Challenges in Testing of Web Applications

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Abstract: Testing is one of the most important phase in software development life cycle. It actually plays a very important role in the software product success by improving its quality. There are so many challenges of testing are involved in Web-based applications. But interoperability and integration are the most important testing challenges that are associated with Web-based applications. Now a day's Web-based applications importance and complexity is also increasing and they are evolving and emerging rapidly. This paper introduces the Integration and Interoperability issues of Web-based Applications.

Keywords: Integration, Interoperability, Web Application.

1. Introduction

Testing of Web-based applications [1] is different from conventional software testing, but the goal is to remove errors before deploying the application on networks (internet or intranet). The **Web-based applications** work in a distributed and in an asynchronous fashion. Such applications are complex in nature and inter-dependency between the Web-components may also cause so many errors. These applications are created from different heterogeneous Web-components that interact with each other, and with users through novel ways. These applications are based on number of different components (Web components) written in different languages and frameworks like; Active Server Pages (ASP), PHP Pre-processor (PHP), Java Server Pages (JSP) and Asynchronous JavaScript and extensible Mark-up Language (AJAX) etc. These Web applications can be accessed through the Web browser over the intranet or internet.

Such Web-based applications are distributed in nature and it is not easy to test them. **Testing of Web-based application** is so difficult due to its heterogeneity, multi-platform support, and autonomous, cooperative and distributed nature. In recent years, the Web applications have been integrated into different organizations and with mission critical systems which affect the quality and reliability of such applications and it is crucial and therefore testing of such applications are very time consuming, costly and now contains a big challenge. So, Web-based applications gather such information from different heterogeneous sources. It actually raises the issues and challenges in integration as well.

The integration [2] in Web-based applications of number of software components is a big task. **Integration testing** of Web based applications is most crucial task for the successful operations of such components. So, the integration testing of such components of Web-based applications involves

number of factors which may raised during integration and deployment of the application. So, integration testing is one of the most challenging tasks today. In Web based applications, the overall information with different layout and style is also needed to be integrated transparently. So, it's a complex requirement which includes the issue of interoperability in the Web based applications. **Interoperability** is one of the most important issue in Web based Applications. Interoperability is the ability to share information among number of applications, operating systems, networks and computing components. It is complex and difficult to handle in software as compared to hardware. According to Interoperability testing involves multiple levels:
• The standards meet the business requirements they were intended to address (validation testing),
• The standards conformance of key implementations, what was implemented agrees with the specification (conformance testing), and
• That sets of business applications can successfully operate together (interoperability testing).

The Web applications are run on cross-platform environment therefore the running of different components of Web applications on different platform is an issue. To validate this requirement **Interoperability testing** is used. The running environment of Web applications is heterogeneous and autonomous therefore interoperability testing of these applications is not an easy task. It is one of the most important and challenging tasks to improve the quality of software applications.

Web-based applications [3] are playing pivotal role in many business domains, for example finance, sales, retail, marketing, and management of particular products. In the applications of large enterprises and mission critical systems, the importance of software integration and interoperability cannot be neglected. Different integrated components are developed in different platforms, tools and by using different

methodologies. Therefore, we suggest there should be a separate sub-testing team consisting of 2-3 testers (depends upon the size and type of enterprise or organization) with multiple skills (multi-lingual expertise, standards, methodologies and tools) to handle the issues of interoperability and integration.

1. Types/Categories of Web-based Applications

Along with characteristics [4] of Web-based applications the understanding of different types and categories of these applications is also important for the developer to develop successful applications. The Web-based applications are of many types each of which has its own issues and importance. The following different categories of Web applications are mostly present on the Web:

