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Quality Assurance of Web-Based Applications

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***Abstract*— Use of E-commerce applications is swiftly growing worldwide as businesses are now drifting from obsolete desktop applications to web-based applications. Due to the large volume of these applications and distributed, heterogeneous, multiplatform, multilingual and autonomous computing environment of the internet, quality assurance of web-based products is becoming more significant and decisive. Testing and maintaining are key processes to acquire the optimum quality of web-based applications. There is also a dire need to understand the typical structure of a web application and the divergence between traditional desktop applications testing and web-based applications testing. Quality assurance team uses different kinds of testing and maintenance approaches to ensure the production of best quality web-based products but in fact, conventional testing methods are not enough, so, emphasis on seven basic parameters for quality assurance of web-based applications.**

***Keywords*— Web Applications, Requirements, Quality Assurance, System Testing, Website Structure and Web Versus Desktop Applications Testing**

I. INTRODUCTION

As the time progresses, the internet is quickly expanding in all sectors of our society, which encourage the businesspersons to shift their businesses from obsolete desktop applications to e-commerce applications. On the other hand, testing and maintenance of web-based applications has come forward as a great challenge for quality assurance team because existing software testing and quality assurance techniques are inadequate. Typically, web-based application work in a distributed manner, which makes these applications more intricate. Web-based applications collect data from heterogeneous sources, which raise an issue of integration.

Web-based applications are required to run uninterruptedly as millions of users are being accessed these applications so, its maintenance and testing are much more difficult as compare to outdated desktop applications. Quality is a key factor for any successful business, which reflects the customers' satisfaction. Customers' satisfaction well described by the Robert L. Glass [1] in mathematical equation form as:

"Customer satisfaction = compliant product + good quality + delivery within schedule and budget"

Quality is a sunshade action, which can be applied on every walk during the application maturity process, which manage the near and far quality of software. It is the duty of web developers and SQA team to produce first-class web products, which are far away from bugs. Web developers achieve the optimum quality products by applying quality management approach, effective checking mechanism, formal review, timely reporting, etc.

The Web applications played a vital role in many business areas like sales, marketing & management, finance, etc. QA of web-based application is a wide area and lot of work has already been performed in last decade but this research paper will prove helpful for Software Quality Assurance Team.

In this paper, a typical structure of a website and basic parameters involved in testing or quality assurance of web-based applications are discussed at length. It also portrays the stream of web-based applications testing processes, which help the testers in producing the best quality products.

II. A TYPICAL STRUCTURE OF WEB APPLICATION

Before the discussion of metrics for quality assurance of web-applications, it is necessary to understand the typical layout and functionality of a web application. It is a group of web pages, images, text descriptions, multimedia items and other digital materials, which are hosted by a web server and accessible by means of internet or some local area network. In web-based applications [2], all kinds of information with various format and structure are required to integrate visibly and flawlessly. The web-based application is rigorously interlinked to its operation environment, so, it is impossible to analysis them individually and establish accurately which of them is accountable for every exhibited breakdown [3].

A web application is organize in good manners to look beautiful for the visitors. In the modern era, web applications are being developed in such a way that it is responsive and compatible with all devices. It contains a lot of navigations and hyperlinks, which help the users to go from one page to other. Contents of a website must be changed without any modification in a graphical interface. According to the situation, 3-tier or n-tier model is used for a website but in past, 2-tier models were used which is helpful for scammers as they can easily access users information in these models which is a security breach.

Root directory structure of typical web application is shown in Fig. 1.

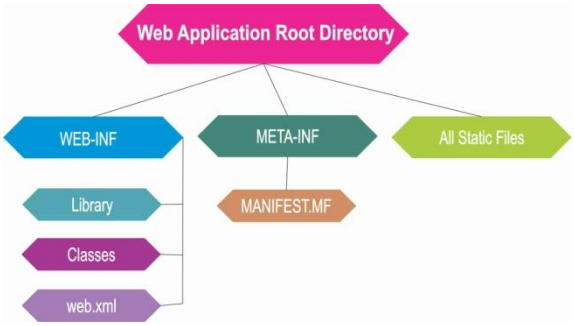

Fig. 1. Root Directory Structure of Web Application

Web-based application can have the following components:

- Static content (HTML).
- Java Server Pages for dynamic web pages.
- Client-side files (CSS, JavaScript) for graphical design of web pages.
- Java Servlet to extend the capability of server.
- Jar files and other java utility classes.
- Web.xml for servlet-based java web application.

