engineer among their employees. They perform static testing and follow only formal process in testing purpose but they perform both manual and automation testing in their firm. As correctness testing, both white-box testing and grey-box testing and for functional testing, unit testing, integration testing, system testing, GUI testing, acceptance testing, are performed. They perform regression testing. They use Selenium automation tool for functional testing of web application and Appium, UI Automator for functional testing of mobile apps. For non-functional testing, compliance testing, usability testing, performance testing, security testing, localization testing, install testing, load testing are performed. Jmeter automation tool is used for load testing purpose and Jira is used for tracking bugs/defects. As security testing, vulnerability scanning, penetration testing, fault injection based testing and risk assessment are performed. They mentioned that limitation of good quality tester is a challenge for them but

they are keep searching satisfactory QA tester. They provide formal training period for SQA team. Though they don't put emphasis on ISTQB training but they have two ISTQB certified testers. They don't follow any level of Standard. As per their opinion, context driven testing could help Bangladesh software firm to reach its goal.

Analysis of Firm "J": This firm basically develops banking solution, mobile apps, app development, AEM development, ML and AI, cloud solution, BI solutions, ERP, sharepoint, E-Commerce, AR VR solution which are .Net, Java, PHP, Android, MacOS/ iOS platform based. They develop applications for clients.. They perform in-house testing. They have 5% QA engineer among their employees. They perform static testing and follow only formal process in testing purpose but they perform both manual and automation testing in their firm. As correctness testing, both black-box and white-box testing are performed and for functional testing, integration testing, system testing, GUI testing, acceptance testing, are performed. They perform regression testing. They use Selenium automation tool for functional testing of web application and Appium, Calabash, Robotium, Selendroid for functional testing of mobile apps. For non-functional testing, usability testing, performance testing, security testing, localization testing, install testing, reliability testing and load testing are performed. Jmeter automation tool is used for load testing purpose and Jira, Github and TFS are used for tracking bugs/defects. As security testing, vulnerability scanning is performed. They mentioned that limitation of enough resources of automation testing is a challenge for them but they are getting satisfactory QA tester from the market. They provide formal training period for SQA team which is known as "knowledge sharing session". They put emphasis on ISTQB training even they have more than five ISTQB certified testers. They follow CMMI level 3 Standard. As per their opinion, both manual and automation testing should get same priority to develop Bangladesh software firms.

In the second part of this section, a comparison table has been showed of 10 firms on which the survey was conducted.

V. SURVEY FINDINGS

The findings from the survey can be summarized as follows: From the survey we see that most of the firms are developing almost similar categories of software but few firms develop specialized software applications such as micro-finance, face recognition and finger-print matching. The firms develop web-based applications in .Net and Java; they also develop applications for Android and iOS mobile platforms. Around 50% of the firms develop applications both for their clients and for software products, but the other 40% develop applications only for software products and the left 10% develop applications only for clients. Except company B and C, the percentage of QA engineer is very low which can be a threat for Bangladesh software industry because tester plays an important role in software firms. Without proper and methodical testing process, the software may not get its desired quality to be used by their target users. Only 70% of the firms follow formal process

for software testing, one firm (10%) follows only informal testing and rest of the 20% follow both the formal and informal process.

The usage of automation testing technique is very low. Except firm F, other firms follow both manual and automation testing but mostly manual testing is preferred by these organizations. As correctness testing, black-box and white box testing are followed by 30% of the firms, the other 20% are performing all of the three types and the other 20% are performing grey-box and black-box testing and the other 10% are following white-box and grey-box testing. Firm F and G are performing only grey-box and black-box testing, respectively. So it is clear that black-box testing is very popular as correctness testing. As functional testing, all the firms are performing unit testing, integration testing, system testing, GUI testing, smoke testing, sanity testing but the firm B also performs adhoc testing. According to the survey responses, unit, integration, smoke, sanity testing techniques are very essential. Except firm H, all firms perform regression testing. Except firm A, all firms do acceptance testing which is very important for software before releasing in the market. Firm A doesn't perform acceptance testing because they develop products for clients. So they try to focus on the client's specific requirements when they develop that. As non-functional testing, compliance testing, performance testing, security testing are performed by 100% of the firms, usability testing is performed by 80% of the firms, localization testing is performed by 60% of the firms, reliability testing is performed by 50% of the firms, install testing is followed by 80% of the firms. So, compliance testing, performance testing, security testing should must for non-functional testing. One most important non-functional testing is load testing which is performed by 100% of the firms. As security testing, vulnerability scanning is performed by 90% of the firms, penetration testing and fault injection based testing is performed by 70% of the firms, risk assessment is performed by 60% of the firms, only firm A and C perform property based testing. It's clear that each firm is concerned about security testing and vulnerability scanning, penetration testing and fault injection based testing are getting much priority for security testing. For getting developed software, each software firm should must focus on various correctness, functional, non-functional and security testing techniques.

