

# Research on GUI-based Automation Test Technology Driven by Separated Definition Data

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## **Abstract**

*GUI-based software is often developed a complicated test script with existing traditional automation software testing tools. The software automated test development technology consequently carried out some study of existing automated testing with current automated testing tools to simplify the script. The paper proposed a novel test automation technology with separated definition data, which replaced by script development or modification. The definition data are depicted for script driven, page description and test data separately. The test automation technology provided completed function and interface between this method and actual test tool. The test engineers is not need to write the any test script, but modify the definition files for test developing to some extent. The automation functional test technology has support the typical test tool and proved effective in the specific cases.*

**Keywords:** *Automation test, Software test, GUI-based software, Definition Data*

## **1. Introduction**

Software testing is a crucial activity of software quality assurance in software engineering. Software testing work has become a key critical task to guarantee the quality of software during the entire software development and maintain lifetime. In order to overcome difficulties of manual testing in the traditional test, automated test execution has been introduced widely to improve software quality and testing efficiency.

In recent years, software automation test technology is one of the research areas of emerging technologies. Software testing with the automated test tools is very necessary due to the emerging limitations of manual testing. The automated test technology improves the efficiency of software testing to some extent and reduces test workload with repeatable test case. The reuse of the previous test case could improve the accurate. The test results could be comparable. So the automated function test is helpful for software regression testing. The purpose of regression testing is to ensure that a change or release, such as a bug fix, did not lead in new defects [1].

The software test is the important phase during software engineering. The software quality should establish the overall management of the project management with various activities in the different project. The regression test is used for verify and check the bug which existing in the previous software version [2]. The newly release of software, such as software iteration model or software incremental model, should to be tested frequency and continuously. It is the best alternative to adapt software automated test, especially for program changes more frequently in the software. The merits and effects of continuously test are very obvious. As a result of testing, test case design activity completely good, and its expected results can also be

identified. The many software function and interface with the above version is same basically, so functional test is particularly suitable for automated testing [3].

Software testing has many issues which should be solved in software development, especially in the development of increasing new software technology based on popularity network platform. As for browser-server web application, short as B/S, is typical software based on network software systems. With growing of network-based software, automated test execution must be carried out effective in some large-sized and medium-sized web applications before the software put into use. How to improve the function test of B/S application system is issue which focused on method of automated function testing. The software automation is critical and strategic with the new emerging information. Therefore, it is necessary to utilize automation technology to improve the efficiency and heighten the effective. Software test automation consists of many good characteristics, such as automatic, repeatability and efficient. These characters are to enhance the stability and reliability of the software testing. Software test accuracy and reliability is not only to short the software development test cycle, but also to help the product quickly into the market [4].

The software functional testing is necessary to reduce human error and difference between different test engineers with the various technical abilities. Also the software functional testing with automated technology could reduce the cost of testing. In software functional testing, test automation is the use of special software to control the execution of tests, the comparison of manual test. Commonly, test automation involves automating a manual workflow that uses a formalized testing workflow [5].

The main structure of this paper is as follows: the second part gives the key technology about function test. Section 3 introduces the test design and test development using research. The fourth section illustrated experiment result and case study. And then related works and test tool is given. Finally, there are conclusions.

## 2. Key Technology

This section gives automation test technology with components. The principle and related consideration is proposed.

### 2.1. Script principle

Traditional software test automation tool, which uses the record and playback technology. The purpose of automated test tool is that simulate the end-user operation. The technology is the design goal for automated testing tool functionality: a record of all operations of the testers and the response of the tested software, including all operating keys on the keyboard, mouse click and so on, the response of the tested software to capture and compare screen. Although these test methods are easy to apply, but the difficulty of maintaining large. Capture-playback tools ultimately more functionality and flexibility of automated test scripts tools instead. However, the automated test scripts tools need highly developed skills and experience, poor maintenance, a huge cost overhead.