III. WEB APPLICATION TESTING VERSUS DESKTOP APPLICATION TESTING

Web applications' testing is different from desktop application testing due to various factors, few of which are:

- Web applications are facilitated to the diverse and large number of people as compare to desktop applications.
- Security of web applications is more vulnerable as a database is available on the server and malicious users can get access the users' personal and important information. Security threats increase especially in case of E-commerce applications due to the availability of users' credit card details online. Therefore, it is an open challenge for testers to the emphasis on security testing.
- Test cases should be covered the functional usage and technical aspects, such as network speed, compatibility of different devices, etc. For example, high-resolution images may take several seconds/minutes to load on webpage due to low network speed, which creates the bad impression on end users.
- Browsers compatibility test is essential in web-based applications testing but not in case of desktop applications testing.

In addition to above, according to Arora A. and Sinha M. [4], the following non-equivalence issues between web applications testing and conventional desktop applications testing are also raising:

- In web-based applications, it is difficult to find out the errors or flaws as these applications use the multi-tier architecture.

Web applications are capable to deliver software component dynamically at runtime according to inputs given by the user.

IV. BASIC PARAMETERS FOR TESTING OF WEB-BASED APPLICATIONS

Seven basic parameters, such as functionality testing, usability testing, interface testing, compatibility testing, performance testing, database testing and security testing must be observed to acquire the best quality of web products, which fulfill the customer desires.

Software quality management provides valuable assistance to organizations in order to ensure that all software development activities reach the expectations around performance, reliability, security, and maintainability [5].

A. Functionality Testing

Functional testing played a vital role in producing the best quality web product. The main purposes of functional testing are to confirm that whether all the components of a web application are working properly as described in functional specification document or otherwise. Also, check whether the web application fulfills the customer's desire. Actually, this type of testing also called "Component Testing". Functional testing activities should also include link testing, form testing, HTML/CSS testing and cookies testing.

1) Link Testing

It must be ensured that all the web pages are working properly without any disruption.

- Test all outgoing links
- Test all internal links
- Test all mailto links
- Test all anchor links

During link testing, if any link on web page found broken immediately report to web developers for its necessary restore.

2) Form Testing

Web form testing is of utmost importance as it receives information/data from users and store into database. Any interruption can cause a serious loss of information especially in case of E-commerce software. Following test cases should be considered during form testing process:

- Check the validations on each form fields as inappropriate validation of form data invites the hackers and spammers to come forward to fulfill their nefarious designs.
- Check default value of each form field.
- Password validation must be ensured.
- Check, if the user forgets to fill any specific filed then error message must be shown.
- Check the tab orders.
- Check all the buttons (add, delete, save, modify, send, etc) on web forms are working properly or not.

3) HTML/CSS Testing

HTML/CSS validation played an important role in website optimization for search engines. Check the website on several

search engines like Google, Bing, and Yahoo whether the web application is responding well and search engine can crawl site easily without any hesitation.

Also, check:

- Syntax errors.
- Color combination for contrast.
- The standard like ISO, W3C, IETF, WS-I, ECMA, OASIS.

4) Cookies Testing

Generally, cookies are used to maintain the login sessions, which is helpful for users. These are small text files having instructive information, which saved in users' system by their browsers. In cookies testing,

- Test the application by enabling and disabling session cookies.
- Test cookies are working as per expectation or not.
- Test sessions cookies are deleted properly either on cache clearance or reach their expiry.
- Test sessions cookies do not obtain login information from a user on next time login.

Apart from above, according to Hari Sankar Chaini, and Dr. Sateesh Kumar Pradhan [6], functional testing entails the following basic steps:

- Identification of functions which are expected to carry out by the software.
- Formation of input data which is based on function's requirement.
- Determination of output which is based on the function's requirements.
- Implementation of the trial case.
- Comparison between actual and expected outputs.