Since the usage of automation testing technique is low in Bangladesh software industry, the usage rate of automation testing tool is also very low. The survey result reveals that software testing tools are being used in a limited way for load testing, functional testing of web applications and mobile applications, for tracking bugs or defects. For load testing, Jmeter automation is used by almost 100% of the firms. Beside Jmeter, firm B use Loadrunner, firm C use Gatling, firm D use Locust for load testing purpose testing. For functional testing of web applications, Selenium tool is used by 80% of the firms. Firm B also uses Appium, Protractor, Robotium tools for web application testing. firm D uses Sauce Labs tool beside Selenium for this purpose. For functional testing of mobile

Comparison topic	Firm A	Firm B	Firm C	Firm D	Firm E	Firm F	Firm G	Firm H	Firm I	Firm J
Percentage of QA Engineer	6%	17.5%	27.5%	1%	2%	8%	3.9%	6.02%	3%	5.5%
Focused categories of product	Mobile Apps, Face Recognition, Finger Print Matching.	Web MIS, ERP Solutions, Mobile apps, Enterprise Solutions.	Web MIS, Mobile Apps.	Financial Transaction System.	Web MIS, ERP Solutions, Mobile Apps.	Web MIS, Mobile Apps.	Telecommunication Solutions (Soft-switch, Mobile Apps)	Web MIS, ERP Solutions, Mobile Apps.	Mobile Apps.	Banking/Cloud/ AI/ AR /VR Solution, Mobile Apps, ERP, Share point.
Basic testing type(Manual/Automation)	Both	Both (Mostly Manual)	Both (Mostly Manual)	Both	Both	Automation	Both	Both	Both	Both
Static Testing(Yes/ No)	Yes	Yes	Yes	Yes	Yes (frequently)	No	No	No	Yes	Yes
Correctness Testing	Black-box, White-box.	Black-box, White-box.	Black-box, Grey-box.	Black-box, White-box, Grey-box.	Black-box, White-box, Grey-box.	Grey-box.	Black-box.	Black-box.	White-box, Grey-box.	Black-box, White-box.
Functional Testing	Unit, Integration, System, GUI, Smoke, Sanity, Adhoc, Regression, Acceptance	Unit, Integration, System, GUI, Smoke, Sanity, Adhoc, Regression, Acceptance	Unit, Integration, System, GUI, Smoke, Sanity, Adhoc, Regression, Acceptance	Unit, Integration, System, GUI, Smoke, Sanity, Regression, Acceptance	Unit, Integration, System, GUI, Smoke, Sanity, Regression, Acceptance	Unit, Integration, System, GUI, Acceptance	Integration, System, GUI, Acceptance, Regression.			

Fig. 2. Comparison table (part 1).