**Table 1. Relationship of component**

Model Level	Abstract Level	Reality Level
driven code	script	test case
descript segment	operation sequence	workflow
action	user operation	key press, mouse click
test data	data rule	input data
element	objects in web page	control

The record and playback technology is the prototype of automated testing tools, to be able to make the test only through this recording-playback technology tools to gather enough user actions to complete the related business workflows, is the basis of automated testing tools for testing.

Definition 1: Driven code. The initial code starts up test case execution in the software automation test.

Definition 2: Descript segment. The sequence in test case is tested step by step corresponding to workflow.

Definition 3: Action. The most basic user operation is operated by end-user in the software.

The action is the basic GUI operation in browser, such as the click with button, the input in the edit box, selects the drop-down item etc.

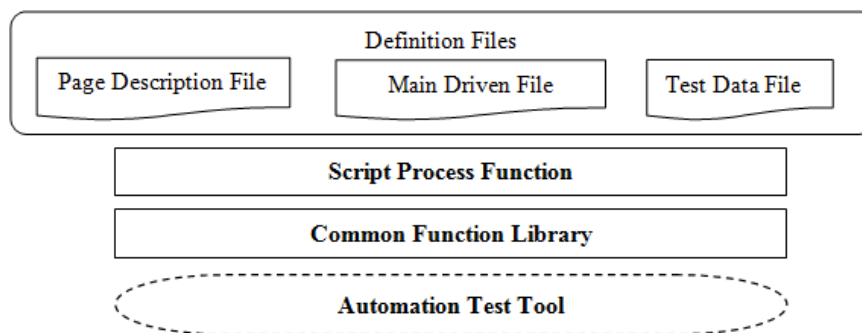
Definition 4: Test data. The data is used to fill the data fields in action, which includes the all possibility of data combination.

Definition 5: Element. For any of the software interface can be identified by automated testing tool. The element is operated by the test engineer during action operation.

## 2.2. Component

The automation framework is designed based on the module principle. The each module should implement the specific script function to some degree. The script should be separated into several parts according to the component. Furthermore, the each part of framework is taking resources in the framework, to improve efficiency and to ensure the use resources efficiency.

However, with the continuous development of Internet technology, especially e-commerce, e-government business workflows increasingly high, the traditional method of automated test scrip is increasing script maintenance workload in test development. Software maintenance in software engineering increased overhead costs has similar contact. Therefore, we propose a component-based test system with separated definition files.



**Figure 1. Component Diagram**

The new component-based test system is designed to fulfill the test development. In the entire workflow of testing, the test script development and test script execution are two important activities. The well-designed test script will help to improve the possibility of test defect.

The major part of this new component-based consists of definition files, functions, and its corresponding to test tools. The definition files are to abstract business workflows. The highly independent should be the maximum degree of reduction in executive action and interaction between the test object and the test data. The function provides the interface between the definition files and test tools. The common function library should retrieve and recognize the possible control and its operation in the web page from the browser.

The mapping relationship between control and script should to retain. This will not only ensure that the control change in the logical workflow execution, but also to avoid the effects of every exchanges in next test execution.

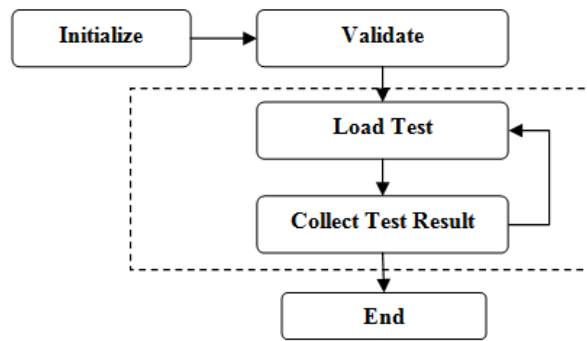
- **Main Driven File.** The Workflow definition file defined the test execution parameter and workflow execution sequence. For example, there are three typical flows in one web-based information system. And then these three flows should be stored in the workflow definition file.
- **Page Definition File.** This file defined the possible control in the web from. The classic control definition is implemented with direct method and description method. The direct method is classical method, which full path recognized. The description method provided the flexible way to facilitate the advanced operation. Here, the control definition in form table will use description method to locate the object.
- **Test Data File.** Different from the page definition file, the test data file is support the massive the test data during the test execution automatically. The data table is separated from the form table. The purpose of data table is provided the test data associated with business workflow.