B. Usability Testing

Usability testing is a non-functional testing technique which illustrates that how simply an application can be used by the end users. Usability testing is a bit more difficult to measure. It includes navigation and content testing of the website.

1) Navigation Testing

Appropriate presentation and design of web-based application create a good impact on users. Navigation testing includes:

- All links, buttons & menus should be visible and reachable from all other pages of web application and no link should be broken.
- Navigation amongst web pages should be easy to use without any interruption.
- The consistency of all options on header/footer and left/right, up/down navigation should be ensured.

2) Content Testing

Web applications are profoundly content-driven [7], as most of the web applications comprising upon graphical data, textual descriptions, videos, audios or multimedia information to the end users due to which content testing is of utmost importance in producing the best quality web product. It includes,

- Helping contents of a web application should be obvious in providing the necessary assistance to users.
- Check the textual descriptions for spelling/grammatical mistakes.
- Proper loading of images with accurate sizes should be ensured.
- Check all the pages for pattern style guidelines, such as fonts, borders, and frames.

C. Interface Testing

Interface testing is actually the verification of communication between two different software systems. Three main domains are covered in interface testing such as application server, web server, and database server.

1) Application Server

Check all the requests are sending perfectly to the database without any interruption and output viewed at client side appropriately. Also, ensure that customers should not face any disturbance during using a fussy web application.

2) Web Server

In this testing, it is ensured that web server is tackling all application requests without any service refutation.

3) Database Server

It makes sure that database provides the expected result on queries. In case of any error return from database server then an error should be displayed to the user and also handle properly.

D. Compatibility Testing

In compatibility test, it is ensured that web application is precisely displayed across different devices. Customers used web application on different browsers, devices, and operating systems, which make the compatibility test bit difficult. In order to avoid the compatibility failure, appropriate information should provide to users about the expected configuration of the running environment and with suitable diagnostic messages to handle any incompatibility [8].

1) Browser Compatibility Test

The key objective of browser compatibility testing is to ensure that the application displayed properly on various browsers, such as Internet Explorer, Firefox, Opera, and Safari etc. AJAX and JavaScript are being used in different web applications, so, the functionality of the same should be ensured. Harald Weinreich, Hartmut Obendorf and Eelco Herder [9] also described that there is a dire need for more flexible browsers, which should be able to adopt any type of website.

2) Operating System Compatibility Test

In this modern era, new technologies are being utilized in web development, which may not work properly on different operating systems. Therefore, the web application must be checked on different operating systems (OS), such as Microsoft Windows, MAC, Unix, Linux etc. before its launching.

E. Database Testing

Database played a vital role in web-based applications, so, its reliability should be ensured. Database testing include,

- Check that all queries are executed properly and taking least time, so that, the best performance of the system could be ensured.
- Check creating, deleting and updating functions are working accurately to ensure data integrity.
- Check that data is receiving correctly from the database and appropriately displayed on web pages.

F. Performance Testing

Performance testing is used to determine how quick some specific function of a system can accomplish under a particular workload. In order to examine the performance of web-based applications, load testing, configuration testing, volume testing, stress testing and isolation testing are used.

Performance testing should be considered as a perpetual activity, which is carried out by evaluating data from access log files [3], to ensure the adequate performance of web-based applications.

1) Load Testing

In load testing, check whether the website work under all loads or not means behavior of web application must be observed under the normal and heavy loads. Also, check the response of application if many users' requests are received simultaneously. Identify the web application processes that directly affect the overall performance of the system. Most organizations are used open source load testing tools like The Grinder, Gatling, JMeter, Tsung, etc.

2) Configuration Testing

In configuration testing, the application is tested with several combinations of hardware and software to find out the best configuration under which the system can work smartly without any interruption. Types of configuration testing are,

- Hardware Configuration Testing
- Software Configuration Testing

Generally, hardware configuration testing is performed in laboratories where physical devices are available for checking purpose.

In software configuration testing, an application is test with several Operating Systems, different software updates, etc. It is a time-consuming process as it takes some time to install and uninstall the software.

3) Volume Testing

In volume testing, verify if there is any data loss and check the response time of the system. It is also checked that whether data is overwritten without any prior notification.

