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A Study and Analysis on

Software Testing Tools

[1]R.Akiladevi,[2]P.Vidhupriya,[3]V.Sudha

[1]Assistant Professor, Department of CSE,Rajalakshmi Engineering College,Thandalam, Chennai, India

[2]Assistant Professor, Department of CSE,Rajalakshmi Engineering College,Thandalam, Chennai, India

[3]Assistant Professor, Department of CSE, Kumaraguru college of Technology, Saravanampatti, Coimbatore, India

ABSTRACT

Software testing is one of the most important phases in software development lifecycle (SDLC). Software testing is the process of evaluating the software product with the intent to find whether it satisfies the user requirements or not. It involves identifying bug or error or defect in a software product without correcting it. There are various automated tools which help as to test the software products with accuracy. This paper analyzes some of the test management, functional and load testing tools**.**

Keywords: Functional Tools, Load Testing Tools, Software Testing, Test Automation, Test Management Tools.

INTRODUCTION

Software testing is the process of detecting defects/bugs in the product during execution. It acts as the part of quality assurance. It assists the software developers in delivering a defect free product. It also helps in validating a product against client's specifications/ requirements.

Software development lifecycle (SDLC) explains the process involved in developing software by the software industry. Mainly there are five phases. They are Analysis, Design, Implementation, Testing and Maintenance. Software development, begins with customer specification of requirements and then it will progress through Analysis, Design, Implementation, Testing and ongoing support of the completed software. Theoretically, it is understood that testing phase will start once implementation is completed [9]. But in practical, testing is the parallel process that begins at requirement elicitation itself. Once project requirements are identified, that has to be parallel checked. Suppose if there is any error that can be identified at early stage instead of identifying after implementation. This will helps to reduce the

rework.

The objective of testing is to find errors/bugs in the system. Best and successful test cases can be used to find even the undiscovered and uncovered errors with high probability [9]. In a project, testing is the most important and also expensive process. It is mandatory to spend 40% of the effort for testing. But 100% bug free software is not always possible. If there is any defect in the delivered product, then the testing team has to take the responsibility. So the testers have the mandatory role in delivering the bug free software. The tester must possess the following qualities like operability, observability, controllability, decomposability, simplicity, stability and understandability [9].

TESTING AND ITS ACTIVITIES

The process of testing involves the following steps. Initially the Test plan has to be prepared which is a document describing the scope, methodology, testing environment, schedule, major risks etc. The next step is to prepare a test case which is used to test a particular scenario in detail. It includes information about input, testing procedure, environment required, expected and actual results, etc. Then the execution of the test case will happen according to the testing schedule in test plan. Test result contains the summary of testing activities and information about whether the test cases are pass or fail. The various activities involved in the process of software testing is shown in Figure 1.

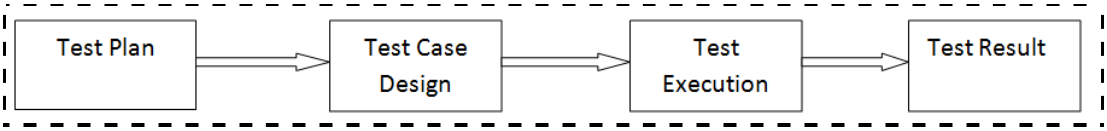

*Figure 1.*Activities in software testing process

There are two types of testing, they are static and dynamic. Static testing means identify the error before executing the program. Techniques used for static testing are code inspections and review. It identifies logical, standard and control errors. Dynamic testing means identify the error after executing the program. It is further classified into two types, Functional testing (Black box) and Structural testing (white box). Functional testing will test the entire functionality of the system by comparing expected output with actual output. It will not focus on the internal design of the program. Whereas Structural testing will mainly focus on the internal design of the program like path coverage, statement coverage, control structure and program complexity etc. thereby improving the design and usability.

METHODS OF SOFTWARE TESTING

Testing can be done in two ways. They are Manual Testing and Automation Testing.

Manual Testing: In manual testing, testers will initially prepare the test plan and test cases based on the requirement specifications. Test cases will contain the information about the input to be given to the system and the corresponding output. Quality of testing depends on how far the test cases have covered the requirements. Test cases should also cover the incorrect scenario to detect how the system is responding for the particular scenario. One main drawback of manual testing is which required more time and resources.