### **2.3. Test Execution Method**

The key file in three separated definition files is main driven file, which mainly drive the entire test sequence related to test case. The main driven file gives the specific steps of the current business workflow, which each step required for entry to locate web, control and data.

During test design, test scenario should be designed. The test scenario is corresponding to business. The main business consists of script, function and data. The web page form is stored in a separate data file. With underlying public function, which also called common function, includes general functions, web forms, data access and COM object, wherein the general function mainly to provide command commands, date acquisition, date time transformation, event record, test results record and other functions. The page definition files give the page basic information; mainly provide page or form operation in various systems.

Test execution procedure consists of below steps: initialize and validate the data files, and then load the test. The initialize and validate is the process which initial the test and verify the three data is available and data in files are valid and practical. The load test should run the test for many times. Each time is corresponding to iteration, which composed with different test data. In every iteration,



**Figure 2. Test Execution Diagram**

In page definition files, it can be fixed parameters to locate elements positioning of elements in a lot of automated test tools, not a defined way can be completed, the need for the completion of the combination of multiple definitions. The element and element type of relationship is defined ElementType and ElementValue field, which will all these attributes described in definition files. In page definition file, the correspondence between the value of all the controls are placed in the data file, and each column with a column name paired storage in the test data file. The DataID column value corresponds to, as shown below. The data file is independent of the position of all use cases related to data retention. The field, DataValue is different data, which required filling the data field, the data field names

The advantages of automated functional test system is using a data-driven testing framework, which has the following characteristics: testing framework with data-driven features using external files stored test data is required to achieve the independence of the test data. Test script with custom variables instead of the actual data to be automated test execution when the specified test data obtained from the data file, so the test data, the changes will not affect the test script.

Design a test case in the framework of the test case in iteration in the test system in its modular design test cases, test cases are independent. The test suite set a trigger flag field of automated test tools in accordance with the settings of the test engineer of this field, which select the appropriate parameter to run the test script. Therefore, the test case is simple to modify the test suite with the flag can be run test scripts to meet different testing requirement with flexible method. Moreover, the design of the test suite using the test cases in manual testing method helps to follow the manual testing, test case management mechanism, and automated test design and management of test cases can also save time. .

The test framework driver designed script for the entire testing workflow control, functions of this part is package into a single executable file. Thus, testers used only before the test to modify the library functions, the test case sets and test script sets, and then automated testing execution began.

## 2.5. General Function

The general function consists of script process function and common function library

The script process function is the fundamental function to drive the control and its data. The function collections consists of control locate, control validate, control active and so on. These functions are necessary in the framework. The need to design the

corresponding function in the framework unified operation. Function is one of the key elements of the drive data file, and different underlying tools, and its function also inconsistent. Here, as defined in the framework of many basic functions.

The Common function library provided the non-control workflow function, such as window close, API or COM call and so on. COM mainly provide services such as EXCEL, XML and other related need to create COM objects in a general purpose operating.

The automated test tool should manage the lots of control in the page form. This function in framework and execution sequence is important points in the framework. Thus, this section presents these techniques. The form file could be reused in the framework, consists of database query, read object management as independent atomic function with specific function library.

According to the object properties, classical test tool often use direct object description. However, the page definition file is not suitable for this direct description method. For example, we adopt the novel method to make test using Quick Test Professional test tool, the one method is `Browser("CreationTime:=0").Navigate Environment("url")` and other is `Browser("micclass:=Browser").Navigate Environment("url")`.