• *Interactive:* These types of applications are usually provides the mutual interaction and communication way among the community of users like chat rooms, instant messaging etc.
• *Informational:* In these types of applications read-only information is provided to the end users through different and simple navigations and links.
• *Customizable:* Through these applications end users can customize the contents of the applications according to their needs and preferences. For instance, a user can customize email settings according to its needs and preferences.
• *Download/ Deliverable:* These kind of applications provide the facilities of downloading different applications, files etc. For example, if a user wants to upgrade or update Microsoft Windows, he/she can do it through the Web applications provided by the Microsoft.
• *Form-based Input:* Through these applications end users can submit their data, queries to the database of the organization and extract the required information.
• *Transactional:* Through these Web applications users make the request or place the order to obtain goods or services. For instance online shopping, online ticketing purchase.
• *Web Services:* Web services allow us to create the interoperable distributed applications. These are cross-platform technology and can be developed in multiple technologies and make the data available to different applications that run on different platforms. Familiar Web Services include Business to Consumer (B2C), Business to Business (B2B), search engines, stock tickers, FedEx tracking, and credit card services etc.
• *Web Portals:* These kinds of applications provide the facilities to the users to other contents of the Web or services which are not in the domain of the portal applications.
• *Data Warehouses:* These applications provide the facilities to the user to query their request in the collection of large databases to retrieve and extract particular information. Google is a good example of such kind of applications.

2. Architecture of Web applications

These patterns also provide [5] the architectural views of the Web applications. The architectures of the Web-based

applications is rely on the technology popularized by the World Wide Web, the Hypertext Markup language (HTML), and its primary transport medium, Hypertext Transfer Protocol (HTTP). At start of Web the architecture of Web applications were very simple. Figure 1 describes the simple architecture of Web applications. Client sends request through web browser to server and gets requested HTML documents from server in response. This system was only capable of navigation of mostly textual information in HTML form and it did not make use of server functionalities.
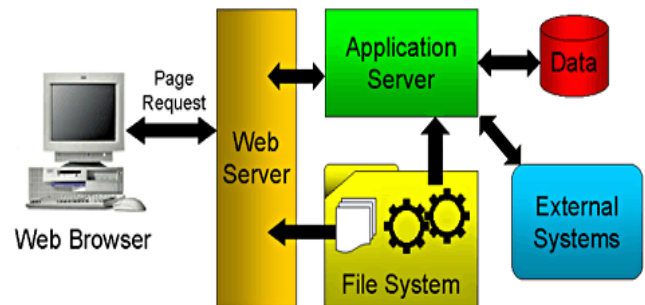

Figure 1 - A simple architecture of Web-based Application

3. Integration and Interoperability Issues of Web-based applications

The Web-based applications [6] are actually based on collection of different Web components written in different languages and frameworks. These different components communicate and interact with each other to share information and data, and present to the consumer or user. This raises the issue of integration of these different components. The integration is a big issue in the heterogeneous Web-based applications, because different components might be developed in different languages and platforms. These differences in programming languages and development tools can create the problems and difficulties in integration of those components. It is possible that after integration these components could not perform as they were expected. Therefore, integration testing plays key role to find out errors which occur before and after the integration of different components and services of the Web applications. Integration testing plays important role but it is not an easy task. Integration testing of the number of components of Web-based applications involves lot of important factors, which might be higher on integration, packaging and deployment of the application. So, integration testing is one of the challenging task in web applications. Web-based applications have become the crucial components of our life and are involved in critical activities. Now the business integration is key endeavour of Enterprises. In current business run, the Enterprise's decision makers want to align their business with the current market. They are adopting the Service Oriented Architecture (SOA, also called Web services (a type of Web applications)), which is essential for their businesses. Now, most of the small medium enterprises (SMEs) are aligning their business processes in SOA. This provides a way to make business processes automated, open and interoperable. Now, most of biggest business organizations have automated their business process and they need to think about interoperability to cooperate with other business processes for achieving business goals. Maintaining interoperability among different automated business process

and components and Web components is an important but challenging task in Web-based applications. According to interoperability of software system is the ability to share information among different computing components, operating systems, applications and networks. For Business-to-Business (B2B) Web applications, efficient integration is required to achieve the interoperability. The different frameworks for B2B integration have many research issues which need to be addressed. For example, process-based integration of services, and dependable integration of services, etc. The interoperability of Web based applications cannot be guaranteed due to many reasons;
• The Web services standards and specification supported can be different
• Error handling mechanism can be different
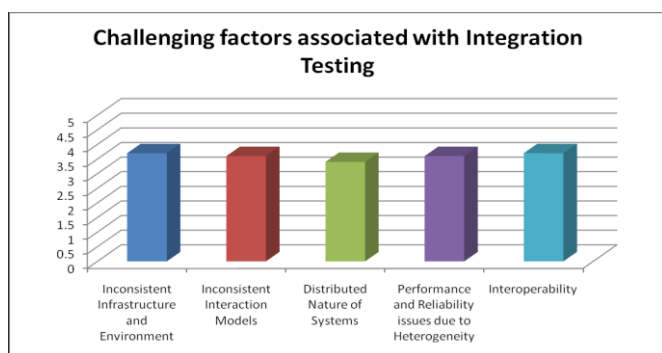• Difference in supported protocols etc.