Comparison topic	Firm A	Firm B	Firm C	Firm D	Firm E	Firm F	Firm G	Firm H	Firm I	Firm J
Non-Functional Testing	Compliance, Usability, Performance, Load, Localization, Install, Security.	Compliance, Usability, Performance, Load, Localization, Install, Security.	Compliance, Usability, Performance, Load, Localization, Install, Security.	Compliance, Usability, Performance, Load, Localization, Install, Security.	Performance, Security, Load.	Performance, Security, Load.	Compliance, Usability, Security, Load.	Compliance, Usability, Performance, Load, Localization, Install, Security.	Compliance, Usability, Performance, Load, Localization, Install, Load.	Usability, Performance, Security, Reliability, Install, Load
	Vulnerability Scanning, Penetration, Fault Injection, Property, Risk Assessment	Vulnerability Scanning, Fault Injection based testing, Risk Assessment	Vulnerability Scanning, Fault Injection based testing, Risk Assessment	Vulnerability Scanning, Fault Injection based testing, Penetration.	Vulnerability Scanning, Fault Injection, Penetration, Risk Assessment	Penetration.	Vulnerability Scanning, Fault Injection based testing.	Vulnerability Scanning, Penetration, Fault Injection, Risk Assessment.	Vulnerability Scanning, Penetration, Fault Injection based, Risk Assessment.	Vulnerability Scanning, Penetration, Fault Injection based testing.
Security Testing	Selenium.	Selenium, Appium, Robotium, Selendroid, Protractor.	Selenium.	Selenium, Sauce Labs, Appium, Calabash, UI Automator.	Selenium.	Selenium, Selendroid, UIAutomator , Robotium.	Selenium, Selendroid, UIAutomator , Robotium.	None	None	Selenium, Appium, UI Automator
	Jmeter	Loadrunner, Jmeter	Jmeter, Gatling	Jmeter, Locust, Custom made	Jmeter	Jmeter	Jmeter	Jmeter	Jmeter	Jmeter
Automation testing tools for Functional Testing	BugZilla, Redmine, Cimbug	Jira	Jira, Github	Github, Mantis	Github, BugZilla	Self-developed portal	Jira, Mantis	Jira	Jira, Github, TFS.	Jira, Github, TFS.
	Asana	CMMI level 3	None	None	CMMI level 3, ISO 27000	CMMI level 5	CMMI level 3	CMMI level 3	CMMI level 3	CMMI level 3

Fig. 3. Comparison table (part 2).

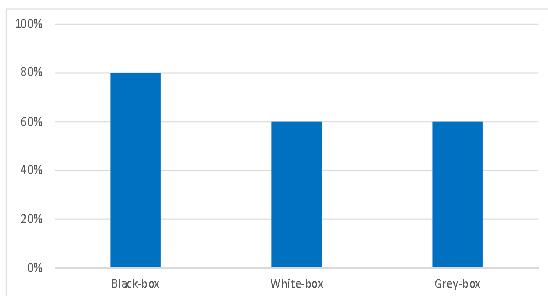


Fig. 4. Usage of Correctness testing techniques in software firms.

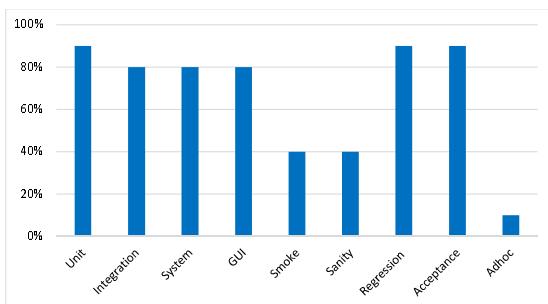


Fig. 5. Usage of Functional testing techniques in software firms.

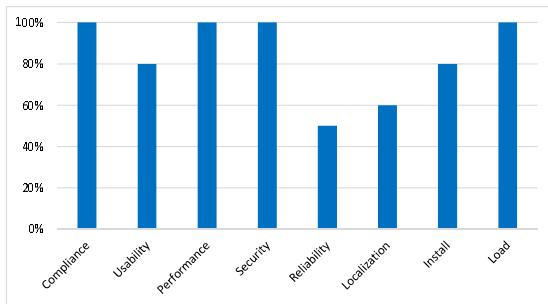


Fig. 6. Usage of Non-Functional testing techniques in software firms.

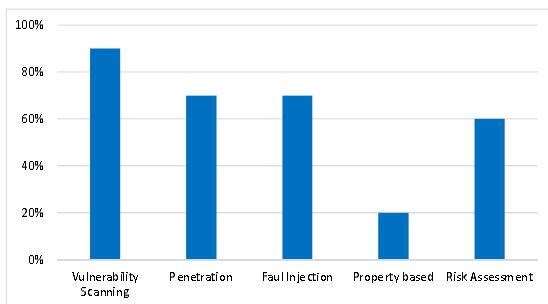


Fig. 7. Usage of Security testing techniques in software firms.

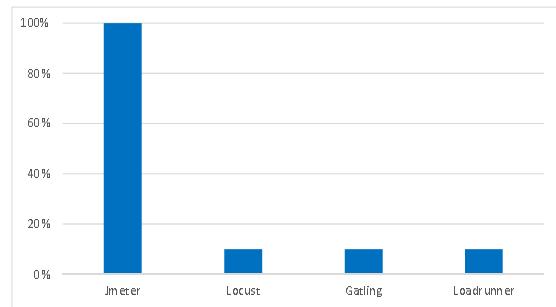


Fig. 8. Usage of automation tools for load testing.