In this framework, the purpose of function should be compatible with the different test tool. For the element locate in this framework, we adopt the `describe` method to locate the element in the web page or applet. For directly described using function, we use the method as three step:

1. Set `od = Description.Create()`
2. `od("micclass").value = type`
3. Set `o = Browser("micclass:=Browser").Page("micclass:=Page").ChildObjects(od)`

Through the DOM programming method, property of web control is the key to distinguish the object. Therefore, the control should be identified according to corresponding directional operation. In order to avoid in the conventional QTP automation project, object library should be maintenance continually with the each publish of new software release. As the new release of software, control should be check available one by one in object library.

Controls in traditional software and web control in web-based software should be encapsulated with mapping tag. In package specifically interact with details, so as to realize the element name and test of mapping between objects. The different business rules, different test requirements is provide different types of test data, includes an input data, output data, pointing to the operation data, workflow data and test expected result.

Form file, data file and auxiliary file usually uses Excel file format to store. Before test execution, many form files should be loaded by QTP test tool. Form definition file, data definition file and main driven file are used to define by Excel.

### 3. Test Design

Framework introduced by the previous section, here we introduce that how to use the framework design automated test scripts. Mainly consists of two phases: test design, test development. These two stages consistent with our traditional test design stage. Need to determine in the test design stage to perform the test, as well as the implementation of the method and conditions of these tests should also define the test

design standards. The test development workflow defined in the test design workflow step, the data clearly described, do automated testing reusable, maintainable, especially regression testing can further do.

### **3.1 Business Design**

According to the test requirements, testing objectives need to be familiar with the related business workflows and their requirements. Business workflow is clear to design the number of test suite. The test coverage is corresponding to requirements are defined. Business workflow test path coverage is the most common, the most basic coverage requirements. Of course, according to user needs, we can be higher requirements for the degree of coverage. In general, this is determined by the specific test objectives, of course, a high level of coverage usually requires more design time and cost in the workflow steps and data.

Development the traditional automated test script is complicated with different coverage requirements. Each script corresponds to a business workflow. However, in the framework, the workflows are flexible. Business workflow design analysis in the framework, mainly including the size of the pages involved in the analysis of business workflows, the circumstances of the particular coverage.

Test execution should adopt effective control and ensure that business with or without ability of test engineers. In the framework, the test execution can be carried out orderly. Perform according to the demand and the actual situation, can be divided into serial execution, execution, repeating the three basic ways, in complex test demand, can be mixed with a variety of basic way to implement. The implementation workflows the need for effective monitor automated or artificial and collects test data.

The main advantage of the test data file storage methods for the test is more intuitive and more easily handled. The form of data storage is often in the form of a data file stored. Currently, the most automated testing tools support a variety of file format, such as csv format, xls(Microsoft Office Excel) format.

### **3.2 Script Develop**

To solve too large and complex script, the script should be simplified. The highly abstract, high quality automation script should be designed. The scripts is the basic script collection, consists of general workflow function. The script develop is to avoid the strong coupling of the associated script. In practice, there is no consensus what approach test engineers use to develop and maintain test scripts.

According to the characteristics of the Web system projects, as well as automated testing project for frequent regression testing considerations, this paper chose more popular in the industry is mainly used for regression testing automated testing tools QTP [6].

The test script development is occupied a key position in this framework. The test execution is automated fully based on the QTP test tool. As the basis for results analysis, the QTP test tool could provide the enough function in fact. For automated test script development, special focus should be taken to separate the object names defined by the interface element names and test tools.

## **4. Experiments and Case Study**

Here, we make experiments to compare the execute time of test case between the tradition method and novel framework method which presented in this paper.

### 4.1. Experiments

The experiment is doing to compare the performance with and without this technology under the uniform test tool. The environment of experiment is depicted below: the operation system is Windows XP Chinese Version, the software environment: Quick Test Professional 9.5, Internet Explorer 6.0 and Microsoft Office Excel 2003.

The tested software is a B/S architect system. We consider two typical business operations. The one is the login into the web-based GUI software using Internet Explorer browser, the other operation is search operation.