Automation Testing: In automation testing tester writes scripts and feed to another software to test the products. It improves the test coverage, accuracy and save time and memory. Automation testing tools falls under three different categories. They are Test Management tools, Functional Testing Tools and Load Testing Tools.

TOOLS USED IN SOFTWARE TESTING

This section discusses about the various software testing tools which is focused on Test Management, Functionality and load.

Test Management Tools: It is used to maintain and plan manual testing, run or gather execution data from automated tests, manage multiple environments and to enter information about found defects. Test management tools offer the prospect of streamlining the testing process and allow quick access to data analysis, collaborative tools and easy communication across multiple project teams.

Open Source Tools:

I. **TET (Test Environment Toolkit):** The goal behind creating the Test Environment Toolkit (TET) was to produce a test drive for check functionality and interfaces [7].

II. **TETware:** TETware is the supported version of the Test Environment Toolkit, offering additional platform support and capabilities. It provides an easy-to-use multi-platform uniform test framework into which local, remote, distributed and realtime test suites can be incorporated [7].

III. **Test Manager:** It is used to facilitate regular Software Development activities, automate & manage the testing activities [7].

IV. **RTH- Requirements and Testing Hub:** It provides the bug tracking facilities [7].

Commercial Tools:

I. **HP Quality Center/ALM:** It is a set of software tools for application development and testing. It includes tools for requirements management, test planning and functional testing, performance testing, developer management, and defect management [7].

II. **QAComplete:** Manage, organize, and report on all your testing efforts in a central place using QAComplete. Centrally store your manual and automated testing assets to promote reusability. Allow your testing teams to communicate more effectively, while staying organized and keeping a track of changes with proper version control [7].

III. **T-Plan Professional:** Test Process mgmt tool, Test ANY system. As automation runs at the GUI level, the tool can automate most applications [8].

IV. **Automated Test Designer (ATD):** ATD is a unique tool for creating Test Cases based on Functional Requirements. It uses an advanced and rigorous Neural Network Optimization algorithm and reduction methods, in order to generate the minimum number of test cases to certify 100% of the Requirements rules [8].

V. **Testuff :**Testuff test management is an on-demand service for managing and executing manual software tests and for reporting defects. This test management suite includes: Requirements management, test cases, test planning and execution, defect reporting, video recorder and player, time management, integration to all bug trackers and automation tools and much more [8].

VI. **SMARTS:** Assurance Suite, delivers critical data center management insights that empower IT operations teams to deliver service assurance for applications and services. Smarts monitors the availability and performance of physical and virtual networks, storage environments, and servers [9].

VII. **QAS.TCS (Test Case Studio):** QAS.TCS provides a central platform for the entire test team, with functionality extending to test case planning, definition, parameterizing, and even automated test execution at your option [7][10].

VIII. **PractiTest:**PractiTest is an end-to-end QA and Test management solution, designed to help users control their Testing and development process, focusing on how to manage their project and its information, and how to communicate testing outcomes to all the relevant stakeholders. It also supports a new type of test that encourages Exploratory and Session Based Testing practices [8].

IX. **Test Manager Adaptors:** Test Execution Adapters, which enable you to use testing tools other than IBM/Rational Robot/XDE Tester to implement tests in conjunction with IBM/Rational Test Manager. SegueSilkTest Adapter, Mercury Astra QuickTest Adapter, and Mercury WinRunner Adapter [7].

X. **SpiraTest:**SpiraTest provides a complete Quality Assurance solution that manages requirements, tests, bugs and issues in one environment, with complete traceability from inception to

completion. Highly intuitive web application that provides a complete picture of a project's status and health yet requires only a web-browser [8].

XI. **TestLog:**TestLog is an integrated test case management system. It provides a tool for test teams to create and update effective test cases. The test log provides the overall test run summary, indicates passed and failed tests and contains detailed information about each test operation, including the reasons of failed operations [8].

XII. **ApTest Manager:** ApTest Manager provides affordable test management for QA projects. It improves consistency, organization, and control throughout the testing process [8].