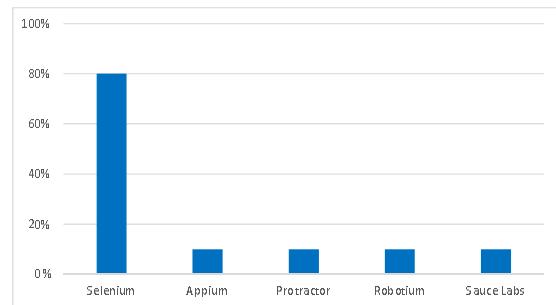


Fig. 9. Usage of automation tools for functional testing of web application.

application, Appium is used by 40% of the firms, Robotium is used by 30% of the firms, Selendroid is used by 30% of the firms, Sauce Labs is used 10% of the firms, UI Automator is used 30% of the firms, Calabash is used by 20% of the firms. Firm A,C,E, G, H don't use any automation tool for mobile application testing. Bug tracking is the most important term in the world of software testing. For bug tracking, Jira automation tool is used by 50% of the firms, BugZilla is used 20% of the firms, Github is used by 40% of the firms, Mantis is also used by 20% of the firms. Firm A uses Asana tool; firm B also uses Redmine, Cimbug; firm J also uses TFS tool and firm G also uses their own development portal for bug/defect tracking.

Fourth, although the position of Bangladesh software industry is on saturated point, still these firms are facing some challenges. When we conducted the survey, the respondents mentioned the challenges that they were facing since last

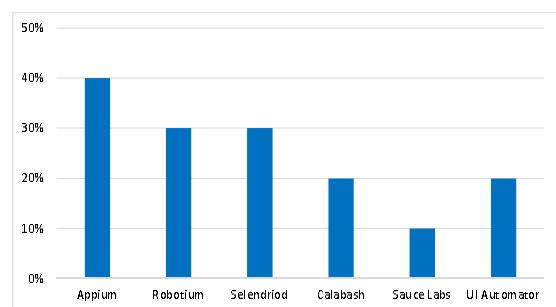


Fig. 10. Usage of automation tools for functional testing of mobile apps.

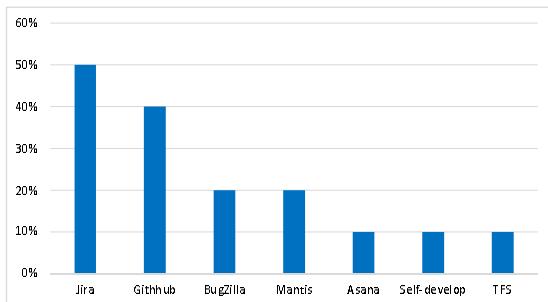


Fig. 11. Usage of automation tools for tracking bugs/defects.

decade. The most common problem of Bangladesh Software firms is not getting sufficient quality assurance tester in the job sector. Although there are some but their performances are not satisfactory. The respondents think that the lack of education system in Bangladesh is the main reason behind this situation because the fresher don't have any practical knowledge related to quality assurance. The usage of automation testing is low because certified test engineers and test automation engineers are not sufficient in the market. On the other side, some firms mentioned challenges like-lack of resources, lack of proper time, lack of enough automation resources and insufficient performance of load testing, integration testing. Full cycle testing which takes longer time is also a challenge for Bangladesh software industry. Less idea about testing tool is also an integral part of lacking Bangladesh software industry.

Finally, the five level rating scale of the questionnaire reveal out the overview of each software firm. According to their response, some of the firms are strongly agree and some are only agree that they are concerned about the defects in production because that may impact on the satisfaction of customers. The existing tools used by each firm provide strong support for mobile which reveals a neutral opinion from the respondents. Each firm strongly agree that the output from their testing tools/process is sufficient for their engineers to validate and prioritize issues. The existing tools for application architecture provides strong support which reveals a result of combination mixture like some firms are agree, some firms are neutral and some are disagree. According to the respondents, almost each are dissatisfied to find automation experts compared to other skill sets.

VI. CONCLUSIONS

Software Quality Assurance is an important and integral part of modern day software development process. New tools and techniques are emerging in the industry for better quality and convenience of the QA engineers. In Bangladesh, QA was not taken seriously in the initial decades of journey. In this paper, we have presented the survey results that we have conducted in the leading 10 software firms in Dhaka and made a comparative analysis. This paper will help the students and professionals of quality assurance teams to get a situation analysis of the existing practices in Bangladesh.

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