Figure 3. The screen snap of being tested software

The login operation consists of operations: open browser and open the web page, the input the login name and related password, then click the OK button and check the whether the login success, the last step is close the browser. The results could see left part in Figure 4, the time using method in this paper is more than using test tool directed, about the 6-7 second per test execution.

The second operation is search, consists of operation: open browser and open the web page, the input the login name and related password, then click the OK button to enter the system, and then open the specific function ‘all project’, input the search condition and click the FIND button.

The compare results see as the time of test execution is not significance between direct and in this paper. So we consider the time of initial and verify data file could be waste time. After success of the data file initialize, there is no significant difference in execution time.

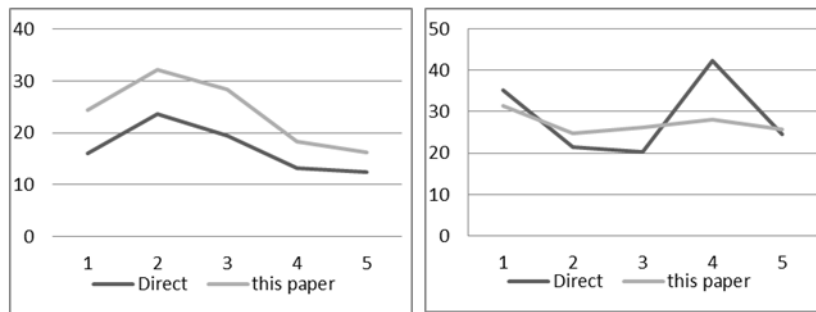


Figure 4. The comparisons between test tool and using method in this paper

### 4.2. Case study

Here, we give the detailed case to illustrate the run in this test design technology. Considering one insurance company, the majority of software maintenance is system



software upgrade in release update monthly. The software upgrade consists of the change of software requirement. The important content and basic common entrance test operation system. In order to improve the efficiency of use, insurance company adapt QTP automation as testing tools for the main core business system and accident insurance claims workflow system, which a vehicle claims reimbursement system, these several important system is involved in the business scene using automated test script test.

Due to its insurance business with annual business scale and business form changes, especially adding the intermediary management system, auto insurance underwriting operation system, new life insurance system in the IT system construction. Existing business scene test scripts and data have been unable to adapt to the continuous upgrading of the business system.

As for the reason of more and more modification on test script, the script is difficult in not only comprehensible but also edit script is high risk, for that any minor edition will lead the script not to run. Therefore, we use test automation test design technology proposed in this paper on consideration on the entrance test demand. Here, test engineers used test workflows repeatability, combined with insurance IT construction planning objectives and expansion for considering the present insurance system operation, the basic operations commonly. From the operational functions of the system and the original testing resources two aspects carries on the exhaustive analysis.

According to the customer test requirement, test engineers design 20 typical business scenes. Under these business scenarios, test develop engineers create the specific test procedures and adopt equivalence class partitioning method to design test data. And then, use the QTP to record a functional test script, which consists of set check points to verify whether the operation has taken place or verify the object state, set a data driven application test parameters. In the test script VBS script language is used to modify script, including adding test data source to the system of automated functional testing. Test script has two stages in playback generally: test development and regression testing phase. In test development phase, the first recorded a version of the test application. And then playback script is to verify whether a script work as test expected, which the stage as the validation application the baseline of expected behaviors. In regression test phase, play back scripts is used to be testing the latest application program version and establish baseline comparison in construction of test development stage. Regression testing reveals since the last build since may have been introduced into the application of any difference. These differences can be assessed to determine whether they are actual defects or deliberate changes. After the test results, the test efficiency is greatly improved and achieved the function goal of test automation through the test script playback analysis.

## 5. Related works

Automation testing tools could reduce human intervention to non-technical, unskilled, repetitive, redundant test activities. Therefore, the goal of complete testing is to achieve lots of unmanned activities and automatically generate test reports, analysis of test results [7]. The purpose of automated test is to fasten the efficiency of software testing, shorten the test cycle, improved software quality and guaranteed software to be able to control in advance.