4) Stress Testing

Stress testing determined the application's availability and reliability under heavy load or inadequate computational resources. The basic goal of stress testing is to identify how an application response under extreme conditions.

Examples of stress condition are:

- Reduction of resources in case of failure of a disk drive.
- Unpredicted sequencing and outage recovery.
- A denial of service (DoS) attack.

5) Isolation Testing

Isolation testing is used to reduce the chance of bugs in web application. In this process, the system is broken down into several modules in order to track the defects in isolation easily but it is a time-consuming process, which may cause more cost.

G. Security Testing

Strong security measures are required to be taken in web-based applications in order to defend the sensitive and important data provided by the users, so that, victorious data transformation could be ensured. Security testing played a vital role especially in E-commerce applications where sensitive information of customers like credit card details is stored. The most dangerous areas of web-based applications testing is web security [10], a security breach can cause severe financial and data losses. During security testing of web-based applications, the tester should keep the record of all the issues observed by him in the previous testing, as this information would be helpful for designing and modeling the effective test strategy [11].

Both the application as well as the running environment can be responsible for security failure [3]. Due to heterogeneous, multiplatform, and autonomous computing environment of internet and possibility of accessing a web-based application by a large number of users, making these applications more vulnerable as compared to traditional desktop applications.

In security testing process, testers are required to check URL manipulation, Cross Site Scripting (XSS), SQL injection and password cracking in order to produce the best quality web product.

1) URL manipulation

If a security breach occurs then scammers can easily edit the URL string in a browser. The biggest threat is the existence of fake website which looks like a real one whose main purpose is to install malware on user's machine to get someone personal information. The basic purpose of this testing is to ensure that scammers could not manipulate URLs to get the access to important data of users. It also ensures that the users should not redirect from real website to fake version. Consumer information is passed to the server for fetching information via HTTP GET request. Hackers can maneuver every input variable passed from this GET call to the server to

corrupt data or getting access to information in order to fulfill their wicked desires.

2) SQL Injection

SQL injection is a process in which hackers insert SQL statements into a text field and extort the contents of a database. These attacks are very crucial because hackers can obtain important information from the server database. If special care is not observed then scammers can add, delete or modify the database easily. Therefore, find out the source code of web-based application wherefrom MySQL queries is executed on a database by taking some inputs from a user. As a precautionary measure, special characters received from users should be escaped appropriately.

3) Cross-Site Scripting (XSS)

By using XSS, malevolent users can utilize the scripts to lift the user data, so, the testers must be checked the web-based application for cross-site scripting. It is ensured that no text field is accepted any script like JavaScript because mostly hackers used the JavaScript to get the access to a user cookies. In order to explore the user or server data on a browser, hackers enter the script as '&query' parameter. For example,

http://www.xyz.com/index.php?userid=123&query=abc

4) Password Cracking

The easiest way for malicious users to access to any person's account is password cracking. Username and password stored in cookies must be encrypted as the attackers can steal cookies information by guessing or using password-cracking tools, therefore, during security testing, testers should ensure password security. During web development process, enforce password having a sufficient number of characters containing the combination of alphabets, numbers and special characters in order to strengthen the security measures. Furthermore, in order to prevent from automated login, check the working of CAPTCHA if added. Testers must be required to check the system behavior by putting invalid inputs like username or password in input fields.

The central idea of security testing is to identify the vulnerabilities of a web application, therefore, it is important to note that during security testing, the following things may not be modified:

- Customer data or existing user hosted by a web application.
- Configuration of a web application.
- Configuration and services running on the server.

V. CONCLUSION

In this paper, several testing tactics, typical website structure and comparison between web applications testing & traditional desktop applications testing are described at length that will lead to better web-based applications in term of functionality, performance, reliability and security as the conventional desktop applications metrics are insufficient.

Software Quality Assurance activities, principles, and its methods should be pursued in early stages of web application development phases for maintaining the performance, quality, efficiency and cost of the web product. This activity should be helpful for web application developers to reduce the workload and failure chance of these applications as people look forward to the availability of web-based application 24/7. This paper can help the testers in the initialization of more strapping plan, measures, and approaches in producing a paramount quality of web-based applications.

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