Test Methods Applicable to GIS

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Abstract: In software development, the testing process has the most significant parameter. According to the type of data held by geographic information systems (GIS) and the way in which data is analyzed, processed and displayed, the test of geographic information systems differs from testing other forms of information systems. We reviewed previous literature related to the testing of GIS in general and crowdsourced, automated, outsourcing testing in GIS systems. There is no much literature on GIS testing is available because there are standardized methods, devices, and protocols that have been used and applied in this field.

Keywords—Geographic Information System (GIS); Crowdsourced Testing; Automated Testing; Outsourcing Testing

1. INTRODUCTION

To test is to evaluate something according to specific standards. Such process can be similar to verification and supervision systems in which the user experiences his/her defined requirements. Thus, some differences may arise between the real and expected outputs. The process of discovering errors or any requirements missed in the developed software or system is called Software Testing. Therefore, it helps the stakeholders getting the exact information concerned the product's quality and safety.[1] Also , Software Testing can be regarded as a dangerous activity with many risks. One of the most important steps for software tester is to show the light on how to summarize the several tests into a unified set of tests that can be managed. Such step will enable them to make reasonable decisions concerned what most important risk to the test specifically [2].

Software testing is a major element of software quality assurance. Levels of testing depend on the doer of the testing process at each stage. Unit Testing, Integration testing and System Testing are the three main steps in the whole cycle. The software developer or the quality assurance engineer, known as a software tester, can take the responsibility of testing those steps. Software Development Lifecycle (SDLC) involves the above-mentioned steps solely. It is essential to break the software development into modules set where each team or individual takes the control of a specific module. After that, the developer tests each unit or module, after completing them, to check whether that developed module is up to expectation or not, which is defined as Unit Testing. Secondly, Integration Testing is the next main step in SDLC. As soon as they developed the modules of a single software system separately, they are integrated together with some errors appearing in the design once the integration has been finished. System Testing is the last third step in the SDLC. It means putting the whole software with all perspectives into test. Through this step, one can ensure that the integrated units do not interfere or effect on the programming of any other module negatively.

Nevertheless, the process of testing large or complicated systems can waste much time, with lengthy procedures. Such testing step becomes harder when it involves several components within the application. As a result, enhanced software testing process would be necessary for premium optimization.[3] On the other hand, testing the elements of Geographic Information Systems (GIS) is not an easy task, as we often face the challenge of verifying the correctness of the outputs.[4] This paper is organized into six   sections. This section introduces the testing of systems. The second section is about testing in GIS. The third section is about crowdsourced testing. The fourth section is about the automated testing. The fifth section is about the outsourcing testing. Finally, the paper ends with a conclusion.

2. TESTING IN GIS

Geographic information system is a system that presents spatial and geographic data and is broadly used in several business fields such as public health, crime, environment, and resources, among others. Various kinds of geographic data are collected on a daily basis, especially remote sensing information. Such a huge amount of information need to be processed and analyzed using the GIS rather than manually. GIS offers special solutions compared with the other forms of applications. GIS features the following characteristics:

Localization and mapping: GIS can identify locations very accurately. Its geographic mapping features are unique because of the appropriate functioning of this software when it comes to its legends, route displaying and the features of mapping including traditional maps, 3D maps, and augmented reality components.

Complexity: GIS is marked with complexity. Since GIS carries out testing across various platforms through different devices and operating systems, it guarantees flawless results and analysis.

Search capabilities: GIS software offers the feature of providing location-based searches. That is, a user using a GIS application can personalize the search options to identify or look for a specific location depending on his or her location.

Accordingly, there are several major steps involved in the process of testing. The most significant step is the identification of a strategic scope for the testing process, test planning and execution, and providing reports of the results reached by bug fixes and enhancements. These processes need to be clear from the beginning so as to ensure the comprehensiveness of the approach regardless of the application's complexity.