Software automation test tools enable developers and testers make the entire test workflow easily in test execution. Nevertheless, due to lack of skills and software change, software testing is not easy and unsuccessful sometimes.

In order to help solving these problems in software test, some new frameworks which support for automating tests in distributed environments are proposed. The typical framework of manual black-box testing is developers or tester to specify the granularity of execution control and aids communication between various stakeholders and software developers [8]. As GUI-based applications evolve, test engineers should modify their corresponding test scripts so that they can use existing test case for successive releases. In [9] gives tool-based and manual methods to maintain the test scripts. Test engineers make their decisions ad hoc, based on their engineer experience and of the tool-based approach versus the manual [10].

From test requirements to the final automated test scripts, the highly simplified test framework is not only be able to adopt the current business system automation test execution to a high degree of scalability, but also able to make the new software compatible with the framework [11]. The original purpose of the automated testing framework for its design can reduce the cost to achieve and maintain automation scripts, test engineers to focus on the application of test case design [12].

The script module test framework is needed to develop some small-scale, relatively independent of the script on behalf of the module and function test application, and then adopt a classification of these small-scale script to build the larger test scripts. Small-scale scripts constituted more complex test scripts. Testing framework should be the easiest to learn and use, in front of a component to build an abstraction layer to hide applications other parts. It provides a module in the application design. Modifiability and scalability, in order to improve the combination of automated test cases the script modular test framework applied the principles of abstract or package [13, 14].

Keyword-driven automated testing is another test framework, which support test different sequences or more different paths with data-driven automated testing. It is a stand-alone application automation framework suitable for manual testing, automated testing. Keyword-driven automated testing framework built on top of the data-driven method contains instructions or keywords and not just data. These tests have been developed into a individual file, use the keywords they are independent of the implementation of test automation test tools. Keyword-driven automated testing is an effective method in data-driven automated testing. Keyword-driven automated testing features are included in the whole workflow with keyword-driven control [15, 16].

The variables in the input is read from the data file (data pool, CVS files, Excel files, *etc.*) in data-driven testing framework, the output value and loaded into the capture or programmed scripts. In data file framework, the input values and output values using the variable in the test script. Record test status and information log code to program the navigation data file read test script. The test cases with data file are not in the script, although keyword-driven testing framework is somewhat similar with other framework, the script provided a mechanism for transferring data [17, 18].

The commercial automation test tools have been chiefly described for using as solutions for testing an application. HP Quick Test Professional, shortly as QTP is software automation function test tool, which provides functional test and regression test automation for software applications and system. The purpose of using QTP wants to use it to perform repeatable functional tests for software regression testing with new release version of the same software. QTP combines the object recognition technology, data-driven and keyword-driven technologies. The QTP is responsible for the operational level test. The keyword-driven simplified the design and maintenance of test script. QTP test scripts, which composed by VBscript language, consist of keyword view and expert view. QTP support plug-in technology, which identify a variety of

objects, could suitable to test the standard the Web objects, ActiveX controls, and Visual Basic in typical windows application and internet explorer browser [6].

SilkTest is part of Segue test tool suite, which consists of web-oriented applications, Java applications, and traditional C/S application for automated functional testing and regression testing tool. In order to improve the efficiency of the test, the SilkTest provides a variety of means to increase the degree of automation of the test, including the generation of test scripts, test data of the organization, the management of the testing workflow, test results with analysis [19].

## 6. Conclusions

This paper studied automated functional testing technology which no use develop classical test script with test tool. The paper proposed the new component design and develops technology with current test tool. An independent definition files are designed and defined during the test development. The definition files, which are driven, description and data files, are only need to fill the relevant information for test. The study is functional testing for Internet application with current automated test tools. The Quick Test Professional test tool is used as basic test tool to implement the underlying test. Lastly, we describe some experiments to illustrate the minor performance influence with this method. And then case study is introduced.

A well designed technology and related functions could get test result in actual application test. But for different application, there are various features and test results. For further works, test engineers could provide ability to improve the performance in terms of optimizing functions.