Figure 2: Challenging factors of Web-based applications associated with integration testing.

According to the results, the most challenging factors in integration testing are inconsistent infrastructure and environment, and interoperability with average 3.7 out of 5. The two others critical challenging factors in integration testing are inconsistent interaction models and performance and reliability issues due to heterogeneity with average criticality level 3.6 out of 5.
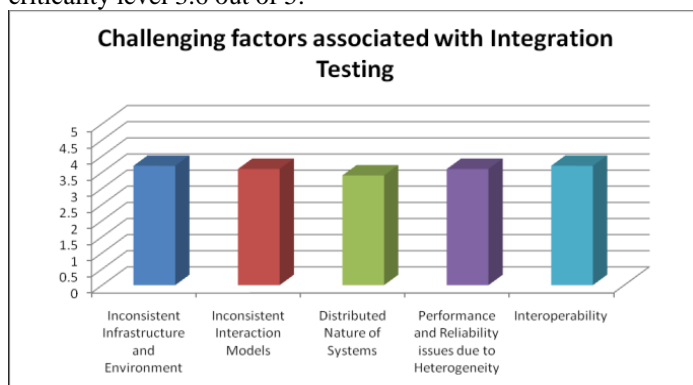

Figure 3:Challenging factors of Web-based applications associated with interoperability testing

According to the results, the most challenging factor in interoperability testing of Web-based applications is the difference in implementation standards in industry with average criticality level 3.8. The other important challenging factor is diverse information retrieval and operating systems with average criticality level 3.7 out of 5. The other critical factors are organizational level issues , technical level issues, data heterogeneity, semantic issues are also critical with average criticality level 3.1 ,3.4, 3.3, and 2.8 out of 5. The average results of such critical challenging factors in interoperability testing are shown in the Figure 3.

4. Testing Challenges to Web-based applications

The main aim of testing Web-based applications [7] is not different from the testing of conventional software applications. That is to find out the errors and bugs in the applications before deployment on Internet, or Intranet. Due to the enormous involvement of different interdependence Web components, the complex nature of applications, heterogeneity and distributed nature, we can find plenty of bugs and errors in Web applications. We can find more errors but how? It's a very big challenge in Web-based applications because the importance of rooting out errors in Web applications cannot be understood. Due to the large number of different elements and a lot of interdependent components of Web-based application the Web engineer faces many challenges during the designing and testing of these applications. Many assumptions about the environment, platform and other resources are required. Web-based applications are error prone and have many failure points that must be considered before designing and deploying the testing approach. Following are the few major challenges regarding testing of Web-based applications: **The enormous and varied users:** The Website provide the user interface of the Web application to the end user and these end-users possess different skill sets on the Website by employing a variety of different browsers by using different operating systems and devices. The user can access the Web application using a wide range of connection speeds. **Business Environment:** The business environment play major role in the testing of web based applications in case of e-commerce Web application a lot of issues like tax calculation, shipping costs determination, completing and executing financial transactions, tracking of customer profiles. **Locales:** The user of Web-based application can be of any nationality and country therefore the internationalization issues such as language translations, time zone considerations, and currency conversions are the big challenges

Testing Environments: To test the Web applications [7] is very expensive and time consuming because we need a duplicate of the production environment. That is Web servers, application servers, and database servers that are identical to production equipment are required to ensure the quality and test the Web applications. For best testing results, the duplicate of network infrastructure is also required. In case of financial transactions application testing we need all the duplicate resources (software and hardware) to ensure the high quality of the application. **Security:** Security is one of the biggest challenges in the Web-based applications, because the Web application is open to world after deployment on the Internet or Intranet. Therefore protection from unauthorized access is very crucial; otherwise hackers can attack to the application and can rip off the customers' personal information and credit card information. **Integration testing challenge:** Enormous different Web components are involved in the Web based applications. These Web components are developed by different vendors and are integrated to the applications according to the