XIII. **DevTest:** DevTest helps to create and manage release and test cycles, plan and assign test tasks to the testing teams, execute test coverage, and submit product defects all from within a single application [8].

Functional Testing Tools: Functional testing is a type of testing which verifies that each function of the software application operates in conformance with the requirement specification. This testing involves checking of User Interface, APIs, Database, security, client/ server applications and functionality of the Application under Test. The testing can be done either manually or using automation. Different vendors provide different set of tools under these categories. Both Open source and Commercial testing tools are available. Here we have listed some of the testing tools under different categories.

It mainly concentrates on

(i)Mainline functions: Testing the main functions of an application

(ii) Basic Usability: It involves basic usability testing of the system. It checkswhether an user can freely navigate through the screens without any difficulties.

(iii)Accessibility: Checks the accessibility of the system for the user.

(iv)Error Conditions: Usage of testing techniques to check for error conditions. It checks whether suitable error messages are displayed.

Open Source Tools:

I. **Selenium:** Selenium is a portable software testing framework for web applications. Selenium provides a record/playback tool for authoring tests without learning a test scripting language (Selenium IDE) [7] [8].

II. **SoapUI:** SoapUI is an open-source web service testing application for service-oriented architectures (SOA) and representational state transfer (REST). Its functionality covers web service inspection, invoking, development, simulation and mocking, functional testing, load and compliance testing [8] [11].

III. **Watir:** It is an open-source (BSD) family of Ruby libraries for automating web browsers. It is simple and flexible. It supports multiple browsers on different platforms [8] [12].

IV. **HTTP::Recorder:** It is a browser-independent recorder that records interactions with web sites and produces scripts for automated playback[8] [13].

V. **WatiN:** easy way to automate your tests with Internet Explorer and FireFox using .Net [8] [14].

VI. **CanooWebTest:** Ant and Http Unit to implement functional testing of web applications.to support writing tests before the implementation. The tool used for acceptance testing. It is easy to extend [8] [15].

VII. **Webcorder:** This is a free GUI software testing tool I developed in VB to allow for simple end user web testing [8] [16].

VIII. **Solex:** Solex is a Web application testing tool built as a plug-in for the Eclipse IDE. It provides functions to record a client session, adjust it according to various parameters and replay it later typically in order to ensure non regression of the application's behavior [8] [17].

IX. **Imprimatur:** Web application testing tool. The tests are described in a simple XML file. Along with the standard GET and POST actions, Imprimatur handles HTTP sessions and file uploads. The responses can be validated using regular expressions and response code checks. Open source [8].

X. **SAMIE-Simple Automated Module For Internet Explorer:** Perl module (SAM.pm) that allows a user to automate Internet Explorer. This free tool is designed for quality assurance engineers that need to run tests for their browser applications [8][18].

XI. **Swete:** Swete provides cross platform console based tools for regression testing of web applications. The tools may be used when refactoring and during development to ensure that new functionality doesn't break previously completed features [8] [19].

XII. **ITP:** Web application testing harness. Lightweight, yet powerful! Test scripts written in XML. No programming required! No changes required to your application. Supports sessions/cookies, POST form data. Command line based for integration into other tools [8].

XIII. **WET:** Framework for Web automation testing. It has many features like multiple parameter based object identification for more reliable recognition, support for XML object repository, better popup handling, HTML results, Precondition Support, Teardown support, Parametrization of the scripts, Parameterization of the objects, External Library support and more[8].

XIV. **WebInject:** WebInject is a free tool for automated testing of web applications and web services. It can be used to test individual system components that have HTTP interfaces, and can be used as a test harness to create a suite of [HTTP level] automated functional, acceptance, and

regression tests. WebInject offers real-time results display and may also be used for monitoring system response times [20].

XV. **Katalon Studio:** It is a test automation framework such as Selenium and Appium by eliminating their technical complexities to allow testers to efficiently setup, create, run, report and manage their automated tests. It also offers a viable alternative to commercial test automation solutions that are unaffordable to many small and medium-sized teams [8].

Commercial Tools:

I. **QuickTest Pro:** provides functional and regression test automation for software applications and environments. It supports keyword and scripting interfaces and features a graphical user interface. It also allows developers to test from a single console all three layers of a program's operations: the interface, the service layer and the database layer[7].