Not much literature on GIS testing is available because there are standardized methods, devices and protocols that have been used and applied in this field. A comprehensive and advanced definition of testing plans has not yet been achieved by several organizations, whereas many others have not yet even devised a plan at all. The organizations which apply GIS modeling often make use of more than one device to accomplish this task. For example, a company can use both AutoIt and MATLAB to carry out the process of a test automation for GIS. It is, therefore, of significant importance to raise awareness about the best GIS testing methods known worldwide. The following features are what guarantee a high-quality GIS testing:

Data testing: This feature is the most important one offered by the software. The major portion of the testing process, therefore, involves data. On the other hand, the review process focuses on the rules and the restrictions for providing data, the particular values, and the characteristics of the geo-processing framework. It is also needed to include running scripts that are timely adjusted to ensure convenient testing results.

Filter testing: This process involves the smart filtration of geo-data by the GIS software. The GIS application filters the results rather than presenting all of them at once. To make sure the retrieved data are accurate, there is a need to apply all types of filters (attribute and spatial ones) to evaluate and assess their efficacy.

So it is important to note that the above-mentioned rules are general and apply to the majority of GIS applications. Specific models should also be created to be compatible with the software tested.

There are various categories of GIS software, each featuring unique characteristics and complexities. The most well-known types are the desktop mapping and global positioning system (GPS) applications. The desktop mapping software is supplied with features that search for required data and enable data processing and analysis.

Among the list of popular applications are the Computer-aided design (CAD) programs which are more complex than desktop mapping tools. These programs are capable of designing, drafting, and displaying geo-data and this complexity is reflected in the testing practices adopted.

The GIS systems are complex and diverse including image processing, mobile GIS, routing GIS, spatial and photogrammetry databases, and cloud-based service solutions. Their complexity is attributed to the fact that they require specific operation resources, databases, input types and devices that support geo-data (namely queries, visualization, and analysis).

The features offered by the GIS programs can be either simple (basic) or advanced, based on the type and uses of the program. The simple GIS features include: map digitization, keyboard information entry, the transformation of raster into vector, data plotting, the generation of reports, and web mapping. The more advanced features GIS programs offer include: graphical generation, spatial analysis and measurement, linear referencing, perspective views, and scale changes, among others.[5]

3. CROWDSOURCED TESTING

Crowdsourced testing is a test method that is done by different users to validate the software based on predefined requirements, usually testers get paid after the test is done, this motivates them to complete the test quickly. the result of the crowdsourced testing is reports (test reports) are composed of simple natural language and screenshots.it provides a way to tackle the most important challenges that engineers face when they test and validate mobile apps such as higher test costs due to the diversity of mobile devices and platforms and difficulty in conducting large-sale user-oriented performance and usability testing. Engineers and developers most check and inspect the reports to ensure the quality of the test and detect faults.

3.1 BENEFITS OF CROWDSOURCED TESTING

Teams engaged in crowdsourced testing are timely when it comes to helping clients in a bid to manage any workload peaks. The peak-demand testing criteria consequently leads to very effective utilization of testing resources. Fewer resources can be used to manage daily QA testing whenever necessary. The use of fewer resources is made possible since firms receive high volume resources for a short period of time.

Crowdsourced testing leads to execution of QA tests and better results faster than traditional testing methods. Clients heavily rely on the timely results from developers who are able to get timely and relevant bug information. The speed of crowdsourced testing is attributed to the large global team involved in the task.

The development teams for the software focus on on-demand crowdsourced QA services which essentially help to minimize cost. The on-demand criteria also help to reduce the amount of labor as the development teams only work when their services are required. The on-demand criteria used for crowdsourced testing also essentially improves the efficiency of the QA.

This simply means that crowdsourced testing enables real user to quickly determine where their mobile application falls short and may need to be revised, fixed or updated. This usability capability helps the companies not to lose clients.