business need. The integration of these components can result in the malfunctioning; therefore integration testing of these components has great importance and is one of the biggest challenges for the Web engineers. **Compatibility issues:** It is one of the significant challenges to test the Web application that is the browser compatibility, because a number of different browsers are being used in the market today and each has its own behavior. There are standards existing for browser operation but most vendors try to enhance their browsers to operate in a non-standard way. The integration of different Web components also raises the issue of compatibility because there are different components of different vendors are used and that might not compatible with each other. **Interoperability issues:** When the Web based applications are developed through integration approach of different technologies then the issues of interoperability like seamlessness, scalability, reliability, performance and security are apparent. So interoperability testing is very crucial to ensure these attributes and high quality. But interoperability testing is itself a big challenge. There are a lot of more challenges associated with Web based applications, for instance, performance, usability, scalability, conformance, reliability and system testing, and detail of which is beyond the scope of this thesis work. Most testing challenges depend upon the nature of the Web applications. More complex the Web application, more effort will be required to test the Web application.

5. How can we improve the integration and interoperability testing?

In our opinion a dedicated effort is required to cover all the possible issues and challenging factors of integration [8] and interoperability testing especially in more complex and large-scale Web-based applications. We need new testing strategies and methodologies to solve the challenging issues of both integration and interoperability testing. Along with this, we suggest, there should be a separate sub-testing team based on 2-3 personnel (depends upon the size and type of enterprise or organization) with multiple skills (multi-lingual expertise, standards, methodologies and tools) to handle the issues of interoperability and integration. It can be very supportive to software organizations which are developing large scale Web-based applications to improve their testing process by applying a separate sub testing team.

CONCLUSION
The main issue of this research is to test challenges in Web-based applications in respect to integration and interoperability factors. The research is based on the detailed study of literature and industry survey of ten companies. The studies and survey results show that most critical testing challenges to Web-based applications are integration and interoperability along with performance and security. These challenging issues of testing require a lot of efforts to be resolved. Both Integration and interoperability have great impact on the overall quality of Web-based applications. The results of industrial survey show that almost 70 to 80 percent quality of Web-based applications is based on integration and interoperability. Both integration and interoperability have their own specific critical issues and challenging factors which make testing process more difficult. According to the

survey results, most critical challenging factors of integration testing are inconsistent infrastructure and environment, and performance and reliability issues due to heterogeneity. The most critical challenges associated with interoperability testing efforts are differences in implementation standards, and diverse information, data retrieval and operating systems. The results also show that most widely used testing approaches to solve challenging issues of integration are end-to-end integration testing and increment/decrement testing approaches. The most widely used testing techniques to cover the issues of interoperability are functional testing and fault-based testing. Most of the companies do both integration and interoperability testing manually and not using automated testing tools except of the two companies. The results and their analysis show that the existing techniques are not enough to solve the challenging factors of integration and interoperability testing. We need generic methodologies, architectures, infrastructures and testing approaches to cover all the possible issues and problems that may occur during integration and interoperability testing. In this way the process of testing will be very simple and easy to conduct. It is also observed that both integration and interoperability are related to each other and if, we successfully cover all the possible issues and challenging factors of interoperability testing then it will not only reduce the testing effort of integration testing but also other testing issues like, performance, security, scalability and reliability as well. Finally, we conclude that since Web-based applications are playing pivotal role in many business domains, for example finance, sales, retail, marketing, and management of particular products. Secondly, the importance of software integration and interoperability also cannot be neglected in large enterprises and mission critical systems. Different integrated components are developed in multiple platforms using different methodologies and tools. Therefore, we suggest that there should be a separate sub-testing team consisting of 2-3 testers (depends upon the size and type of enterprise or organization) having multiple skills (multi-lingual expertise, standards, methodologies and tools) to handle the issues of interoperability and integration.

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Author Profile

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Professor Mamta Madan is an accomplished professor of Computer Science. She started her journey in academics by graduating with B.Sc (Hons) Physics from Delhi University with excellent academic record and was awarded by National Graduate Physics Society Association at Delhi University for getting first position in the college. She further studied at Jamia Milia Islamia and holds dual Master degrees, in Computer Application (MCA) and Business Administration (MBA). Further in her pursuit of education she completed her Master of Philosophy (M.phil) and Doctoral research (P.hd.) in Computer Science from Banasthali Vidyapith - Rajasthan.

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