II. **QuickTest Professional (QTP):** An automated regression testing tool to identify any gaps, errors/defects in contrary to the actual/desired results of the application under test[7] [8].

III. **Rational Robot: [1]** Rational Robot is an automated functional, regression testing tool. It provides test cases for common objects such as menus, lists, bitmaps and specialized test cases for objects specific to the development environment.

IV. **Sahi: [2]** Sahi is automation and testing tool for web applications coming in an open-source and a proprietary version.

V. **Soap Test:** Automated tool for testing Web services. SOAP test facilitates server functional testing by automatically creating a test suite from a WSDL document that tests every operation associated with that document [7].

VI. **Badboy: [3]** Badboy is a powerful tool designed to aid in testing and development of complex dynamic applications. Badboy makes web testing and development easier with dozens of features including a simple yet comprehensive capture/replay interface, powerful load testing support, detailed reports, graphs etc.,

VII. **TestComplete: [4]** TestComplete is a functional automated testing platform. Tests can be recorded, scripted or manually created with keyword driven operations and used for automated playback and error logging. TestComplete is broken out into three modules: Desktop, Web, Mobile. Each module contains functionality for creating automated tests on that specific platform.

VIII. **QA Wizard: [5]** QA Wizard Pro automates the functional and regression testing of web, Windows, and Java applications, and load testing of web applications. Using a single application to perform both functional and load tests.

IX. **Netvantage Functional Tester:** Functional and regression automated web testing tool [7].

X. **AppsWatch:** Appswatch is an automated performance testing tool for functional, regression, and GUI testing. It runs tests from the user's Desktop. It is protocol independent and works with any application accessible from a windows desktop [7].

XI. **Squish:** Professional test tool which allows to create, debug and run automated GUI tests for Qt, Tk, XView and HTML/Web applications [7].

XII. **actiWATE:** a Java-based software platform intended to make the test automation process simple and cost-effective for automation of regression testing of web applications[7] [8].

XIII. **liSA:** No-code, enterprise-strength automated testing solution for J2EE applications, websites and web services. liSA uses "inline testing" technology to talk to every component within your infrastructure. New one-click wizards enable even non-developers to connect to, analyze and interact with live EJBs, databases, messaging layers and web services/SOAP objects[7].

XIV. **vTest:** Functional and regression testing with a host of powerful web functional testing features. It empowers, to thoroughly verify and validate the web applications in a variety of environments. It support enhance productivity by generating automated test scripts, replaying both automated and custom test scripts, generating test reports and spotting software bugs early in the development cycle[7].

XV. **Internet Macros:** Low cost automation testing. It adds record and replay functionality similar to that found in web testing and form filler software [8].

XVI. **Ranorex:** Windows GUI test and automation framework for C++, Python and for the .Net languages [7].

Load Testing Tools: Load testing is the process of putting demand on a software system or computing device and measuring its response. Load testing is performed to determine a system's behavior under both normal and anticipated peak load conditions.

Open Source Tools:

I. **Jmeter:** Java desktop application designed to load test functional behavior and measure performance [7].

II. **FunkLoad:** FunkLoad is a functional and load web tester, written in Python, Regression, performance and stress [7].

Commercial Tools:

I. **WebLOAD Professional:** a tool for load testing Internet and Intranet applications. It aims to be easy to use and providing near real-time performance measurements of the application under test. This is particularly useful when you are doing optimization as you can see the impact of your changes almost immediately [7].

II. **HP LoadRunner:** It is used to test applications, measuring system behaviour and performance under load. HPE LoadRunner can simulate thousands of users concurrently using application software, recording and later analyzing the performance of key components of the application [7] [8].

III. **LoadStorm:** The easy and cost effective load testing tool for web and mobile applications.StormRunner Load is Software as a Service (SaaS) solution for Web and mobile application performance and cloud testing, for both internal and external applications [7].

IV. **NeoLoad:** Simulates hundreds of virtual users on your web site, getting performance statistics and revealing errors under stress [7].

V. **Loadtracer:** GUI-based tool for load/Performance /Stress/ Scalability testing of web applications. Using this tool more number of virtual clients can be generated to hit the web server at a specific time. It simulates multiple instances of web client accessing a Web Server based on the simulating information obtained from one web client during a session with a web server [7].