3.2 CHALLENGES OF CROWDSOURCED TESTING

Crowdsourced tests are known for the faster delivery of results but not all tests are suitable to be tested under crowdsourced testing. If instructions exceed 15 steps long, the test cases can be quite complex. The ideal length of instructions is about 10 steps [8]. the tests with longer instructions often failed due to errors. Redesigning and splitting up the tests however, mitigated the risk of error for such tests with long instruction steps**.**

Crowdsourced testing limits the test runs based on a payment plan or subscription from the client and as such most developer run testing suites on a stable release candidate. The approach however has a downside that results only come later in the development cycle and as such any bugs can only be caught then.

3.3 CROWDSOURCED TESTING USAGE

It is essential for users to understand that even though crowdsourced testing is a fast and reliable QA test tool; it is not suitable for all types of software. The primary goal for developers should be to understand which software does crowdsourced testing work best with. Such understanding will then help the developers to effectively use crowdsourced testing for optimal results. Between system software and application software, crowdsourced testing tends to work best with application software. Even though crowdsourced testing can be used to test system software, it is more effective with the application software [9]. Application software is best suitable for crowdsourced testing as it has short steps of instructions compared to system software. The instructions steps in the system software normally exceed the 15 steps threshold and as such are complex for crowdsourced testing.

3.4 CROWDSOURCED TESTING FOR GEOGRAPHIC INFORMATION

Geographic information systems can essentially have information that contains georeferenced and non-georeferenced data. The georeferenced data is typically referred to as crowdsourced geographic information and has spatial crowdsourced information that is produced by either social media platforms or volunteers. Crowdsourcing therefor can be used in the management and testing of geographic information system and especially in the defense sector in a bid to manage data sets and improve security.

4. AUTOMATED TESTING

Software testing is one of the stages of the SDLC whose mission is to detect errors or malfunctions in the program and it is considered a relatively difficult and expensive stage. There are two ways of testing are manual or automation. Manual testing has many defects and problems that have been resolved and avoided in automated testing of programs. Therefore, setting up and using automated tests may help us reduce costs of this tests and improve product quality. so that enabling for this software to do automated testing for software or project, produces reports, and compares actual results with expected results. Might be costly in some project but the results will be positive. Automated testing is simply the process of using a program to test a program. Where Automated tests automate manual tests and make these tests via software. All operations are automated, whereby the script is run on the testing tool and the test is done. The tester in the automated test may or may not know the internal program details. What distinguishes automated testing from Manual testing is that it reduces software development and maintenance costs and also reduces effort and errors. Testing automation tools enable developers and testers to easily automate the entire process of testing in software development. There are many automated open source and closed source testing tools for testing applications, software, or projects. There are different types of it: static, dynamic, test management and utilities.[14][15][16].

4.1 BENEFITS OF AUTOMATED TESTING

1- Automated tests can be used in agile software and projects, as the agile method requires the program to be delivered to the customer repeatedly and tested continuously. Hence, automated tests facilitate the possibility of delivering work more frequently to the customer more than if it was tested by human testers. This method is characterized by facilitating the work in the agile methodology and saves time and effort.
2- Automated tests save time and effort, and the results may be ideal, unlike manual tests, which can be stressful, take longer and boring time, and are also subject to human errors.
3-Automated tests help detect errors in the shortest time and with minimal effort, thus improving product quality and increasing efficiency.
4- Operating time is shorter, in addition to being this test effective and efficient in many aspects.
5- We can use and run automated tests on many different devices at the same time, unlike manual tests.
6- Useful in long term projects, if you have many tests, the automated tests will less expensive.
7-Reduces human errors and possible work costs of human testers.
8- It is characterized by speed if the tests are performed well.
9- Through automated testing, we can reuse test scripts.

4.2 CHALLENGES OF AUTOMATED TEST

1- Automated testing does not completely replace manual tests because they are suitable for testing parts of the software.
2- The use of automated tests is not done in a direct manner until after these tests are repeated and simulated also experiences.
3- Some test types are not suitable for automation such as: Installation setup Testing and Error handling, etc.
4- There may be gaps in automated testing software.
5- The need to train testers on tools.
6- The need for specialists to design the automated test framework.