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## References

- [1] S. Berner, R. Weber and R. K. Keller, (Eds.), "Observations and Lessons Learned from Automated Testing", Proceedings of the 27th Int'l Conf. on Software Engineering, (2005) May 15-21; St. Louis, MO, USA.
- [2] A. Bertolino, (Ed.), "Software testing research: Achievements, Challenges, Dreams", Proceeding of the 2007 Future of Software Engineering, (2007) May 23-25; Minneapolis, Minnesota, USA.
- [3] Z. Liu, Q. Chen and L. Cai, "An Automated Function Test Framework for Business Workflow Test Based on Data File", Advanced Science and Technology Letters, vol. 45, (2014).
- [4] M. Fewster and D. Graham, "Software Test Automation: Effective Use of Test Execution Tools", Addison-Wesley Publishing Co., New York, (1999).
- [5] G. J. Myers, C. Sandler and T. Badgett, "The Art of Software Testing", John Wiley & Sons, Inc. Hoboken, New Jersey, (2011).
- [6] HP QuickTest Professional, [http://en.wikipedia.org/wiki/HP\\_QuickTest\\_Professional](http://en.wikipedia.org/wiki/HP_QuickTest_Professional).
- [7] D. J. Mosley and B. A. Posey, (Eds.), "Just Enough Software test Automation", Pearson Education, Inc., Upper Saddle River, New Jersey, (2002).
- [8] S. Singla, D. Kumar, H. M. Rai and P. Singla, "A Hybrid PSO Approach to Automate Test Data Generation for Data Flow Coverage with Dominance Concepts", International Journal of Advanced Science and Technology, vol. 37, (2011).
- [9] D. Huberty, (Ed.), "Software Quality and Software Testing in Internet Times", Springer, Berlin, (2002).
- [10] E. Dustin, J. Rashka and J. Paul, (Eds.), "Automated Software Testing: Introduction, Management, and Performance", Addison-Wesley Professional, Upper Saddle River, New Jersey, (2004).

- [11] Q. Xie, M. Greehanik and C. Fu, (Eds.), "REST: A Tool for Reducing Effort in Script-Based Testing", Proceeding of the 2008 IEEE International Conference on Software Maintenance, China, (2008) September 28-October 4; Beijing, China.
- [12] N. K. Rao B. and R. Reddy A., "Features of Adaptive Test Suites", International Journal of Software Engineering Research and Practices, vol. 2, no. 3, (2012).
- [13] E. H. Kim, J. C. Na and S. M. Ryoo, (Eds.), "Implementing an Effective Test Automation Framework", Proceedings of the 33rd Annual IEEE International Computer Software and Applications Conference, (2009) July 20-24; Seattle, Washington, USA.
- [14] G. Zayaraz and P. Kalamegam, "A Test Framework based on CPN Model for Functional Testing of Web Service Composition", International Journal of Advanced Science and Technology, vol. 53, (2013).
- [15] A. M. Memon and M. L. Soffa, (Eds.), "Regression Testing of GUIs", Proceedings of the 9th ESEC and FSE-11, (2003) September 1-5; Helsinki, Finland.
- [16] M. Greehanik, Q. Xie and C. Fu, (Eds.), "Experimental Assessment of Manual Versus Tool-Based Maintenance of GUI-Directed Test Scripts", Proceeding of the 2009 IEEE International Conference on Software Maintenance, (2009) September 20-26; Edmonton, AB, Canada.
- [17] J. Tang, X. Cao and A. Ma, (Eds.), "Towards Adaptive Framework of Keyword Driven Automation Testing", Proceedings of the 2008 IEEE International Conference on Automation and Logistics, (2008) September 1-3, Qingdao, China.
- [18] A. Kaur and S. Goyal, "A Bee Colony Optimization Algorithm for Fault Coverage Based Regression Test Suite Prioritization", International Journal of Advanced Science and Technology, vol. 29, (2011).
- [19] Silk Test - Test Automation – Borland, <https://www.borland.com/products/silktest/>.

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