VI. **Forecast:** Suite of tools for system load testing, performance measurement and multi-user functional testing [7].

VII. **ANTS – Advanced .NET Testing System:** Load and scalability testing of .NET web services and applications[7]

VIII. **vPerformer:** vPerformer is a cloud enabled web performance and load testing tool that can be used to assess the performance and scalability of the web applications. vPerformer allows you to evaluate the response of your web application when it is concurrently accessed by a large number of virtual users[7] [8].

IX. **Webserver Stress Tool:** Stress testing tool that provides a consistent and cost-effective way of testing web sites, web servers, and intranet applications with web interfaces. It is a powerful HTTP-client/server test application designed to pinpoint critical performance issues in your web site or web server that may prevent optimal experience for your site's visitors [6].

X. **Load Impact:** Performance testing for DevOps. Websites, web apps, API or mobile apps can be tested with up to 1.2 million concurrent users. The important feature of Load Impact is the clear and easy to use dashboard. Results take only a few minutes and metrics are charted in a color-coded graph. Perform real-time testing with 25 virtual users for 5 minutes in free account which generates usage report of CPU, Memory, Disk I/O, Network I/O[7] [8].

The summary on the analysis of various software testing tool (Open Source and Commercial) discussed above is depicted in Table 1 and Table 2.

Table 1

Open Source Tools

Tool	Vendor	Scripting Language	supports	Purpose
Test Management tools				
TET (Test Environment Toolkit)	The Open Group	C	C, C++, Perl, Tcl, Shell, Python, Ruby, and Korn Shell.	Toolkit for checking functionality and interfaces
TETware	The Open Group	C	UNIX, Linux and 32-bit Microsoft Windows	a universal management and reporting framework
Test Manager	Applied Testing and Technology	Java	Delphi, Win32, .NET, Java, and Web applications.	Managing testing Activities.
RTH	Sourceforge		IBM AIX, Linux and Windows	Requirement management and bug tracking facilities.
Functional Testing Tools				
Selenium	GitHub project, Google Code Projects, SeleniumHQ		Java, C#, Python and Ruby	a suite of tools to automate web browsers across many platforms
SoapUI	Eviware software	Java	IDEA, Eclipse, and NetBeans	web service testing application.

Watir	Sourceforge	Ruby libraries	Internet Explorer on Windows	Provides browser-based tests of web applications.
HTTP::Recorder	Opus	Perl	Web	a browser independent recorder that records interactions with web sites
WatiN	Sourceforge	C#	Internet Explorer and FireFox.	Web Application Testing In .NET
CanooWebTest	Canoo Engineering AG	java	Java, Groovy Obj,Web and JavaScript	testing of web applications
Webcorder	Crimson Solutions	VB		GUI software testing tool
Solex	NEOMAlogic	java	Eclipse	Web application testing tool built as a plug-in for the Eclipse IDE.
Imprimatur	GitHub project, Sourceforge	Java, Xml	OS Independent	Imprimatur is a web application testing tool. Support HTTP authentication
SAMIE		ActivePerl	Windows	Simple Automation Module For Internet Explorer.
Swete	Neal Lester	Swete_script	XML	provides cross platform console based tools for regression testing of web applications.

WET	Qantom Software		XML	Framework for Web automation testing
WebInject	WebInject		JSP, ASP, CGI, PHP, Servlets, HTML Forms	testing of web applications and services
Katalon Studio	KMS Technology	KDT	Web and Windows GUI	Mobile Testing, UI testing, Web testing, Desktop testing
Load Testing Tools				
Jmeter	Apache	Java	HTTPS	Java application designed to load test functional behavior and measure performance.
FunkLoad	Nuxeo SAS	Python	XML and DAV	Performance web tester

Table 2

Proprietary/Commercial tools

Tool	**Vendor**	**Scripting Language**	**supports**	**Purpose**
Test Management Tools				
HP Quality Center/ALM	Hewlett Packard Enterprise			Requirements management, test planning and functional testing, performance testing, developer management and defect management.
QA Complete	SmartBear	Visual Studio	Windows	Track, Organize, Report on