7- One of the drawbacks of automated tests is that their maintenance may represent a burden on the institutions and organizations operating with such systems.

8- Automated tests are used rarely.

9- Somewhat expensive in some projects.

4.3 AUTOMATED TESTING FOR GEOGRAPHIC INFORMATION

Automation testing for GIS is more effective and faster than the action of humans, this will save time, money and a lot of manpower. Automation testing can offer more accurate results and fewer errors, as it is difficult for a user to replicate every detail of the process exactly. Automation is tool and good option to do the process which was originally intended for automated software development testing [17].

5. OUTSOURCING TESTING

Today's market socially, organizationally and technologically allows companies to function effectively and efficiently to be successful, Outsourcing is used to achieve the above objectives, The art of software development outsourced to offshore companies has expanded significantly, Increased importance and workload of software tests prompted some firms to outsource the testing firms Outsourcing Testing is a type of outsourcing in which an independent company conducts software testing .The most needed forms of software testing outsourcing today are tension, efficiency and security testing [18][19][20]. Outsourcing testing can be categorized into three types:

Basic: The client company has a good test team that designs test specifications and test cases. outsourcing testing has to follow instructions from the client company and testing the project according to the description received from the client company which contains specifications and test cases.

Intermediate: The client company has a test team and the testers in an outsourcing company need to collaborate with the client company's testers. Client company testers and testers in an outsourcing company work together to create the test plan, design the test cases, build the test system and complete the entire test process.

Advanced: The client company does not have a test or development team so they outsourced all their IT works and the outsourcing companies' testers need to help the client company to establish the test plan, design the test cases, build the test system, and complete the entire test process [20].

Outsourcing testing it has many benefits such as Predictable quality of the software, improving Service Consistency, reducing risks through rigorous testing, reduce the pressure on their inside test teams, improved time to figure out better design, growing efficiency of the program Savings on prices [18][19][20].

The success of outsourcing testing may be impacted by numerous challenges such as consumer satisfaction which is one of the major challenges for outsourcing testing projects,

unfamiliar domain, time constraints, and inadequate documentation [20].

5.1 OUTSOURCING OR IN-HOUSE?

- Outsourcing is based on a mechanism that differs from the In-house test in that the Outsourcing test is relying on external companies to test the projects that have been selected, while in the In-house test the projects are tested by testers inside the company itself.

- Often the focus is on system testing in Outsourcing testing, on the contrary, in In-house testing, its focus is on unit testing.

- Outsourcing testing requires testers to have knowledge of the fields and its requirements. It requires testing in multiple fields and may be differ from each other, while in In-house testing, testers may work in one or two domain that are often related.

- The Outsourcing test setup differs from the In-house test because of the corporates security and privacy policies.

- In the Outsourcing test, the goals may be less clear and specific, and they might be change, on the contrary, in the In-house test, in which the goals are often clear, specific, and implemented with precision.

- Documentation requirements in the In-house test are less than the Outsourcing test, which requires documentation of all what is done in this test, thus the production of documents is more in the Outsourcing test [20].

5.2 OUTSOURCING TESTING FOR GEOGRAPHIC INFORMATION

It is possible to consider geographic information systems like other information systems in that it is possible to use outsourcing testing company to conduct the test processes.

6. CONCLUSION

Testing involves evaluating something according to particular criteria. Testing the Geographical Information Systems (GIS) elements is not an easy process. Testing of geographic information systems differs from testing other forms of information systems but it has common features with testing other types of information systems in that it will involve a structured testing processes involving unit, component, system, volume and user acceptance testing. Crowdsourced testing has for some time now proven to be an effective method of software testing. Crowdsourced testing does have both merits and demerits and having weighed both, most developers now turn to crowdsourced testing. In essence crowdsourced testing has proven to be efficient than the conventional methods of software testing. The combination of manual testing and automated testing may be the most cost-effective and accurate result solution. It is possible to consider

geographic information systems like other information systems in that it is possible to use outsourcing testing company to conduct the test processes.

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