				Manual & Automated Tests
T-Plan Professional	T-Plan, Limited		Windows	A SaaS based Test Management Suite
Automated Test Designer (ATD)	AtYourSide Consulting			Tool for creating Test Cases based on Functional Requirements.
Testuff	Testuff Ltd	Visual Design (Scriptless)	Windows and MAC OS	On-demand service for managing and software tests and for reporting defects.
SMARTS	BayTech			Tool for QA
QAS.TCS (Test Case Studio)	IBM		Lotus Notes	Smoothly integrate Test Case Studio with existing Notes based groupware solutions.
PractiTest	PractiTest	Visual Design (Scriptless)	Linux, Windows and MAC OS	QA & Test Case Management for Professional Testing
Test Manager Adaptors	RingZero			Test Execution Adapter
SpiraTest	Inflectra	Visual Design (Scriptless)	Windows	Defect Reporting tool Quality Assurance
TestLog	PassMark		Windows	Product testing
ApTest Manager	ApTest		OS Independent	Web based test repository, test execution, report generation, regression testing.
DevTest	TechExcel	.NET	Windows	Complete Quality Assurance Test Management

Functional Testing Tools				
QuickTest Pro	Hewlett Packard	VBScript	Windows	Regression Test
Rational Robot	IBM Rational	Java	Windows	Automated functional, regression testing tool
Sahi	Tyto Software	JavaScript	OS Independent	Web Automation Tool
SoapTest	Eviware software			Testing Web services
Badboy	Badboy	Local Scripting	Windows	A powerful tool for testing complex dynamic applications.
Test Complete	SmartBear Software	Visual Design (Scriptless)	Windows	Power Up Desktop, Mobile, and Web Apps
QA Wizard	Seapine Software	Local Scripting	Windows	Automated functional, stress, and load testing
Netvantage Functional Tester	Netvantage		Internet Explorer	Web testing software
AppsWatch	NRG Global		Citrix and SAP	Monitoring Application Performance
Squish	Froglogic	JavaScript, Perl,Python,Ruby and Tcl	Windows, MAC OS, Linux, Android and iPhone OS	Squish is the leading cross-platform/cross-technology GUI test.
actiWATE	Actimind	java		Software platform for

				automation of regression testing of web applications
liSA	ITKO	java	Script independent	Unit, functional, regression, integration, load, and performance tests.
vTest	Verisium	JavaScript	Windows 2000, XP, 2003	Functional and regression testing tool for web applications.
Internet Macros	iOpus/Ipswitch	javascript		It adds record and replay functionality similar to that found in web testing and form filler software.
Ranorex	Ranorex software		C++, Python and .Net languages	Windows GUI test and automation framework for
Load Testing Tools				
WebLOAD Professional	Radview Software			Performance tool for testing Internet and Intranet applications
HP LoadRunner	Hewlett Packard Enterprise Software	ANSI C	Windows and Linux	It is used to test applications, measuring system behaviour and performance under load.
LoadStorm	LoadStorm®			Load testing tool for web and mobile applications
NeoLoad	Neotys			Simulates hundreds of virtual users in web site, getting performance statistics and

				revealing errors under stress.
Loadtracer	Trace Technologies			GUI-based tool for load/ Performance / Stress/ Scalability testing of web applications
Forecast	Facilita	.Net, Java, Citrix and Database clients	Web	Suite of tools for system load testing, performance measurement and multi-user functional testing.
ANTS – Advanced .NET Testing System	Red Gate	.NET		Load and scalability testing of .NET web services and applications
vPerformer	Verisium		Windows	Web performance and load testing tool
Webserver Stress Tool	Paessler AG	VBScript	all 32-of bit versions Windows	Performance, Load and Stress test for Web Servers.
Load Impact	IBM	Java and Python SDKs	Mac, Mobile Web App, Windows, Web-based.	Cloud based Performance testing tool.

CONCLUSION

Software Testing plays a vital role in the development process as it adopts the customer's reliability and satisfaction. It also ensures the Quality of the Product / Project being developed. This paper deals with various automation tools involved in the process of software testing and a study on each of them. Depending on the various scripting language used and execution environment a suitable tool can be chosen. This paper portrays the survey of three different automated tools its pros and cons.

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